

Arkoma Playbook



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Arkoma Basin: *The Playbook*

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

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Dual-Lateral Horizontal Producer Completed

Initially flowing 9.38 million cu. ft. of gas, Newfield Exploration Co. of Houston has completed the first dual-lateral horizontal Woodford producer at a site in the western Arkoma Basin near Coalgate, Okla.

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Operators collect land for major gas programs.

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Drilling Inc.'s Rig
#25 are in the midst
of Fayetteville
drilling operations
for Chesapeake
Energy in White
County, Ark.



Photos courtesy of Lowell Georgia

The Arkoma Shales

The Fayetteville and Woodford shale gas plays in north central Arkansas and southeastern Oklahoma are delivering solid volumes of gas to the nation's markets.

Edited by Peggy Williams

Senior Exploration Editor, *Oil and Gas Investor*

The Fayetteville Shale in north central Arkansas and the Woodford Shale in southeastern Oklahoma hold trillions of cubic feet of gas in place, and producers have been engaged in massive drilling programs to tap that gas.

One of the nation's leading unconventional gas operators, Oklahoma City's Chesapeake Energy Corp., estimated that the rich 200-ft- to 300-ft-thick shale sections under its holdings in the Fayetteville may yield ultimate recoverable gas reserves of 6 Tcf.

Houston's Newfield Exploration Co. is even more sanguine about the potential of the Woodford. By that company's calculations, its acreage in the southeastern Oklahoma shale play could hold a treasure trove of 3 Tcf to 6 Tcf of recoverable gas. Houston's Southwestern Energy Co. — the biggest leaseholder in the Fayetteville — has built such a prime position that it has exposure to ultimate gross recoverable reserves of 11.2 Tcf.

Fistful of Fayetteville

With such a treasure trove in front of it, Southwestern invested US \$1.2 billion in its Fayetteville Shale drilling program during 2008. Average well results have rocketed upward, climbing from 1.5 Bcf per well in 2007 to 1.9 Bcf a well last year. The company produced 134.2 Bcf from the Fayetteville Shale in 2008 and closed out the year at an astonishing 720 MMcf/d. Going forward, it expects its 2009 Fayetteville production to hit between 229 and 232 Bcf.

To understand the target that Southwestern is pursuing today in the region is to appreciate how a little serendipity a few years ago played a significant role in the company's remarkable growth in the play.

This article is adapted from the June 2007 *Oil and Gas Investor* article "Fayetteville and Woodford Shales," by late Senior Financial Editor Brian A. Toal.

It all began in 2002 when the operator discovered that its older wells in the shallow Wedington sand in the northwest Arkansas part of the Arkoma Basin were actually producing four to eight times more gas than should have been in place in that Mississippian-age sand.

"What we found was that we were getting gas contribution in those old, conventional wells from the surrounding 50-ft- to 70-ft-thick shale sections above and below the Wedington," explained Harold Korell, Southwestern chairman and chief executive officer. "That's when the first light bulb came on."

Still, 50-ft to 70-ft shale sections didn't seem very prospective. So the company undertook a study of the eastern part of the Arkoma in north central Arkansas where the majors had drilled deeper wells through the Mississippian to look at the Arbuckle play during the 1970s.

In the Fayetteville Shale, Southwestern Energy believes it has exposure to 11.2 Tcf of recoverable gas reserves. Newfield Exploration, which holds 137,000 net acres in the Woodford Shale, believes that play could yield 3 Tcf to 6 Tcf of recoverable gas reserves.



Calves nurse as cattle graze in a lush Arkansas pasture in the heart of the Fayetteville play.



“We found that the shale sections in the eastern part of the basin, particularly in Conway and Van Buren counties, were more than 200 ft thick,” recalled Korell. “That’s when the second light bulb went on for us — that we had thick shale targets in the Fayetteville, at depths ranging from 1,500 ft to 6,500 ft.”

The black, organic-rich Mississippian Fayetteville is the geological equivalent to the Barnett Shale in north Texas and Caney Shale in Oklahoma. The Fayetteville occurs below the Pennsylvanian sands that are the major conventional gas reservoirs in the Arkansas Fairway of the Arkoma.

The Arkansas shale is thermally mature and its total organic content (TOC) ranges from 4% to 9.5%. Its gas contents are between 60 and 220 standard cubic ft per ton, and gas-in-place is 58 Bcf to 65 Bcf per section. From a thickness of 50 ft in the Fairway, the shale expands to as much as 325 ft in counties to the east.

To unlock the Fayetteville’s potential, Southwestern initially focused on drilling horizontal wells, typically with 2,000-ft lateral extensions, so that the well bore could make more contact with the low-permeability shale rock.

At the same time, the company used a combination of both slickwater fracs and cross-linked gel fluids in its well completions. Sand was pumped into the shale reservoir in an effort to optimize the rate at which gas flowed back into the well bore.

At present, Southwestern drills its wells for an average completed cost of \$3.1 million apiece. Laterals run 3,850 ft. During 2008, wells placed on production averaged initial rates of 2.7 million a day, up more than 1 million a day from 2007 rates. It has shifted to slickwater fluid completion on all its wells.

Recently, the company has been testing closer perforation cluster spacing in its horizontal wells. It is pleased with the results, gaining 20% to 25% improvements in early production. This could translate into corresponding increases in ultimate recoveries.

All told, the company has spud 1,230 wells in the Fayetteville play, of which it operated 1,015. At year-end 2008, it had drilled and completed 804 wells, of which 726 were horizontals.

The company’s year-end 2006 companywide reserves totaled a little more than 1 Tcfe; its annual production, about 72 Bcfe. In 2008, total proved net gas reserves booked in the Fayetteville shale play alone were 1.5 Bcfe.

“So the potential of the Fayetteville far exceeds — by multiples — our current reserve and production profile,” said Korell.

Major joint venture

Chesapeake Energy Corp. is another major player in the Fayetteville. In 2005 — after studying Southwestern’s experience in the emerging play — the



One of 28 ponds that Seeco has constructed in the Fayetteville play is a source for frac water.

company began moving aggressively. By the following year, it had amassed some 350,000 net acres it considered prospective, particularly in White County in the central part of the Fayetteville fairway, as well as in Van Buren, Conway, Faulkner, and Cleburne counties.

The big attraction? Steve Dixon, executive vice president and chief operating officer, said, “We felt that at shallow depths of 2,500 ft to 5,000 ft, the Fayetteville wouldn’t be very costly, that its shale sections were thick enough over such a large area that it could have multiple Tcfs of gas reserves in place, and that the play was repeatable such that we could just drill well after well, build infrastructure and turn it very much into a gas manufacturing-type operation.”

That’s not all. Since the company is fracturing so many different types of shale wells throughout the country, it believed it could leverage that extensive knowledge into better approaches to drilling and completing Fayetteville wells.

Aubrey K. McClendon, chairman and chief executive officer, said, “Traditionally, the industry had to solve for geological risk every time it went out and drilled a well, but with the advent of horizontal drilling and better completion technologies, such as multi-stage, slickwater fracs, we’re no longer solving so much for geological risk as we are engineering risk.”

2006 was a relatively modest one for the producer

in the Fayetteville. In 2007 and 2008, however, Chesapeake went at the play with a full head of steam.

Ultimately, the play will be developed on 80-acre spacing. “That means we can eventually drill about 4,500 new wells, each with ultimate recoverable reserves of 1.6 Bcf,” McClendon said. “After royalties, we expect to net 1.4 Bcf per well. Multiply that by 4,500 wells and it becomes clear that we’ve potentially captured about 6 Tcf of gas under our Fayetteville leasehold. So this shale play is very significant for Chesapeake.”

Then, in a stunning move, Chesapeake sold a 25% interest in its Fayetteville assets, including approximately 135,000 net acres of leasehold and production of 45 MMcf/d, to BP America. The major oil company made the move into the Fayetteville in third-quarter 2008, putting a stamp of approval on one of North America’s homegrown plays. Consideration was \$1.9 billion of cash and future drilling carries.

Today, Chesapeake’s 420,000 net acres rank it as the second-largest leasehold owner in areas it considers core and first tier. It produces approximately 180 MMcf/d of net gas (285 million gross operated). By the close of this year, it expects those volumes to climb to 235 million net and 400 million gross operated.

The firm plans to run approximately 20 rigs through the year to further develop its leasehold. Nearly all of its 2009 drilling costs, or approximately \$535 million, will be paid for by its joint-venture partner BP.

Lowering costs

A start-up in late 2004, Houston's Petrohawk Energy Corp. wasted no time getting into both the Fayetteville and Woodford plays.

"Our decision to pursue prospects in the Fayetteville and Woodford is a part of our overall strategy to grow within gassy basins," said Floyd Wilson, Petrohawk chairman and chief executive officer. "These activities were very complementary to our resource-type drilling in the north Louisiana Cotton Valley play and other parts of the Midcontinent.

"So in the case of the Fayetteville and Woodford, it wasn't like we were casting off in a new direction. They were simply different plays, new acreage, where we felt we could bring to bear our experience in horizontal drilling and modern frac technologies to create good economics."

In the Fayetteville, Petrohawk started off drilling in early 2006.

"The challenge for every operator is getting costs down and turning the play into more of a manufacturing-style drilling program that's repeatable, somewhat cookie-cutter, so that there's not a lot of R&D work required on every operation," Wilson said.

To lower costs, Petrohawk used high-angle and extended-reach drilling technology with polymer and oil-based muds, said Weldon Holcombe, senior vice president of Petrohawk's Midcontinent division. "This allows us to have less nonproductive time when drilling-fewer trips, fewer hole problems and less time running casing."

In the completion phase of its Fayetteville horizontal wells, the company is using a series of up to eight openhole packers to isolate each 300-ft to 400-ft frac stage in the lateral sections of its wells while it sequentially stimulates each isolated section of the formation with very large, high-rate, slick-water fracs, preceding them with acid.

In 2008, the company drilled 143 horizontal wells in the Fayetteville on its 157,000 net acres. Its gross operated production was approximately 145 MMcf/d at year-end. It focused on using cemented liners and increasing its average lateral length and number of frac stages.

At the beginning of 2008, only 4% of its wells used cemented liners, its average lateral length was 2,286 ft, it fractured six stages in a well. During the fourth

quarter, 100% of its wells had cemented liners; lateral lengths averaged 2,655 ft, and 7.6 stages were fractured in each well.

These efforts paid off in superior completion rates, as Petrohawk's initial potentials (IPs) on its Fayetteville wells grew from 1.9 million per day in the first quarter to 2.4 million in fourth-quarter 2008.

Oklahoma's Woodford

The Arkoma Basin's Woodford Shale play centers on southeastern Oklahoma's Hughes, Coal, Pittsburg, and Atoka counties. This organic-rich, Devonian-aged shale is the most active play in the Sooner state.

Operators with sizeable positions in the Arkoma Woodford, which covers some 1,500 sq miles, include Newfield Exploration, Antero Resources, Continental Resources, Devon Energy, St. Mary Land & Exploration, PetroQuest Energy, and XTO Energy.

Average per-well costs in the play have been \$5 million and recoverable reserves 3 Bcf, but operators appear to be successfully pushing well costs downward and ultimate recoveries upward.

The Mississippian/Devonian-aged shale ranges up to 220 ft thick, its TOC contents rise as high as 14%, and it has high silica contents, between 60% and 80%. Drilling depths range down to 11,000 ft. Woodford wells make little to no water, and most drilling is in a rural corner of Oklahoma. Plenty of old vertical wells in the area lend well-control data, meaning few surprises.

Houston-based Newfield Exploration is the marquee company in the Woodford shale play. The company began its involvement in 2003. It made its first Woodford Shale discovery that year. Its first horizontal well came onstream in 2004.

To date, some 750 horizontal Woodford wells have been drilled by industry, and Newfield has operated 225 of those. The company has 165,000 net acres of leases. This year, it plans to run 11 operated rigs in the play. In mid-December 2008, its Woodford production surpassed 250 MMcf/d, and its total Woodford production volumes in 2008 increased 65% over 2007 levels.

Cost control is a prime objective of every E&P company these days, and Newfield notes that it has reduced its costs to drill a lateral foot of Woodford by more than 40% from 2007 to 2008. The cost reduc-



“...AS WE DEVELOPED OUR KNOWLEDGE and expertise in the Barnett, we started looking around the country for other places that would be prospective for shale gas.”

—J. Larry Nichols, chairman and chief executive officer, Devon Energy

tions came from faster drilling, pad drilling, refinements in completions, and increased lateral lengths. In 2006, Newfield’s Woodford laterals averaged 2,500 ft; this year it plans for laterals up to 5,000 ft long.

Additionally, the company has experimented with multilateral completions in the Woodford. Its first well featured 8,500 ft of lateral hole and had an IP of 13 million a day. During its first three months of production, the well averaged 8 million a day.

Newfield is also trying a super-extended lateral. This well has a 5,600-ft horizontal section and was completed with 12 frac stages. Initial rates have not yet been announced, but are expected to be released shortly.

Oklahoma native

For Oklahoma City-based Devon Energy Corp., its entry into the Woodford in southeastern Oklahoma in early 2003 was a natural extension of its earlier success in the Barnett in the Fort Worth Basin.

“When we bought Mitchell Energy & Development in 2002, we saw that the technology to get gas out of dense shale bodies as in the Barnett was really opening up,” said J. Larry Nichols, Devon chairman and chief executive officer. “And as we developed our knowledge and expertise in the Barnett, we started looking around the country for other places that would be prospective for shale gas.”

The Woodford, particularly in Coal and Hughes counties, looked very attractive, in terms of having the requisite thickness and geologic characteristics to apply the knowledge the operator had gained in the Barnett, he added.

Devon targets the shale at depths ranging from 6,000 ft to 10,000 ft. “It’s a pretty rich black shale, the thickness ranging from about 140 ft to 175 ft,” said Stephen J. Hadden, Devon senior vice president, E&P. “Potentially, the gas reserves under our acreage could be as much as 1 Tcf.

“As we learned with the Barnett, matching the right frac technology with a particular reservoir is

always important when it comes to unlocking the optimum value in shale plays,” Hadden noted. “Early in the Woodford play, we tried some gel fracs, but later moved to slickwater fracs. We found them cheaper and more efficient, in terms of getting better production performance.”

Slickwater fracs, he pointed out, allow for higher pump rates and higher volumes of water and sand to penetrate a targeted formation such that an operator can optimally extend the fracture system and get more of the formation’s gas flowing into the well bore.

Another value-added technology Devon has brought to bear in the Woodford is 3-D seismic. “Being able to image a reservoir in great detail before we drill helps us avoid geological hazards that might be present in a shale formation and determine the optimal locations to position our horizontal wells,” Hadden said.

In the completion phase, the operator is also employing microseismic technology. “It’s a tool that allows us to track and map the path a frac job may take in a well bore, such that we can actually see how the frac is being distributed in a reservoir,” he said. “In short, it provides a good picture of how effectively we’re completing a well.”

To handle the increasing amount of production that will result from Devon’s stepped-up horizontal drilling in the Woodford, the company is continuing to expand its gas-gathering system in the region. It completed its \$30 million Northridge gas processing plant with capacity to produce up to 200 million a day. The plant started operations in October 2008.

Certainly, the Woodford has been an incredible growth story. From modest production of some 25 MMcf/d (all from vertical wells) in early 2005, the black shale has grown to volumes of 550 million a day in mid-2008. When that’s added to the tremendous Fayetteville gas total of some 1 Bcf a day at year-end 2008, it’s clear that the Arkoma Basin shales have become a considerable contributor to the nation’s gas supply. ■

Buying Arkoma

Investment dollars continue to pour into the Fayetteville and Woodford shales, but can valuation metrics keep pace with the high bar set by recent deals?

By Lance Dardis

Managing Director
Scotia Waterous, Houston

In the Arkoma Basin, the development of the Woodford and Fayetteville shales has made this part of the Mid-Continent region one of the hottest unconventional play areas in the US. Located just to the north of the Ouachita Mountains frontal belt, the Arkoma Basin stretches 300-plus miles across two states and includes the Fayetteville Shale play in central and western Arkansas and the Woodford Shale play in southeastern Oklahoma.

The Arkoma Basin is one of several foreland basins formed during the late Paleozoic Ouachita orogeny, which includes the Fort Worth and Black Warrior basins. Organic-rich shales, such as the Woodford, Fayetteville, and Barnett, were deposited on a shelf or in a basin area marginal to the Ouachita Front.

Fayetteville Shale

Production from the Arkoma Basin Fayetteville Shale occurs in Cleburne, Conway, Faulkner, Pope,

White, and Van Buren counties in northwest and north central Arkansas. The modern play began in 2002 and 2003 when Southwestern Energy Co. of Houston became interested in developing the shale. Today, expanding infrastructure combined with improved drilling techniques and falling costs have improved economics in the area. More than 800 wells have been drilled since the beginning of 2006, and current production has topped 800 MMcfe/d.

When Southwestern Energy reported its full-year 2008 results, it revealed that in 2008, it spud 604 wells in this play. By Feb. 15, 2009, its gross operated production was 750 MMcf/d.

Its average initial potential (IP) per well was 2.7 million a day, and its finding costs were about US \$1.21/Mcf.

Although there is strong demand for core Fayetteville acreage, the challenge is that the play is

dominated by a small number of companies that entered the area early on, when leases could be had at a relatively low price per acre. Southwestern, Chesapeake Energy, Petrohawk Energy, XTO Energy, and now BP, through its joint venture with Chesapeake, account for a majority of the play's production and undeveloped leasehold. Southwestern, with approximately 860,000 acres in the trend, has drilled on less than half of its Fayetteville position.

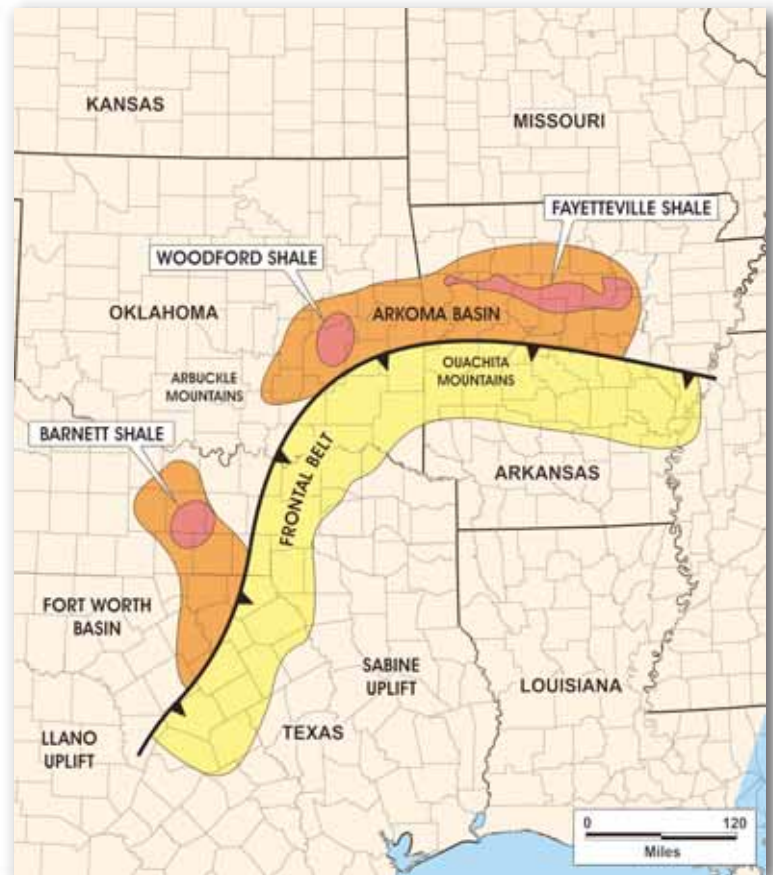
Transaction activity in the Fayetteville has been dominated by a few consolidators, with Petrohawk and XTO leading the way.

In June 2007, Petrohawk acquired 32,500 net acres, mostly in Van Buren County, Ark., from an undisclosed seller. Petrohawk followed that acquisition less than six months later with an acquisition of producing properties from a number of parties, including Contango Oil & Gas Co. and Alta Resources, for \$343 million, bringing Petrohawk's total net acreage position in the Fayetteville to approximately 125,000 acres.

According to research firm IHS Herold Inc., this transaction marked the first such deal that provided an implied valuation benchmark for producing reserves in the Fayetteville Shale, at \$3.15 per Mcfe, an implied 3P (possible reserves) value of \$0.69 per Mcfe, and an implied production value of \$17,182 per daily flowing Mcfe.

Not done with its Fayetteville consolidation efforts, Petrohawk made another acquisition in January 2008, paying \$231 million for an additional 18,500 acres of mostly undeveloped leasehold in Van Buren and Cleburne counties.

XTO Energy has also been a significant Fayetteville buyer, spending more than \$3 billion on multiple transactions during the first seven months of 2008. The first of these acquisitions involved Contango's remaining 20,000 core acres in the Fayetteville, including the interests owned by Contango's partners, for which XTO paid \$236 million in January 2008. One month later, XTO announced that it had entered into agreements with as many as 25 sellers to acquire properties in several onshore areas for an aggregate purchase price of \$1 billion, including undeveloped acreage in the Fayetteville, Woodford, and Barnett shale plays, which XTO valued at \$470 million.



In April 2008, XTO purchased producing properties, leasehold, and gathering systems in the play from Southwestern Energy for approximately \$520 million, giving XTO more than 300,000 net acres in the Fayetteville Shale trend. According to Herold, the deal implied a proved reserve metric of \$2.46 per Mcfe, an implied 3P reserve metric of \$0.52 per Mcfe, and an implied daily production metric of \$37,486 per Mcfe.

This deal also implied a metric of more than \$9,000 per acre. According to the press release, XTO expected the acreage acquired to hold resource potential in excess of 1.0 Tcfe.

In July 2008, XTO announced another multiple-party, multiple-basin transaction involving a significant chunk of undeveloped Fayetteville acreage for an aggregate transaction value of \$1.3 billion. According to its February 2009 investor presentation, XTO's daily Fayetteville output is now 30 MMcfe, and it has interests in 380,000 net undeveloped acres in the play.

XTO plans to drill as many as 125 Fayetteville wells in 2009.

In the Arkoma Basin, which stretches some 300 miles, the Woodford and Fayetteville shales were deposited in the late Paleozoic era.

Recent Fayetteville Shale Transactions

DATE	BUYER	SELLER	AMOUNT (\$MM)	ACRES
Sep-08	BP America, BP Plc	Chesapeake Energy Corp.	1900	135,000
May-08	XTO Energy Inc.	Southwestern Energy Co.	520	55,600
Dec-07	Petrohawk Energy LLC	Contango Oil & Gas Co., Alta Resources LLC, GPM Energy LLC, MND Partners LP, Tepee Petroleum Co.	343	24,000
Jan-08	XTO Energy Inc.	Contango Oil & Gas Co., Alta Resources LLC, GPM Energy LLC, MND Partners LP, TePee Petroleum Co. Inc.	236	20,000
Feb-08	Petrohawk Energy	Undisclosed	231	18,500

Recent Woodford Shale Transactions

DATE	BUYER	SELLER	AMOUNT (\$MM)	ACRES
Aug-08	BP America Inc.	Chesapeake Energy Corp.	1700	90,000
Dec-08	Undisclosed	Linn Energy LLC	202	NA
Oct-08	Cimarex Energy Co.	Chesapeake Energy Corp.	180	38,000
Mar-08	Undisclosed	Chesapeake Energy Corp.	170	27,000
Apr-08	Constellation Energy Partners LLC	Constellation Energy Group Inc.	53.4	NA

Tables courtesy of A&D Watch

In the latter half of 2008, Chesapeake began its monetization efforts involving all its major shale holdings. BP announced its \$1.75 billion acquisition of Chesapeake's Woodford shale assets in July, and entered the Fayetteville just two months later through another joint venture agreement with Chesapeake. With the transaction, BP acquired a 25% interest in Chesapeake's approximate 540,000 net acres in the play.

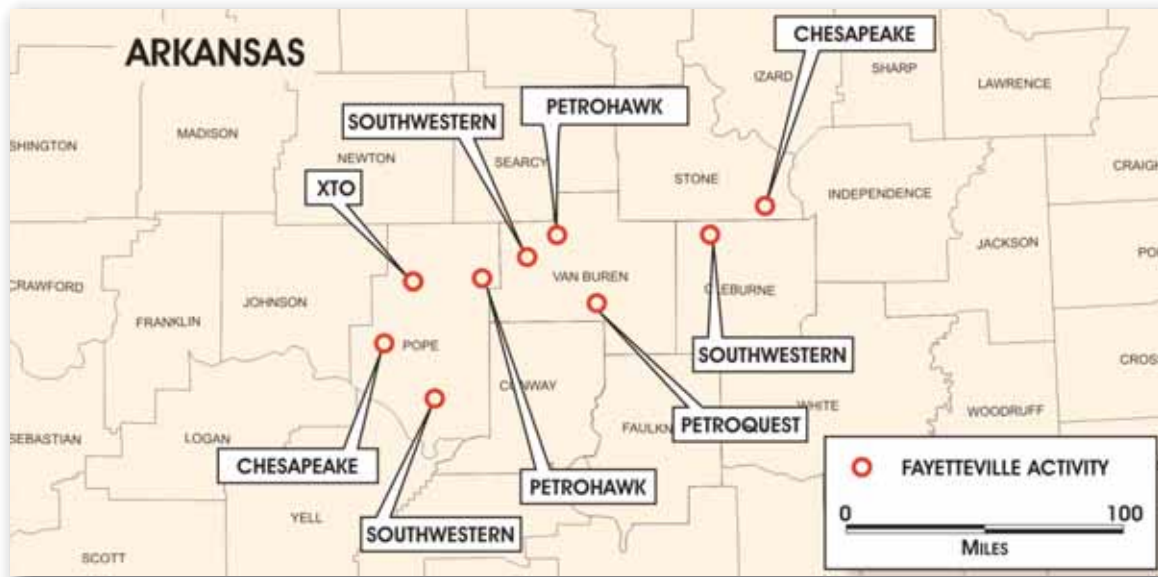
The agreement provided that BP would pay \$1.1 billion in cash upfront and up to an additional \$800 million, by funding 100% of Chesapeake's 75% share of drilling and completion costs in the trend through 2009.

The deal also provided that BP would have the right to participate with Chesapeake on the same 75/25 basis for any additional leasehold in the Fayetteville. According to Herold, the transaction implied a valuation of over \$14,000 per net acre, setting a new benchmark for other Fayetteville leaseholders.

Woodford Shale deals

Activity in the Arkoma Woodford Shale trend occurs primarily in Pittsburgh, Hughes, McIntosh, and Coal counties in southeastern Oklahoma. Since 2003, Newfield Exploration Co. has been touting the Woodford's potential (and a few years ago even hosted a financial analyst and shareholder tour, including a classroom session from its Tulsa offices). The field trip educated attendees on drilling operations and outlined the play's potential.

Today, Newfield has 165,000 net acres in the play (of which at least 85% is held by production), operates almost a third of the active rigs, operates more than a third of the horizontal wells, and produces roughly a third of the play's total production of over 400 MMcfe/d. Other significant players include XTO, Antero Resources, Devon Energy Corp., PetroQuest, St. Mary Land & Exploration Co., Continental Resources Inc., and now BP.



Since December 2007, buyers have paid more than US \$3 billion to acquire interests in either acreage or production in the Fayetteville Shale. Implied values for producing reserves have approached \$3.15 per Mcf and up to \$9,000 per acre.

Despite the fact that Newfield and others have significant positions in the play and that most of the prime acreage has already been leased, a few companies have been able to enter or expand their positions here through acquisitions. In addition to XTO's \$1 billion transaction in February 2008 involving multiple parties and multiple shales, including the Woodford, notable transactions include the sales by Chesapeake and Linn Energy LLC described below.

BP made headlines in July 2008 when it acquired all of Chesapeake's Woodford interests for \$1.75 billion. The assets covered 90,000 net leasehold acres and had estimated production of 50 MMcfe/d. According to Chesapeake's comments prior to the transaction, the properties contain over 2.0 Tcfe of reserve potential. As such, per Herold, this transaction implied a resource metric of \$0.88 per Mcfe — and at the time it set a new valuation bar for the Woodford, although the subsequent plunge in commodity prices and the overall economy is likely to have a material impact on the metrics paid in future Woodford transactions.

In October 2008, as commodity prices continued to fall and deals were being cancelled throughout the industry, Linn Energy was able to find or hold the buyer for its Woodford deep rights to the tune of \$202 million. Linn retained the shallow portion of its acreage in Oklahoma.

Future transaction activity

For the foreseeable future, the appetite for shale assets will be strong. Newcomer shale plays such as the Haynesville in Louisiana and Marcellus in the Appalachian Basin will likely continue to attract the broadest interest, and the Barnett in north Texas will continue to be considered the granddaddy of the shales — and a great investment if you can get access to the right address. But the Arkoma Woodford and Fayetteville shales will certainly attract substantial investment dollars.

In all probability, these dollars will come from new entrants. International E&P players are strategically looking for exposure to the US shales and want to put big dollars to work. StatoilHydro's \$3.4 billion investment in Chesapeake's Marcellus acreage is an example of an international new entrant in a major US shale play.

The shale plays may be akin to the deepwater Gulf of Mexico, where in both cases the resource is massive and so is the capital required to develop it. Companies will thus follow the deepwater Gulf of Mexico trend in the shales by seeking joint-venture partners instead of trying to go at it alone, thereby spreading capital and risk.

The Arkoma Basin shales will therefore compete with the industry's mega-investment opportunities not just in the US, but throughout the world. ■

A rig working the Woodford Shale for Newfield Exploration turns to the right day and night as the operator works its substantial position in the gas play.



Photo courtesy of Newfield Exploration Co.

Arkoma Basin Players Test Technology

Educated drilling and completions take gas shales to new heights.

By Don Lyle

Contributing Editor

Operators in the Fayetteville Shale in Arkansas and the Woodford and Caney shales in Oklahoma staked their claims in the gas-rich formations, drilled to hold their land positions, and embarked on a quest to combine the most efficient drilling and completion technologies to leverage their assets.

Just as Mitchell Energy and later Devon Energy completed the early, expensive part of the learning curve in the Barnett Shale in northern Texas and maintained a dominant position, Southwestern Energy led the Fayetteville play and Newfield Exploration Co. stepped in as the landmark company in the Woodford Shale on the Oklahoma side of the basin.

Service companies and dozens of additional operators arrived with their own plans to make the shales work profitably. Together, they converted the Arkoma play into the second most successful shale development, after the Barnett, in the world.

Each operator has an individual approach that works for that company. As a group, they put together nearly every technique that converts an untried gas play into a successful development.

Companies operating in the Arkoma shale plays – Caney, Fayetteville, and Woodford – are profiled on the following pages.

Key Players 

Antero Resources Corp.

Antero Resources Corp., backed by executives with extensive and successful backgrounds in shales and horizontal drilling, lists more than 100,000 acres of properties with Woodford Shale potential in Oklahoma among its growth prospects.

According to the company's Web site, it started producing from the Woodford in June 2006 and increased that production to 85 MMcfe/d gross (72 MMcfge/d net).

It currently keeps one drilling rig busy in the play, and it has drilled and completed more than 100 horizontal wells in the basin.

When the company secured US \$1 billion in financing through Warburg Pincus in 2007, it was operating 11 drilling rigs and produced 34 MMcf/d of gas from its Woodford properties. It also put together more than 40 miles of gathering lines with some 100 MMcf/d of line capacity.

Antero holds another 26,000 net acres with Woodford Shale potential in the Ardmore Basin of Southern Oklahoma and completed its first horizontal well in that play.

Between the time the company formed in 2002 and the end of 2005, Antero assembled more than 70,000 net acres of leases in the Barnett Shale in the Fort Worth Basin. By the time it sold those properties to XTO Energy in 2005, it was the top vertical well operator in the basin with production rates more than 10% higher than the next best operator. It maintains an affiliation with XTO.

Between February 2003 and its sale to XTO, Antero increased production from 17 MMcfge/d to 150 MMcfge/d from 250 wells. At one point, it was the second-largest producer in the Barnett and the second most active driller with up to 12 rigs working at the peak. By the sale date it had drilled more than 80 horizontal Barnett wells with laterals up to 4,200 ft long. It also was an early user of multistage fracture techniques and microseismic fracture mapping.

To help move the gas, Antero acquired and built more than 100 miles of gathering lines, 21,800 hp of compression capacity, 217 MMcf/d of gas dehydration capacity, and 125 MMcf/d of carbon dioxide treating capacity.

In addition to its Arkoma Basin properties, Antero holds properties in the Piceance Basin of Colorado and holds 117,000 acres in the Marcellus play in West Virginia and Pennsylvania through an arrangement with

Dominion Resources, one of the largest operators in the Appalachian Basin.

Antero originally signed on for 205,000 acres of Dominion property for \$552,000, but, as hydrocarbon prices dropped, the companies cut back giving Antero drilling rights on 114,259 Marcellus acres for \$347 million, or about \$3,037 an acre.

Antero's current production is around 138 MMcf/d gross, 115 MMcf/d net. ■

David H. Arrington Oil & Gas Inc.

David H. Arrington Oil & Gas Inc. has built a reputation as a wildcatter and a gas finder with substantial interests and experience in both the Barnett Shale of North Texas and the Fayetteville Shale in Arkansas.

The company's 1-14H Beverly Crofford horizontal test in Conway County, Ark., was a new field discovery. The company drilled the well to about 8,000 vertical ft and kicked off horizontally to a measured depth of 11,565 ft in the Fayetteville in Section 14-7n-15w nearly 6½ miles north of Menifee, Ark. It perforated the well from 8,060 ft to 11,210 ft but didn't report initial potential.

It followed up with the successful 2-14H Beverly Crofford development well completed two months later in the same section. Again, it didn't report initial production potential.

Also in Conway County, Arrington permitted the 1-3H Norman new field wildcat in Section 3-7n-16w. That well was projected to a vertical depth of 6,500 ft and a measured depth of 10,000 ft.

It also permitted the 1-20H Embry horizontal new field wildcat in Section 20-7n-17w, also aimed at the Fayetteville Shale. That well was scheduled to reach a total depth at 12,000 ft after drilling vertically to 8,500 ft.

Moving to Independence County, Ark., Arrington drilled the 1-28H Pulliam shallow new field discovery in the Fayetteville. That well, in Section 28-11n-6w reached total depth on a horizontal lateral at 6,000 ft and produced from perforations along the horizontal leg from 2,120 ft to 5,912 ft.

It also drilled the 2-28 Pulliam in the same section. It was holding reports on that well for additional data.

The company also completed the 1-23 Helena Port in Section 23-3s-4e in Phillips County, Ark. In 2006 in the Fayetteville, but it has not yet reported results on that well, according to IHS Inc. ■

Aurora Oil & Gas Corp.

Aurora Oil & Gas Corp., a prominent independent in the Antrim Shale play in Michigan and the New Albany Shale play in Illinois, holds a small overriding royalty interest in the Woodford Shale in Oklahoma.

Through early 2008, the company held 36,802 gross, 32,753 net, acres with Woodford Shale potential but didn't get around to active operations.

In May 2008, Aurora entered a purchase and sale agreement to sell its properties to Presidium Energy LC for a promissory note with a 9% annual interest rate for US \$12 million. According to Aurora, the value of the deal was more than \$15 million. That sale was part of an arrangement with interests of other interest owners in approximately 67,000 gross Woodford Shale acres called the Oak Tree Project. Aurora retained a 3% overriding royalty interest in the project, which now covers 71,000 acres. The companies completed the sale on Sept. 15, 2008. Since that time, Presidium completed five initial vertical test wells in the project area.

moved decisively and took advantage of some of the top expertise in the field.

It moved into the Arkoma Basin with major purchases in the Woodford Shale in eastern Oklahoma and the Fayetteville Shale in north central Arkansas from Chesapeake Energy.

According to an article in the company's *Horizon* magazine, "Executives in BP North America Gas (NA Gas) have acted quickly and decisively to gain a quality stake in US natural shale gas plays; starting with the US \$1.75 billion acquisition of the Woodford shale play.

"Purchased from Chesapeake Energy, it is located in the Arkoma Basin of Oklahoma and covers 37,000 hectares (90,000 acres)."

That purchase took all of Chesapeake's properties in the Woodford in the Arkoma Basin.

Those properties lie in Atoka, Coal, Hughes, and Pittsburg counties and, at the time of the sale announcement in July 2008, produced some 50 MMcfge/d.



"SHALE GAS IS GOING TO BECOME an important component of natural gas supply in North America during the next decades. We want to be part of this trend and continue to develop in other locations."

— **Andy Hopwood**, vice president, BP America Inc.

Presidium was founded by John V. Miller, formerly vice president of Aurora from May 18, 1997, until Feb. 29, 2008.

According to William W. Deneau, chief executive officer, "Completing this transaction creates a winning solution for all parties involved. It generates greater proceeds for the property than were originally anticipated and extinguishes the litigation associated with our joint venture partner in that project area. This is an ideal resolution to a risky and unproductive asset in our portfolio. Going forward, our 3% overriding royalty interest will allow us to participate in what could be a tremendous upside while eliminating downside risk to our enterprise." ■

BP North America Gas

BP North America Gas moved into the great US shale stampede late in the game, but when it moved, it

With the sale announcement, Andy Inglis, BP chief executive of exploration and production, said, "This acquisition has the potential to more than double our existing production of over 200 million standard cubic ft per day from our Arkoma operations."

Andy Hopwood, vice president, BP America Inc., added, "This is an important move for NA Gas. As natural gas prices continue to rise in North America, BP has determined that investment in shale gas development aligns with our plans for growth.

"Shale gas is going to become an important component of natural gas supply in North America during the next decades. We want to be part of this trend and continue to develop in other locations," he said.

Two months later, the two companies announced another major agreement involving Chesapeake's Fayetteville properties.

Photo courtesy of Chesapeake Energy

A lot of companies make money by getting into gas shales. Chesapeake Energy Corp. put a twist on that philosophy by making money selling whole and partial interests in its shale holdings.



In that deal, BP signed a letter of intent to buy a 25% interest in all of Chesapeake's Fayetteville shale properties in Arkansas for \$1.9 billion.

The full Chesapeake package consisted of 540,000 net acres of leases and 180 MMcfge/d of gas production. Those properties could support as many as 6,700 horizontal wells. Following the transaction, BP controlled a net 135,000 acres and 45 MMcfge/d of gas production and Chesapeake retained 405,000 net acres.

It wasn't pure cash deal, but it was similar to an earlier arrangement Chesapeake had made with Plains Exploration and Production (PXP) on Chesapeake's Haynesville properties.

Under the new arrangement, BP agreed to pay \$1.1 billion in cash and would contribute another \$800 million in 2008 and 2009 by funding Chesapeake's 75% share of drilling and completion expenses in the Fayetteville. That contribution would earn BP the right to a 25% participation in additional leases.

"This transaction, when combined with our recent Woodford acquisition, establishes a material position in the two attractive shale plays in the Arkoma Basin. Together with our substantial position in the emerging Haynesville Shale play in east Texas, BP has made a strategic entry into three top tier shale plays in North

America and established potential shale resources of 1 billion bbl oil equivalent net to BP. Development of these resources, along with our leading position in coalbed-methane production, and our extensive tight gas plays throughout North America, will enhance BP's position as a leader in unconventional gas technology and enable growth of our North American onshore natural gas production from today's level of 470,000 boe. We look forward to working closely with Chesapeake as they develop the significant Fayetteville play," Inglis said.

It was a great deal for Chesapeake, as well. "The PXP Haynesville Shale joint venture and the BP Fayetteville Shale joint venture together will pay for approximately \$2.5 billion of Chesapeake's drilling and completion expenditures currently planned for the second half of 2008 through 2010," said Chesapeake Chief Executive Officer Aubrey McClendon.

According to the *Horizon* magazine article following the Woodford purchase, 70% of BP North America's 470,000 boe/d of gas production came from unconventional resources. Most of that came from tight sands and coalbed methane.

BP began examining shale gas potential as operators clamored to develop the Barnett Shale in north

Texas and as shale plays began developing in other states. It put a multidisciplinary team to work on the economics of appraising and developing the gas and the application of existing technologies, mainly horizontal drilling and fracture techniques.

That team ranked the plays, looked for opportunities and made its purchase decisions backed by hard economics.

"If we didn't go forward and brave the new challenges of shale gas, BP would be missing out on a major new direction for gas supplies that will highlight the next two decades," Hopwood said.

In a presentation, BP said its position in the Haynesville, Woodford, and Fayetteville shales combined represent some 1 billion boe of resources that could produce up to 100,000 boe/d by 2015. ■

Carrizo Oil & Gas Inc.

Carrizo Oil & Gas Inc. chose a variety of interests in the oilpatch, but it clearly likes gas shales. It picked its shales, gathered land, built expertise in the plays and went to work.

It controls 75,000 net acres in the Barnett in the Fort Worth Basin, 95,000 net acres in the Marcellus in the Appalachian Basin, 57,000 net acres in the Barnett and Woodford in the Marfa Basin of west Texas, 137,000 net acres in the Black Warrior Basin of Alabama, 24,000 net acres in the Fayetteville in Arkansas, and 22,000 net acres in the New Albany Shale in the Illinois Basin.

Clearly, Carrizo's concentration among the shales lies in its activity in the Barnett, followed by the Marcellus. At this point the other shales are in the also-ran category.

It has five rigs working the Barnett, four in the core area. With those rigs it planned to raise production to 100 MMcf/d by the end of March 2009 and 125 MMcf/d by the end of the year. It still has more than 650 Barnett locations left to drill on 60-acre spacing, and its wells could reach 1 Tcf in producible resources, Carrizo officers said in a January 2009 presentation at Pritchard Capital Partners Energy 2009 Conference.

It planned to spend US \$235 million on operations in the Barnett in 2008 and \$3 million in the other shales combined. For 2009, poorer economics persuaded the company to cut Barnett spending to \$150 million and other shales to nothing.

It had participated in 15 Fayetteville wells through 2007 and planned to join in several more non-operated wells to that formation in 2008.

Funds earmarked for acquisitions dropped from \$169 million in the Barnett in 2008 to \$15 million in 2009. Marcellus acquisition fell from \$65 million to nothing, and purchases in other shales fell from \$21 million to \$2 million. Outside of the Barnett, Carrizo drilled two Marcellus wells and awaited completions at the end of 2008. It permitted five more Marcellus wells. ■

Chesapeake Energy Corp.

A lot of companies make money by getting into gas shales. Chesapeake Energy Corp. put a twist on that philosophy by making money selling whole and partial interests in its shale holdings.

The philosophy worked well in the Arkoma Basin as it sold all of its holdings in the Woodford play in eastern Oklahoma and 25% of its holdings in the Fayetteville play in north central Arkansas. Both parcels went to BP in deals with a total value of some US \$3.65 billion.

Chesapeake sold approximately 90,000 acres of properties with Caney and Woodford potential in Oklahoma. Those properties are in Atoka, Coal, Hughes, and Pittsburg counties and, at the time of the sale announcement in July 2008, produced some 50 MMcfge/d.

It sold a 25% interest in its Fayetteville Shale properties in Arkansas for \$1.9 billion; \$1.1 billion of that was in cash and the remainder is being paid in the form of drilling and completion carries on the joint venture properties in 2008 and 2009.

Following the transaction, BP held 135,000 net acres of land and 45 MMcfge/d of production. By the end of 2008, after the sale, Chesapeake still was the second-largest leaseholder in the Fayetteville with 415,000 net acres of land with an implied value – based on the BP sale – of \$6 billion.

For its own purposes, Chesapeake set an implied value of \$12,500 an acre, or \$5.2 billion for the properties.

For 2009, Chesapeake set a \$550-million budget for the Fayetteville but it will put up only \$50 million of that amount. BP will carry the rest.

It planned to operate an average 20 drilling rigs in the play during the year to add 325 Bcfe of new reserves at a finding cost of 15 cents/Mcfe for the company.

Figuring 80-acre spacing for the Fayetteville properties, Chesapeake had sites for a net 3,700 undrilled wells and an estimated 2.2 Bcfe per well in recoverable hydrocarbons.

Throughout the play, it held 535 Bcfe in net proved

reserves, 6.6 Tcfe in risked unproved reserves, and 8.9 Tcfe in unrisked unproved reserves.

The company's Fayetteville net production reached 145 MMcfe/d by the end of September 2008.

Following the Fayetteville deal, Andy Inglis, BP chief executive of exploration and production said, "This transaction, when combined with our recent Woodford acquisition, establishes a material position in the two attractive shale plays in the Arkoma Basin. Together with our substantial position in the emerging Haynesville Shale play in east Texas, BP has made a strategic entry into three top tier shale plays in North America and established potential shale resources of 1 billion boe net to BP."

A mid-2008 report by IHS Inc. said Chesapeake was producing 100 MMcfe/d of gas from the Fayetteville and production had climbed 900% over the past year. At that time, the company was drilling horizontal wells at a cost of \$3 million and it had drilled some 140 horizontal wells since it entered the play in 2007.

Chesapeake backed its enthusiasm about its Fayetteville holdings in October 2008 when its Chesapeake Energy Marketing Inc. subsidiary signed a 10-year agreement for firm transportation of 375 MMcfe/d of gas with an option to add another 125 MMcfe/d on the new Fayetteville Express Pipeline being built by Kinder Morgan Energy Partners LP and Energy Transfer Partners LP.

"We are pleased to announce that we have secured substantial new takeaway capacity for our Fayetteville Shale production that will provide Chesapeake and our 25% partner, BP America, with improved access to more favorable natural gas markets at an attractive transportation rate. This agreement helps to reduce both basis risk and pricing volatility and will accommodate the substantial growth we anticipate from the Fayetteville Shale play in the years ahead," said Aubrey K. McClendon, chief executive officer of Chesapeake.

A May 2008 IHS report showed the kinds of production Chesapeake got from its Fayetteville wells. Its 3-17H Martindill 8-7 in White County, Ark., flowed 3.33 MMcfe/d of gas through perforations between 4,985 ft and 10,112 ft from a northwest lateral.

In the same quarter-section, the 1-17H Martindill tested 1.97 MMcfe/d from a lateral perforated from 5,053 ft to 8,422 ft after an acid treatment and a five-stage fracture treatment. Between October 2006 and

February 2008, the well produced 563 MMcf of gas and averaged 669 Mcf/d of gas in February.

McClendon told analysts in an August 2008 presentation recorded by Seeking Alpha, "In the Fayetteville, we are drilling our best wells ever, due to improvements and where we position our laterals within the Fayetteville; longer lateral lengths, better completion techniques, and the arrival of certain new 3-D information that help us avoid geological pitfalls."

Answering a question from an analyst, McClendon showed insight for his attitude for the Fayetteville and possibly for BP's entry into the play. He said, "...if you're worried about a gas surplus in America, if you recognize that the Gulf of Mexico is going nowhere, if you recognize that Canada is really going nowhere, if you recognize that the Rockies are bottlenecked again for the next couple of years, you really only have to solve for the Barnett and they Haynesville, and if you listen to what EOG said this week and believe what we said today, and if you believe what I said about the Haynesville, that it won't be able to exceed pipeline constraints, then there are really only two other shale plays out there that you really need to bother with, and that would be the Fayetteville and the Woodford. And we think those increases a year are 200, 300, 400 million a day (for each play) and certainly not market movers. And finally, the play that people have expressed concern about would be the Marcellus, and it's not going to be anything significant for probably another five years or so."

In time, he added, the Fayetteville will be bigger than the Woodford because it covers more territory. ■

Continental Resources Inc.

The Arkoma Basin Woodford play may not be Continental Resources' biggest but it looks like one of the best for the company.

Continental holds 47,000 acres in the Woodford, compared with more than 12 times that acreage (581,000 acres) in the Bakken Shale play in Montana and North Dakota where it holds the title of largest leaseholder. It considers both areas impact plays for the company, according to a corporate presentation.

At the end of the fourth quarter of 2008, it figured 3 Bcf/well in gross reserves for a Woodford well, assuming eight wells per section.

In the fourth quarter of 2008, it produced 3,276

boe/d from the Woodford, up from 1,338 boe/d in the same quarter a year earlier. By year-end 2008, it posted 30.7 million boe in proved reserves in the Woodford, up from 8.9 million boe at the same time the previous year.

To reach that level, the company drilled 41 gross, 9 net, wells during the fourth quarter. Those wells added 25% to its Woodford production in the fourth quarter of 2008, compared with the end of the previous quarter. It dropped its rig count from six rigs in the third quarter to one rig in the fourth quarter.

Its best well in the play at that point was the Blevins 1-1H in Hughes County, Okla. That well, with Continental holding a 41% working interest, average 8.1 MMcf/d of gas during a seven-day production test. It later raised the seven-day average rate to 10.4 MMcf/d. That well was east of the company's Salt Creek exploratory area.

The company found good results from simul-frac treatments on its Woodford wells. It completed the six-well Luna-Pratt simul-frac project in the third quarter of 2008 by stimulating the horizontal laterals of the six wells, one pair at a time. The wells averaged 3.8 MMcf/d gross each in seven-day production tests, with little variation among the wells.

It started drilling the simul-frac wells in March 2008 and finished that four-well job in late April with flow rates averaging 3.8 MMcf/d of gas per well, or 40% more than original wells in the spacing units. Following up on the simul-frac technology, Continental used the treatment in seven wells in its Pasquali area. The wells flowed at an average rate of 2.44 MMcf/d of gas with the best well flowing at nearly 3.6 MMcf/d of gas. The two simul-frac wells in the Wilson project flowed at 8.57 MMcf/d and 5.98 MMcf/d of gas, respectively.

Although Continental had planned to spend US \$99 million on the Woodford in 2009, the company cut that figure to \$56 million for drilling-related activity plus \$7 million for land and seismic acquisition in its revised capital expenditure budget, which was announced Feb. 26, 2009. That still will allow the company to participate in 63 gross, eight net, wells in 2009.

The company considers its Ashland area a development area for the Woodford, while the Salt Creek and East McAlester areas are exploratory projects.

During 2008, it acquired 25 sq miles of 3-D seismic over Salt Creek and 55 sq miles of 3-D seismic over East McAlester to optimize well planning and production.

Devon Energy Corp.

Devon Energy Corp. engraved its name on the gas shale landmark when it took over Mitchell Energy & Development Corp.'s Barnett Shale operations in north Texas and pioneered rapid development, advanced technology, and a land rush for gas shale formations across the country. Eastern Oklahoma's Woodford shale is part of the land rush, and Devon is a big name in that play.

Devon set a number of records as its Barnett operations made it the biggest gas producer in Texas and helped make it the third-biggest gas producer in the nation. It drilled the first Barnett horizontal well and the first horizontal well on 1,000-ft spacing. It also was the first company to reach 1.0 Bcfge/d of net production and has since added another 150 Bcfge/d. It also was the first company to reach 1 Tcf of gross cumulative gas production.

The Barnett and Woodford have some similarities, according to Devon figures, The Barnett lies at about 7,500 ft and the Woodford lies at 7,550 ft. Both formations offer 6% porosity. At about 389 net ft, the Barnett is more than twice as thick as the Woodford's 175 ft. That is reflected in the gas in place. The Barnett offers 147 Bcf/sq mile compared with 60 Bcf/sq mile for the Woodford.

The company has more than 3,800 Barnett producing wells on 801,000 gross acres in the Barnett and in 2008, the company drilled 659 wells (559 operated) in the play.

Devon drilled its first Woodford well in 2004 and its first horizontal well in the play in 2005. Still, the Woodford trailed Barnett operations significantly with an average of 64 MMcfeg/d of net production in the fourth quarter of 2008, according to Steve Hadden, executive vice president of exploration and production, at the company's fourth-quarter conference call, recorded by Thomson Financial.

That figure was up 35% from the third-quarter average and 165% compared with the fourth quarter of 2007.

In 2008, the company drilled 132 horizontal (48 operated) wells with an average per-well initial production rate of 4.4 MMcf/d. At that time, it had six rigs working the play and planned to run 3 rigs and drill 26 operated wells in 2009.

To support its Woodford operations, Devon completed the US \$30-million Northridge gas processing plant with a capacity to process up to 200 MMcf/d of liquids-rich gas. That plant started operations in

DEVON SET A NUMBER OF RECORDS as its Barnett operations made it the biggest gas producer in Texas and helped make it the third-biggest gas producer in the nation.



early October 2008. Devon has purchased or acquired 310 sq miles of 3-D seismic to de-risk the play. At year end, Devon had 100,000 gross acres of Woodford properties in Pittsburg, Hughes, Coal, and Atoka counties in Oklahoma. ■

Edge Petroleum Corp.

Edge Petroleum Corp. set its sights on Fayetteville/Moorefield shale production on the Arkansas side of the Arkoma Basin and it's pushing forward carefully to raise its production.

The company entered the Arkansas Shale play in 2005 with the acquisition of 5,661 gross, 4,692 net, acres in the heart of the eastern core. The properties were prime territory with nearby properties held by Chesapeake and Southwestern Energy and on strike with wells completed by Chesapeake at initial rates of 3 MMcfge/d to 5 MMcfge/d. The Fayetteville/Moorefield is more than 500 gross ft thick in the area in southern Cleburne County.

Edge's initial well tested between 1.1 MMcfge/d and 1.3 MMcfge/d as it recovered frac fluids, but the frac treatment broke through to water below the formation.

By the end of the following year, Edge had one company-operated well and participation in one outside-operated well. Those totals rose to five operated wells and two outside-operated wells to give the company a total nine gross wells by the end of 2007. At that time, Edge had potential for 246 wells on proved, probable, possible, and exploratory locations.

John W. Elias, chairman, president, and chief operating officer, said, "We ended 2007 with production and proved reserves lower than we expected, due primarily to the drilling of fewer wells than we had planned, a dry hole at a proved undeveloped location on the acquired properties in southeast Texas and a disappointing start to our Arkansas Shale program where fracture stimulation during the completion of our initial wells caused communication with an underlying water-bearing zone. Many of the planned 2007 wells have been deferred and some of the reserves we had originally expected to be classified as proved have been moved to a non-proved category, pushing many of these growth opportunities out into the future. We still believe there may be significant resource potential associated with our Arkansas acreage."



Photo courtesy of Devon Energy Corp.

By February 2008, Edge had 100 Mcfge/d of production from 500 MMcfge of Fayetteville/Moorefield proved reserves. It had 100.8 Bcfge of resource potential in the shales.

By the end of the third quarter of 2008, Edge said it planned to participate with its partners in at least two wells early in 2009 in locations near wells recently completed at rates of more than 2 MMcfge/d.

The company also applied for a permit to re-inject produced water into an existing well. When it gets that permit the company can bring three shut-in wells back on line. Edge has working interests from 80% to 100% in those wells. ■

Hallwood Energy LP

The Hallwood Energy LP, a subsidiary of The Hallwood Group Inc., with some 400,000 acres of Fayetteville leases is one of the most active operators in the play and one of the most active wildcatters.

Hallwood Energy's position in the Fayetteville and its south Louisiana and west Texas properties prompted Canada's Talisman Energy Inc. to take a one-third farmout in some 350,000 gross acres of Hallwood properties

through its FEI Shale Inc. (Fortuna Energy) subsidiary. Fortuna also works Talisman's Trenton-Black River play in New York and is expanding those activities into Marcellus Shale exploitation in New York and Pennsylvania.

Under that arrangement, Talisman will make a series of payments to Hallwood over a period of up to 18 months. Through June 30, 2008, Talisman had paid US \$35 million, primarily in drilling costs, to earn interests in the properties. Hallwood is the operator. Effectively, Talisman agreed to a payment of \$60 million to cover 10% of Hallwood's interests. Talisman had the option of paying the remaining \$65 million, for a total \$125 million for the full one-third interest.

That may change. Talisman also hired Hallwood to provide the Canadian company with consulting services for a year.

On the wildcat side of the ledger, Hallwood has abandoned wildcat locations scheduled to the Fayetteville in Faulkner, Monroe, Prairie, White, and Woodruff counties on Arkansas as it tried to extend the economic pay area.

At the same time, the company has chalked up successes, according to IHS Energy reports.

Its 2-5H Kerr in White County was an extension discovery. The company completed that well with 24 sets of perforations in a gross horizontal Fayetteville section between 6,760 ft and 8,952 ft after reaching a measured depth of 9,100 ft. True vertical depth was 6,900 ft. It followed up with a six-stage slickwater frac treatment. The well tested for an initial potential of 518 Mcf/d of gas.

The 1-15H Conder horizontal test, also in White County, resulted in a new field wildcat discovery. Hallwood drilled that well to a vertical depth of 7,500 ft and finished with a lateral leg that reached 8,402 ft in the Fayetteville.

It perforated in 12 sections between 7,050 ft and 8,333 ft then performed a four-stage fracture treatment. The company didn't report initial production figures.

Still in White County, it completed another new field discovery in the Fayetteville with its 1-22H Crutchfield. That well reached a true vertical depth of 7,900 ft before turning to a lateral leg that reached total depth at 10,000 ft.

It perforated in four segments between 8,192 ft and 8,472 ft in the horizontal leg of the well and finished the job with one fracture treatment with 1,237 barrels of water, 148,520 lb of 40/70 sand, 3.785 Mcf of foam with a slickwater additive, and nitrogen gas. The well tested at 576 Mcf/d of gas through a $\frac{1}{16}$ -in. choke.

More rigs work the eastern Oklahoma Woodford Shale gas play as operators understand the economics and technology.

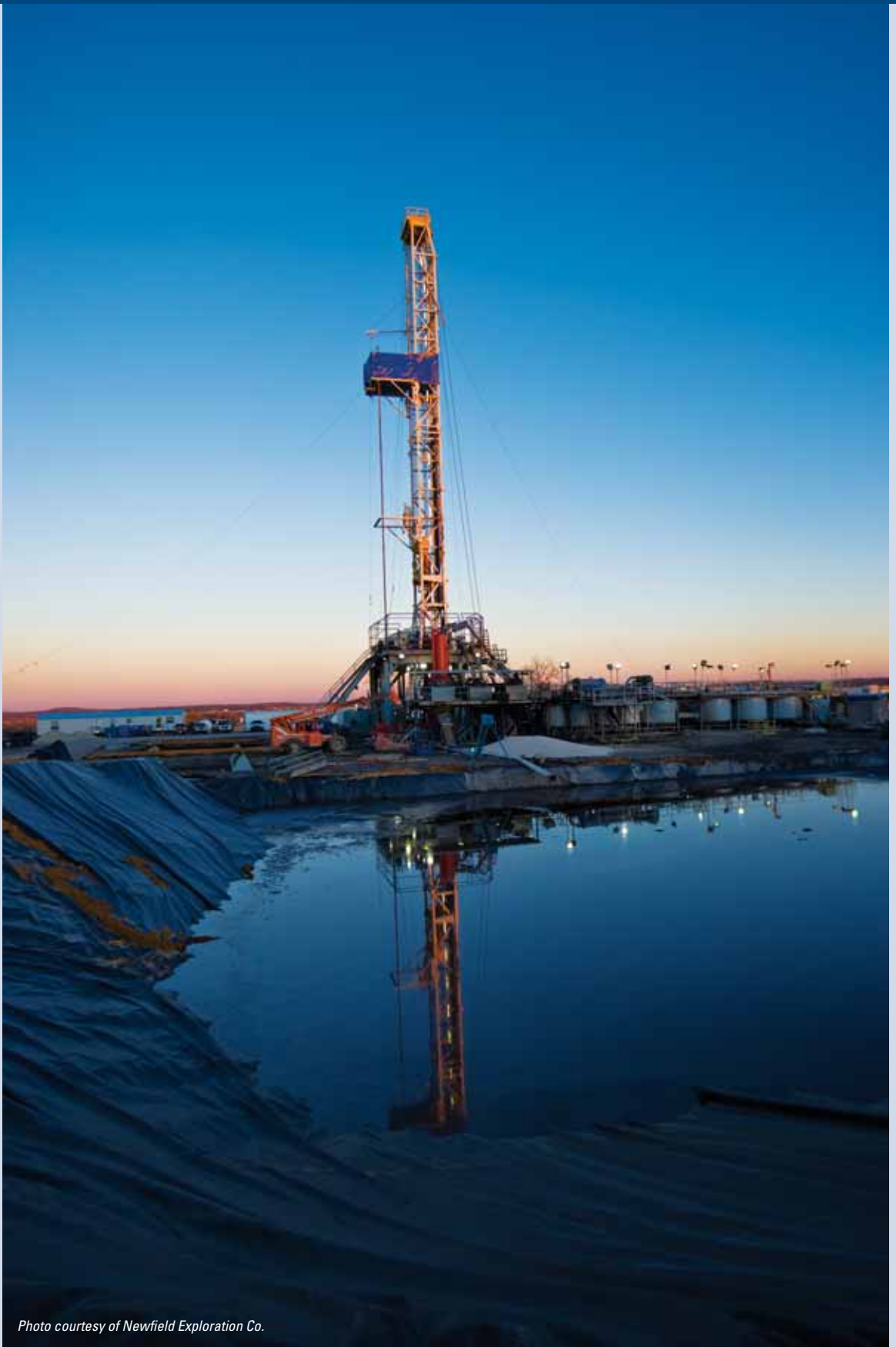


Photo courtesy of Newfield Exploration Co.

Hallwood Petroleum Inc.'s 1-32 Harlan resulted in another new field discovery in White County. That 2007 Fayetteville well drilled vertically to 9,000 ft and tested for 785 Mcfg/d from the Fayetteville Shale. Completion details included perforations in three zones from 8,010 ft to 8,381 ft and a single frac treatment with 1.8 million bbl of water, 346,640 lb of sand in a slickwater job.

Hallwood's 4-34H new field wildcat resulted in a field discovery, also in White County. The first leg of the dual-lateral well drilled vertically to 7,850 ft and reached total depth in the lateral at 9,900 ft. The second leg reached a vertical depth of 8,113 ft and reached laterally to 9,580 ft. It perforated in nine segments in the first lateral, conducted an acid treatment and finished with a three-stage frac to test for 615 Mcf/d of gas. Moving to Woodruff County, Hallwood drilled the 1-8 Conner Farms vertically to 5,728 ft. That new field wildcat discovery took perforations in two sections and a single frac treatment. The company didn't report a production rate.

Hallwood didn't limit its activities to drilling. In July 2008, first gas flowed through its Antioch Gathering System and the company flowed 6 MMcf/d of gas into the Mississippi River Transportation Co. pipeline. The \$5 million gathering system included 15 miles of line in White County. At that time, Hallwood said only one well was hooked into the gathering system. It planned to add more wells with the help of its three active drilling rigs working the Fayetteville Shale. ■

Kerogen Resources Inc.

Kerogen Resources Inc. specializes in identifying unconventional oil and gas shale opportunities that other companies have overlooked, and then applies geoscience and reservoir and production engineering to bring out the potential.

With initial financing and US \$20 million in debt, it concentrated its efforts on the Barnett gas shale, the Bakken oil shale and underlying Three Forks sand in the Williston Basin, and the Montney shale-siltstone-tight sand in British Columbia. In 2008, it raised its net production from less than 200 boe/d to more than 1,400 boe/d with a bright outlook for 2009 and a change in philosophy from a prospect-generation company to an exploration and production company.

Along the way, Kerogen formed a joint venture with Triangle Petroleum Corp. to explore 34,000 gross,

20,000 net acres in the Fayetteville play in Conway, Faulkner, and Pope counties in Arkansas. It added Van Buren County as part of a 52-township area of mutual interest and the companies agreed to drill a horizontal well to the popular shale.

By early 2008, however, Triangle said it planned to sell its Fayetteville properties calling the leases unproven and non-productive.

Both companies showed up at the North American Prospect Expo in early 2009 with Fayetteville leases on their sales list. ■

Lario Oil & Gas Co.

Lario's founder started work in the oilpatch in 1916, but the company's approach to exploration and production is anything but old fashioned. Among its working plays in the US and Canada are the Woodford and Fayetteville shales in the Arkoma Basin, the Bakken Shale, the Barnett Shale, and the Mississippian Chert.

That translates to low-risk drilling with big upside potential in areas where the learning curve can increase production and lower drilling costs.

Lario entered the Woodford Shale play in 2007 with 1,508 net, 12,778 gross, acres of leases. Drilling on the leases started in the fall of 2008, and the company now has small working interests in more than 30 producing wells with another 12 wells permitted.

Based on 160-acre spacing the company has more than 288 proved, possible, and probable drilling locations.

That doesn't mean Lario is a big player. It holds working interests averaging 3.3% on those drilling locations, and it calculates proved, probable, and possible reserves of 23 Bcf net to Lario.

The company also entered a development contract on the 14,000 net acres it holds in the Fayetteville Shale in Arkansas where a 3-D seismic program was initiated.

Impressive production rates on the Woodford and Bakken wells persuaded the company to spend 65% of its capital expenditures in those areas in 2008. ■

Metro Energy Group Inc.

Metro Energy Group was among the first operators in the Woodford Shale in Oklahoma and it works closely with large operators such as Devon Energy and Newfield.

Through its joint venture company it has drilled 28 vertical wells to identify fracture techniques, and it operates 18 wells.

Woodford Shale Economics

	HENRY HUB		
	Price \$5	Price \$7	Price \$9
F&D cost \$1.75			
NPV 10 (\$000)	150	3,550	6,700
Rate of return (%)	11	30	50
Payout (months)	80	32	20
F&D cost \$2/Mcf			
NPV 10 (\$000)	(500)	2,850	5,850
Rate of return (%)	9	23	39
Payout (months)	95	37	23

Graph courtesy of Newfield Exploration Co.

Gas price and finding cost changes make a big difference in Woodford Shale returns.

Among Woodford Shale wells, IHS Inc. identified five development wells operated by Metro Energy.

The 7-19 Snell Heirs in Gregory Field was scheduled to Wilcox at 4,200 ft in May of 2006. It reached to top of the Woodford at 3,663 ft. The company perforated the Woodford between 3,670 ft and 3,695 ft, acidized the well, and conducted a slickwater frac job in the vertical well. It tested for 250 Mcf/d of gas.

It drilled the other four Woodford Shale development wells in Weleetka District East Field. All four were scheduled to the Wilcox but completed with fracture treatments in Woodford vertical wells in 2005.

It completed the 4018 Snell Heirs for 180 Mcf/d of gas, the 1-17 Longview for 150 Mcf/d of gas, the 1-17 Snell Heirs for 135 Mcf/d of gas, and the 2-17 Longview for 240 Mcf/d of gas.

All the wells were in Okfuskee County, Okla. ■

Newfield Exploration Co.

Every shale play has a clear number one player. It's Devon Energy in the Barnett, Southwestern Energy in the Fayetteville, and Newfield Exploration Co. in the Woodford/Caney Shale on the Oklahoma side of the Arkoma Basin.

At the end of 2008, the company was the most active driller with 165,000 net acres in the play and 85% of that was held by production. That production totaled 265 MMcfge/d, up from 200 MMcfge/d at the end of the second quarter, according to a company presentation at the January 2009 Goldman Sachs Global Energy Conference. That acreage covers 2,500 potential drilling locations.

For perspective, at year-end 2008, the industry had 45 rigs working the Woodford play, and Newfield operated 13 of them. Newfield owned 225 operated horizontal wells of the 750 horizontal wells producing for the whole industry.

For Newfield, as with other operators in the basin, the Woodford play includes more than the Woodford. In Newfield's case, it includes the Caney, Wapanucka, and Cromwell formations, as well. Breaking down the year-end 2007 numbers, Newfield had a remaining unrisks resource of 6Tcfe in the Woodford, and an unrisks remaining resource of 3.6Tcf in the other three formations.

Unproved risd reserves totaled 5.3Tcf from 2,150 potential locations in the Woodford and another 1.8Tcf from 1,300 locations in the other three zones.

Newfield planned to spend US \$2 billion on capital expenditures in 2009, down from \$2.2 billion in 2008, but worsening economic conditions persuaded the company to pull back to \$1.45 billion in 2009.

During those periods, it increased the percentage of capital spending devoted to the Woodford from 33% in 2008, to an initial 41% for 2009 and a final 45% for 2009. The only other area in the company portfolio with an increased spending percentage was the Gulf of Mexico.

The money dedicated to the Woodford will keep 12 rigs running and should raise production from the shale by 30%.

The company also works an aggressive program to increase production and lower costs. For example, pad drilling lowers finding and development costs, and extended laterals increase estimated ultimate recoveries from each well.

It's still working on new ideas. Coming up, it will test dual 4,500-foot laterals, it will drill its first Wapanucka formation horizontal well for possible commingling, and it plans to test a "super-extended" lateral of 8,000 ft to 10,000 ft.

Cost control assumes the company has a base line to improve upon. Newfield has a good grip on that baseline.

Assuming average reserves of 4 Bcfge for a horizontal well and an 81% net revenue interest, the company's production tax for the first 48 months, or until payout, is 1.09%. Thereafter, the production tax rises to 7.09%. Wellhead prices in the Arkoma Basin are about 75 cents/MMBtu lower than the Henry Hub price, and high-quality Woodford gas comes out of the hole at 1,050 Btu/Mcf.

The typical production curve starts with initial output of 4.5 MMcfge/d and drops 62% during the first year to about 1.3 MMcfge/d. It falls another 28% in the second year and declines as a shallower level thereafter, easing to a 7% decline in the eight production year.

With that background, the company offers its well economics assumptions at fixed finding and development costs of \$1.75/Mcf and \$2/Mcf.

It drills eight wells horizontal per section. Laterals on current wells run around 4,100 ft, and it costs between \$5 million and \$6 million to drill and complete as Woodford horizontal well.

The economics are straightforward.

Newfield had 600 Bcfge in net proved reserves in the play at the end of 2007, but it estimated future reserves between 5.6 Tcfge and 6.2 Tcfge. It also estimated it would need between \$9.6 billion and \$10.3 billion to extract those reserves.

Production rates don't mean much if it can't reach markets. Newfield signed agreements for 300,000 decatherms per day of gas on the MidContinent Express Pipeline and may add another 150,000 decatherms per day to that rate. It also has 40,000 decatherms of firm capacity in 2008 on the Laclede Energy Resources Line, and that increased to 50,000 decatherms a day in 2009. ■

Pablo Energy II LLC

Pablo Energy II LLC, a subsidiary of Cactus Feeders, the second-largest cattle feedlot company in the US, is one of the more active operators working the Woodford/Caney gas shale play in Oklahoma's Arkoma Basin.

According to the "First Crisman Report on Shale Gas in the Arkoma Basin," by Peter Falko at Texas A&M University, published in August 2008, Pablo ranked sixth among the top 10 operators in the play with 13 producing wells. That placed the company higher on the list than XTO Energy and lower than St. Mary Land & Exploration Co.

During 2008, the company completed 14 wells in Centrahoma, Coalgate, and Olney Northeast fields in Coal County and TA Field and an unnamed field in Atoka County, Okla. The wells showed initial potentials ranging from 759 Mcfge/d to 3.7 MMcfge/d, according to the Oklahoma Geological Society.

IHS Inc. figures show the company completed its 1H-23 Tomlinson in Coalgate West Field in Coal County. That well reached the Caney at 5,992 ft and the Woodford Shale at 6,297 ft and traveled laterally to a total

depth of 10,888 ft. After an acid wash and fracture treatment the well showed an initial potential of 5.3 MMcfge/d of gas from the Woodford.

The company also staked the 2H-25 Battles in Coalgate Field. That well is projected to a vertical depth of 6,750 ft and a measured depth of 11,750 ft.

Pablo reaches beyond the safe approach of working development wells, too. In early 2008 it completed the southernmost horizontal Woodford wildcat in Atoka County. That well, the 1H-24 Cox, showed an initial potential of 3.28 MMcfge/d of gas through a 64/64-in. choke from perforations in 27 three-ft intervals. It acidized the well and fractured the horizontal section in seven stages. That well was almost six miles south of the nearest producing Woodford horizontal well.

The company also made sure early in 2007 that it got its production to market as it formed the Pablo Gathering subsidiary to partner with Enogex Atoka LLC to form Atoka Midstream LLC, a gas gathering and processing company. ■

Pathfinder Exploration LLC

Pathfinder Exploration LLC is a veteran operator in the Fayetteville Shale play in the eastern Arkoma Basin.

The company attracted the attention of Shell Exploration & Production Co., and that company entered into a joint venture agreement with Pathfinder in 2006 to look at Fayetteville Shale prospects in several Arkansas counties. At the time, Shell had purchased approximately 70,000 acres of leases in the play from four independent operators.

Under the agreement, Pathfinder is the operator of the joint venture.

Among projects listed by IHS Inc., Pathfinder started drilling the 1-19H Yingling 9-6 in White County to the Fayetteville at 6,345 ft including a vertical depth of 4,550 ft.

The company still hasn't completed its 1-20H J Smith wildcat, also in White County. It spudded that well in late 2007 and reached total depth at 8,500 ft in February 2008.

The situation was similar for the company's 1-18H Sullivan 9-6 wildcat. It began drilling and reached total depth at 7,113 ft in January 2008 with a 2,300-ft lateral.

In Woodruff County, Pathfinder drilled the 1-12 Fitzhugh 8-4 wildcat to 6,000 ft in late 2007. In early 2009, that well retained tight-hole status. ■

Penn Virginia Corp.

The nation's shale plays rate high with Penn Virginia Corp. and its subsidiaries. The company has substantial interests in the major shale plays in the US, but the Woodford and Fayetteville shales in the Arkoma Basin aren't near the top of its operating priorities.

A 2009 presentation lists the Woodford as an emerging play with the Marcellus Shale and the Fayetteville ranks above "other plays" with the Lower Huron and Bakken shales, the Cotton Valley and Hartshorne coalbed methane.

The company's planned to spend US \$236 million, or 94% of its 2009 capital budget, on 65 development drilling and related activities. The Haynesville Shale in east Texas will get \$87 million of that for 18 gross, 12 net, horizontal wells. Another \$50 million will go into 22 gross, 21.4 net, horizontal Selma Chalk wells.



[PETROQUEST ENERGY, INC.] IS A David among the Goliaths working the Fayetteville on Caney-Woodford plays, small but mighty.

Penn Virginia directed \$58 million of those funds into the Mid-Continent region for 12 gross, 6.4 net, horizontal Granite Wash wells and four gross, 0.8 net, non-operated Woodford Shale wells. It set no money aside for exploratory drilling in either the Woodford or the Fayetteville shales.

A third-quarter 2008 status report said the company was involved in three gross, 0.5 net, horizontal Woodford Shale wells and three gross, 0.3 net, non-operated horizontal Fayetteville Shale wells.

The Woodford wells produced at initial rates of 3.5 MMcfge, 4.5 MMcfge, and 2.7 MMcfge a day. The company release said, "Based on the encouraging results of the five Woodford Shale wells in which we have participated to date, we plan to continue to participate in the drilling of additional wells in the near term in the Arkoma Basin.

A status report in a January 2008 presentation said the company had participated in 14 gross, 6.4 net, Fayetteville wells and four gross, 1.9 net, Woodford wells.

Penn Virginia controlled approximately 40,000 net acres with an unrisksed exploratory potential of some

200 Bcfe in the Woodford/Caney shales in both the Arkoma and Anadarko Basin in early 2008. ■

Petrohawk Energy Corp.

Petrohawk Energy Corp. made a name for itself as one of the premier smaller operators in the Haynesville play in east Texas and north Louisiana, and it's carrying that reputation to its Fayetteville Shale operations in the Arkoma Basin.

The Haynesville remains top priority. Among the 23 drilling rigs the company plans to operate in 2009, 12 will work the Haynesville and two will handle Fayetteville operations. The company also cut its 2009 capital budget from an earlier estimate of US \$1.5 billion to a new level of \$1 billion. The company spent \$395 million on the Fayetteville in 2008 but budgeted only \$100 million for 2009, down from an initially planned \$175 million before the price downturn.

Still, in reducing the capital budget, Petrohawk said it was directing the bulk of its funds toward the plays with the highest returns, and those plays were the Haynesville and Fayetteville shales.

According to a company release, "The reallocation of capital reflects an increased emphasis on development of non-proved locations in Petrohawk's successful Haynesville and Fayetteville shale projects, with the benefit of higher expected overall reserve growth potential for the company. Petrohawk's production guidance for 2009 represents 25% to 35% drillbit growth over 2008 estimated annual production of 305 MMcfge/d.

Future development of the Fayetteville, the company said, will depend on availability of gas processing and gas gathering and pipeline systems.

Petrohawk also has Woodford Shale properties in both the Arkoma and Ardmore basins, but those are not high enough on the priority list that the company talks about them during its presentations. In mid-2008, it held 14,000 net, 15,000 gross, acres in the Caney-Woodford Shale play in the Pine Hollow South

region of MacIntosh County, Okla.

Petrohawk's Fayetteville holdings got a big boost in 2007 when the company bought out Alta Resources LLC, Tepee Petroleum Co., and Contago Oil & Gas Co. holdings for \$343 million. That property in Van Buren and Conway counties in Arkansas included some 24,000 net acres of leases in the play about 50% operated.

Currently, Petrohawk holds 157,000 net acres in the play, 155,000 undeveloped, with 100 Bcfe of proved reserves and 3.1 Tcfe of resource potential from 2,500 net drilling locations.

It estimates well costs between \$1.75 million and \$2.75 million to reach estimated ultimate recoveries between 1 Bcfe and 4 Bcfe per well, according to a January 2009 presentation. It had an aggressive program in the play in 2008. In the third quarter, it was involved in 45 operated and 36 non-operated wells as it working 11 drilling rigs, including one spudder rig. Four of those wells tested for more than 3.9 MMcfge/d of initial production and one tested for more than 5 MMcfge/d.

Those higher production rates came from improved completion techniques, including longer laterals and cemented liners with more perforations, Petrohawk said.

For example, it completed one well with a 10-stage cemented liner frac job with a lateral of more than 3,700 ft, and, at the end of the third quarter of 2008, planned a well with a lateral of 5,500 and 15-stage fractured treatment.

Its production from the Fayetteville during the third quarter exceeded 115 MMcfge/d gross, 65 MMcfge/d net, but that included restrictions from construction delays on the Boardwalk pipeline, which went into service on November.

Not all the wells fall under the Petrohawk name. Company president Floyd Wilson also is president of One TEC, P-H Energy, KCS Energy, WSF Inc., and Winwell Resources. ■

PetroQuest Energy Inc.

PetroQuest Energy Inc. found a seat on the learning curve for the Arkoma Basin shales and it is going to stay in the saddle as long as the good news keeps coming.

The company is a David among the Goliaths working the Fayetteville on Caney-Woodford plays, small but mighty.

On the small side, the company controls 45,000 net

acres in the Woodford, but that's 65% more than the company had at the end of 2007. It holds more than 18,000 acres in the Fayetteville Shale in Arkansas.

Moving up the scale toward mighty, the company's properties in the Woodford have 46.9 Bcfe of proved reserves with more than 360 drilling locations on 80-acre spacing. Add it the 936 Bcfe from probable and possible reserves and the number of locations climbs to 2,371, according to a company presentation in January 2009.

In the Fayetteville, the company has 1.2 Bcfe in proved reserves and 200 Bcfe addition probably and possible reserves with a maximum 2,310 drilling locations.

Drilling results look mighty good. With 492 wells drilled in the Woodford trend through November 2008, PetroQuest completed 26, or 5%. Among those 26 wells are 10 of the 21 top initial potentials in the play.

As the company learned, it increased the number of frac stages from six per well to 11 per well. At the same time, it increase initial potentials 290%, and it increased its average Woodford initial potential rate by 150% per frac stage.

Its first five wells averaged 2 MMcfge/d from the Woodford. Its latest five wells through January 2009 average 5.8 MMcfge/d. Its best well posted an initial potential of 12.5 MMcfge for one day.

During the fourth quarter, the company drilled the PetroQuest 26 with a 4,026-ft lateral for a maximum production rate of 6.4 MMcfge/d, the PetroQuest 28 with a 6,611-ft lateral for 4.05 MMcfge/d and the PetroQuest 29 with a 3,909-ft lateral for 1.88 MMcfge/d.

It planned to complete a well with a 7,057-ft lateral early in 2009 but the well encountered mechanical problems after the first two frac stages. PetroQuest repaired the well bore and produced at rates as high as 3.7 MMcfge/d. The company planned to complete another 16 stages in the well during 2009.

Currently, PetroQuest's Oklahoma properties produce approximately 40 MMcfge/d and its Arkansas properties another 9 MMcfge/d.

It participated in 33 non-operated gross wells, 3.03 net wells, in the Fayetteville in the fourth quarter. It has five non-operated rigs working the play.

PetroQuest planned capital expenditures between US \$80 million and \$100 million for 2009, depending on oil and gas prices, drilling success and completion and facility costs. Like many other companies, it plans to keep capital expenditures below its cash flow.

Well economics are respectable. On its Woodford wells, the company figures a horizontal well cost between \$5 million and \$5.5 million to get an initial production rate between 3 MMcfge/d to 5.5 MMcfge/d. At a gas price of \$4/MMBtu, it generates a 3% return, at \$6 gas the return climbs to 15%, at \$8 gas it gets a 29% return and at \$10 gas the return is 42%.

In the Fayetteville, with 1.4 Bcfge to 3.5 Bcfge in estimated ultimate recovery, a completed well cost between \$1.8 million and \$3.4 million and a maximum monthly production rate between 1.2 MMcfge/d and 3.5 MMcfge/d \$6 gas brings a 9%, \$8 gas a 20% return, and \$10 gas a 33% return. ■

Presidium Energy LC

Presidium Energy LC, a Michigan operator, with an aggressive drilling program in the Devonian Antrim shale in Michigan, purchased a position in the Woodford Shale in Oklahoma during 2008.

Presidium, founded and managed by John V. Miller, bought 67,000 gross acres in the Oak Tree Project in Oklahoma from interest owners. A large piece of that deal was the \$12 million cash purchase of 36,802 gross, 32,753 net, acres from Aurora Oil & Gas Corp. Aurora said the value of the transaction was more than \$15 million, and it retained a 3% overriding royalty interest in the area of mutual interest, which subsequently grew to 71,000 acres.

Miller, a co-founder of Aurora, had been vice president of Aurora from May 1997, until Feb. 29, 2008.

According to Miller, "The company is focused initially on drilling oil prospects from 3-D seismic recently acquired. In the process of drilling wells on oil prospects, data is being gathered on the Woodford Shale in preparation for a planned aggressive horizontal drilling program for Woodford Shale gas. Thus far, five vertical wells have been drilled and casing run for completion."

The arrangement also took Aurora out from under its financial obligations for the property. William W. Deneau, chief executive officer, said, "Completing this transaction creates a winning solution for all parties involved. It generates greater proceeds for the property than were originally anticipated and extinguishes the litigation associated with our joint venture partner in that project area. This is an ideal resolution to a risky and unproductive asset in our portfolio. Going forward, our 3% overriding royalty interest will allow us

to participate in what could be a tremendous upside while eliminating downside risk to our enterprise." ■

SH Exploration LLC

The Fayetteville Shale attracted international attention as SH Energy and Chemical Ltd. of Seoul, South Korea, and Eurenergy Resources Corp. joined forces to form SH Exploration LLC, a company devoted to exploration in the popular shale formation in Arkansas.

SH Energy acquired mineral rights to 3,000 acres of leases in Van Buren County from Source Rock Energy of Arkansas LLC, a subsidiary of Eurenergy. On completion of the deal, SH Energy owned 51% of SH Exploration and Eurenergy owned the remaining 51%.

In June 2008, the companies had completed drill pad construction of the first well and started construction of the pad for a second well in a two-well program designed with parallel 3,000-ft laterals at a vertical depth of 1,700 ft. It planned a simultaneous fracture treatment of the wells, according to Prime Income Asset Management.

August 2008 records from the Arkansas Oil & Gas Commission show SH permitted the Chavez 3-8H B-43 horizontal well with a planned vertical depth of 2,000 ft and a measured depth of 5,200 ft in Fayetteville

The commission's October 10 permit report showed the company had drilled the Chavez 1-8H B-43 horizontal well with a vertical depth of 1,578 ft and a measured depth of 5,574 ft and the Chavez 2-8H B-43 horizontal well to 1,568 ft vertically and a measured depth of 5,672 ft in Fayetteville. The company also permitted the Garner 1-13H B-43 with a planned 1,600-ft vertical depth and a planned 5,300-ft measured depth.

Sedna Energy Inc.

Sedna Energy Inc. is a minor player in the Fayetteville Shale play on the Arkansas side of the Arkoma Basin, but it has a history of operations in other plays in northern Arkansas.

The company is a subsidiary of Dernick Resources Inc. of Houston, which also owns Pathex Petroleum Inc.

Sedna permitted one Fayetteville well and completed the well.

According to IHS Energy records, the company drilled the 1-22H Green Bay development well in 2007 in Oak Grove field. The well reached a vertical depth of 6,330 ft and kicked off horizontally to a total measured depth of 8,910 ft. After perforating at five intervals and fracturing in

four stages, the company tested the well for 200 Mcf/d of gas. It did not take cores or perform a drillstem test. ■

Shell Exploration & Production Co.

Shell Exploration & Production Co. likes the potential of production of oil and gas from shales, as long as that potential equates with economic gains.

The company has invested heavily in shale oil research in the massive shale deposits of northwestern Colorado, and it took an early look at the Barnett Shale in north Texas.

It also likes the idea of partnering with knowledgeable operators. It formed a partnership with EnCana in the Haynesville Shale play, and, in 2006, set up a partnership with Pathfinder Exploration LLC in the Fayetteville.

Shell had purchased approximately 70,000 acres of leases with Fayetteville potential from four smaller operators. It put those properties into a joint venture arrangement with Pathfinder with Pathfinder acting as operator on the venture. The companies planned to evaluate the Fayetteville in several Arkansas counties.

In 2007, the SEECO Inc. subsidiary of Southwestern Energy included both Shell and Pathfinder as it sought to unitize a drilling location in White County. Pathfinder has permitted wells in both White and Woodruff counties in Arkansas. ■

Southwestern Energy Co.

Nearly every play hosts a dominant player, usually the company that saw the potential early, started buying leases in large volumes at low prices and proved up the technology that made the play viable. Southwestern Energy Co. is that company in the Fayetteville Shale.

It drilled its first Fayetteville well in the second quarter of 2004, the first horizontal well in the first quarter of 2005 and conducted the first slickwater frac treatment in the third quarter of the same year.

In a January, 2009, presentation, the company said it raised Fayetteville production to 670 MMcfg/d by December 15, 2008, more than doubling the 300 MMcfg/d it produced a year earlier.

The company had 716 Bcf in reserves and it still had a lot of wells to drill on its 860,000 net acres with Fayetteville potential.

The Fayetteville operations helped Southwestern post record earnings of US \$218.2 million in the third quarter

of 2008, up 328% from the same quarter a year earlier.

"This was a great quarter for Southwestern Energy," said Harold M. Korell, chief executive officer of Southwestern. "Our financial results were outstanding and in our Fayetteville Shale play we continue to see significant improvements in well performance as we implement new completion techniques across the play."

The company expects its average well to cost \$3 million to \$3.25 million to completion in 2009.

Those completions feature longer lateral legs on horizontal wells, increasing use of slickwater fracture treatments and larger frac jobs. Well efficiency also benefits from the use of 3-D seismic. That's the reason Southwestern will use 3-D seismic information on more than 95% of its wells in 2009, up from 70% of its wells in 2008.

Also in 2009, Southwestern plans to use tighter spacing — about 75-ft intervals — on its 2009 wells, and it will lengthen its laterals to an average 3,800 ft.

In previous wells longer laterals gave the company higher production rates.

Southwestern carries its profit potential beyond the drilling and completion phases, as well. By the end of September 2008, the company had put together a gas-gathering system capable of moving 675 MMcf/d of gas over 793 miles. That's a capacity increase from 250 MMcfg/d in the third quarter of 2007.

The company's production increase took place even though the company sold 55,631 net acres, or about 6% of its Fayetteville shale holdings, for approximately \$518.3 million in the second quarter of 2008. The properties were producing 10.5 MMcf/d of gas when Southwestern sold its holdings.

During a conference call with analysts, Korell said, "The Fayetteville shale disposition was to test the market at that time and really sets us up nicely as we go forward. Having said all of that, which is a disclaimer and backdrop, the future will depend upon gas prices and will depend upon the idea generation activities we have internally, it will depend on how our Marcellus turns out, whether something develops on that acreage where someone's going to drill a couple wells for us in Haynesville. There are just so many moving variables."

Final production figures of 2008 could have been higher, but the delay of completion of the Fayetteville lateral of the Boardwalk Pipeline caused a bottleneck in production plans during the quarter. It was scheduled for completion by the end of the quarter. Southwestern



Back Then You Didn't Always Follow the
Conventional Wisdom.



David's interests in the 1970s:

1. Dance Steps to "Stayin' Alive"
2. Date on Saturday Night
3. Fast Car
4. Gas Money for Fast Car



And Today You Still Look for *Unconventional* Opportunities
Where Others Only See Obstacles.

So check out this unconventional offer
on the attached card.



*To learn more about the Unconventional
Gas Center and to subscribe, visit
ugcenter.com/subscribe*

David's interests today:

1. Watching "Dancing With the Stars"
2. Downloading latest new video release from Internet
3. Fast Car and Family Car
4. Unconventional Gas Strategy

Completions

	Wells On Prod	IP Mcfg/d	30th day Ave rate	60th day Ave rate	Ave. lateral Length	Compl. Method
1Q 2007	58	1,261	1,066	958	2,103	11 SW
2Q 2007	46	1,497	1,254	1,034	2,512	24 SW
3Q 2007	74	1,788	1,512	1,350	2,622	69 SW
4Q 2007	77	2,028	1,690	1,499	3,193	68 SW
1Q 2008	75	2,343	2,147	1,954	3,301	77 SW
2Q 2008	83	2,541	2,155	1,893	3,562	All SW
3Q 2008	97	2,882	2,453	2,199	3,736	All SW

Source: Southwestern Energy Co.

Longer laterals and increased use of slickwater fracture treatments resulted in higher production rates.

has 500,000 MMBtu/d of firm capacity on that pipeline, rising to 800,000 MMBtu/day by 2010.

Southwestern also has prepared for future takeaway from the Fayetteville as its midstream services division committed to 1,200,000 dekatherms a day of firm capacity with Fayetteville Express Pipeline LLC when that line starts moving gas in late 2010 or early 2011.

Southwestern also wants to make sure it has new production coming on. It plans to invest \$1.5 billion in the Fayetteville shale in 2009, including some \$200 million for gathering system expansion. That's up from \$1.4 million and \$175 million, respectively, in 2008. The 2009 figure includes some \$65 million in well completions deferred because of the delay in completing the Fayetteville lateral on the Boardwalk line.

By the end of the third quarter of 2008, the company completed 722 operated Fayetteville wells, and 652 of those wells were horizontally drilled. It participated in 580 wells in the first nine months of 2008. Of those wells, 327 were successful, 246 still were in progress, and seven were dry holes.

IHS Inc. statistics show results from some of the Fayetteville wells drilled in northern Conway County, Ark., by SEECO Inc., Southwestern's operating unit. The 1-20H Reyes Salinas 9-15 flowed an initial 5.43 MMcf/d of gas through perforations in a south lateral. The 2-20H Reyes Salinas 9-15 tested for 4.45 MMcf/d of gas. About 1 1/4 miles northeast of the 1-20H well, the company tested 4.42 MMcf/d initially at its 3-16H Magdalena Salinas 9-5. Some two miles farther east, the 2-14H Gary Stark 9-16 tested for 4.86 MMcf/d of gas.

"In 2009, we will continue to operate 20-21 rigs in the Fayetteville Shale play and, with the improvements

in our drilling times, we currently expect to participate in approximately 620 horizontal wells (470 operated), compared to an estimated 520 wells in 2008, as we continue to develop our significant acreage position. As a result of our planned investments, we expect our 2009 production to be in a range of 280 Bcfe to 284 Bcfe, which is an increase of approximately 48% compared to our expected 2008 levels," said Korell. ■

St. Mary Land & Exploration Co.

St. Mary Land & Exploration Co. honed completion techniques in the Woodford Shale in Oklahoma to reduce well costs and sharply increase estimated ultimate recoveries.

With 40,000 acres in the popular play, the company ran two to three rigs in the shale during 2008 drilling horizontal wells with 4,000-ft laterals, although at least one lateral reached 4,200 ft. Even after the sharp price depression, the company likes the Woodford and will continue drilling the play during 2009.

Investment plans call for the company to invest within its cash flow. For the Woodford Shale, assuming US \$42/bbl oil and \$5.30/Mcf gas, the company will dedicate \$46 million of its total \$350 million capital expenditures to the Woodford wells in the core area in Coal County and in the surrounding McAlester, Bandit, and Ashland field areas.

Current plans call for the company to drop rigs as the contract terms expire and ramp up activity after mid-year 2009 when it hopes to get rigs at lower rates due to a decline in activity.

Estimated ultimate recoveries for the company continue to improve. Its latest 10 wells averaged more than 4 Bcfe with a completed well cost between \$4.5 million and \$5.5 million. That program was economic in the year-end 2008 environment.

Typically the company's wells take 30 to 32 days from spud to total depth, but it has drilled as quickly as 25 days and as slowly as 45 days. Spud to sales takes about two months, the company said, and much of the additional time is taken in lining up frac equipment.

In November, St. Mary had completed 24 horizontal wells. Its early wells showed poor results, but the company recovered with more aggressive completions and increased estimated ultimate recoveries sharply from the 2.7 Bcfe to 3 Bcfe it expected early in its operations in the play.

The company's first quarter 2008 report said it planned 10 horizontal Woodford wells with two operated rigs in the first half of the year, and it participated in non-operated wells. ■

Storm Cat Energy Corp.

The Fayetteville Shale has shared its bounty with a lot of companies. Unfortunately, Storm Cat Energy Corp. wasn't one of them.

The company had concentrated its US operations on coalbed-methane wells in the Powder River Basin of northeastern Wyoming, but also tried unsuccessfully to produce coalbed methane in Alaska.

In an effort to diversify, it acquired 18,500 net, 24,500 gross, acres in the Fayetteville play in Van Buren County, Ark. Those properties were near successful operations of Southwestern Energy division SEECO Inc., and Storm Cat planned to work with that company with SEECO as the operator.

It estimated well cost at US \$1.8 million. It estimated an unrisks rate of return of 50%, unrisks finding and development costs at \$1.10/Mcf of gas, and unrisks reserve potential at 195 Bcf on its Fayetteville properties.

On Nov. 10, 2008, the company said it was unable to make timely payments to creditors and its US subsidiaries filed for protection from creditors while it reorganized under Chapter 11 of the US Bankruptcy Act. A short time later, it obtained court approval to arrange post-petition operating rights.

Later, it obtained court permission to arrange \$14 million in financing, and in January, 2009, it was trying to get shareholder approval for that financing.

The company reported a working capital deficit of \$139.5 million on Sept. 30, 2008, compared with a deficit of \$2 million on Dec. 31, 2007. It had invested \$178 million in capital for permitting, drilling, completion, repairs, maintenance, and acquisitions in the Fayetteville play.

Its ability to continue operations depends on getting a debtor-in-possession credit agreement with its creditors and the cash to continue operations, the company said. ■

Talisman Energy Inc.

Canadian energy powerhouse Talisman Energy Inc., leveraging its experience in the Marcellus Shale in New York, bought its way into a solid position in the Fayetteville Shale in Arkansas with Hallwood Energy as a partner.

Unconventional hydrocarbons, with North Sea,

Southeast Asia, and global exploration are the company's focus points, according to an early 2009 presentation, and it plans to spend US \$3.6 billion to develop those focus areas.

The company will fund its capital program from cash flow, as many other companies have done following the oil price collapse, and it based its spending plans on \$40 West Texas Intermediate oil and a \$5/MMBtu New York Mercantile Exchange price for gas. That spending should keep production at about the same level as 2008, about 430,000 boe.

Talisman entered an agreement to buy a one-third interest in all Hallwood properties through its FEI Shale LP subsidiary, also known as Fortuna.

Under the agreement made in June 2008, Fortuna took an interest in 350,000 gross acres controlled by Hallwood, and it will earn acreage by subsidizing Hallwood's drilling costs. By June 30, 2008, it had spent \$35 million on the properties.

Acquisition of the full one-third interest in 108,000 net acres in Texas, Arkansas, and Louisiana will take an investment of \$125 million by Fortuna over 12 to 18 months. The 2008 agreement between the two companies called for 11 wells on the land with potential for up to 1,000 locations.

"This agreement gives us exposure in a number of areas where we have not been active, including the deep Barnett and Fayetteville shales," said John Manzoni, Talisman president and chief executive officer. "We also have a technical services agreement which is a significant part of this deal. Hallwood has a proven track record in the early stage development of shale programs and we will use this to augment our experience in the piloting and development of our unconventional plays."

The technical services agreement commits Hallwood to provide Talisman and its affiliates with technical and consulting services for a year. Specifically, Hallwood will help Talisman with the development of the Montney sand/silt/shale area of British Columbia and Alberta, the Bakken Shale in Saskatchewan, the Utica and Lorraine shales in Quebec, and the Marcellus Shale in New York and Pennsylvania. Fortuna plans 36 gross horizontal Marcellus wells in New York and Pennsylvania in 2009 and could ramp up to 16 rigs in 2010.

Among the properties in the deal are Hallwood's 40% interest in more than 43,000 acres in the Barnett/Woodford Shale play in Reeves and Culberson

counties in west Texas and Hallwood's 24,500 net acres in the Fayetteville Shale in White and Faulkner counties in Arkansas. Fortuna could earn 14,000 net acres in those two areas. ■

Triangle Petroleum Corp.

Triangle Petroleum Corp. of Calgary, Alberta, Canada, and its Triangle USA Petroleum Corp. subsidiary in the US had high hopes for the Fayetteville Shale in the Arkoma Basin, but opportunities moved the shale off the company's list of top priorities.

In early 2007, the company outlined a four-stage plan for its Fayetteville leases. It would conduct detailed geological assessments, acquire land in the core area, acquire and interpret seismic data, and drill wells. First, it planned to drilled vertical calibration wells, and then it would follow up with horizontal wells.

At that time, it had nearly completed the first two stages with Kerogen Resources Inc. of Houston, a company headed by Ronald Harrell, retired chairman and chief executive officer of Ryder Scott Co.

The companies had properties in Conway and Faulkner counties in Arkansas and were accumulating more leases.

They started the third stage, a 3-D seismic program covering some 24 sq miles in Conway County, and Kerogen, the operator had permitted its first vertical well and contracted a drilling rig. It planned to spud the well in March 2007. That well was scheduled to 6,500 ft, and the venture partners planned a second well in the third quarter that year. The companies also planned to have evaluation work done and start drilling their first horizontal well in the third quarter.

"We believe that our Conway County acreage will emerge as a solid producing area due to the combination of favorable geologic controls and higher reservoir pressures, which enhance reserves potential and deliverability," said Ron Hietala, Triangle USA president.

The companies entered a new joint venture agreement in October 2007, with plans to build on their 20,000 net, 34,000 gross acres, of Fayetteville properties in Conway, Pope, and Faulkner counties where they each held a half interest. It also included a 52-township area of mutual interest in those three counties and Van Buren County. The agreement was to last three years.

That arrangement committed Triangle to drill and complete on new net horizontal well. It would pay two-thirds of the cost to earn a half interest in the well.

Thereafter, all wells would be completed on a 50-50 basis. Triangle also agreed to reimburse Kerogen for some US \$458,000 in land costs.

Early in 2008, Triangle committed \$7.2 million for one well, acquisition of seismic data, and land acquisition in the Fayetteville Shale.

By April 2008, however, Triangle said it planned to focus near-term exploration activities on emerging shale projects in the Maritimes Basin of Eastern Canada.

"Based upon escalating land prices in the Arkoma Basin and the lack of progress in accelerating its exploration program with its partner in the basin, the company decided to monetize its 10,400-acre non-operated net acres in this project area by selling its position this year. In conjunction with that decision, the company's unproven, non-producing properties in the Arkoma Basin Fayetteville Shale project were deemed impaired, which resulted in a non-cash impairment loss of \$6.5 million during the fourth (fiscal) quarter," the company said.

In May, Eastern Canada took a higher priority when Ryder Scott Co. estimated original in-place gas resources in Triangle's Horton Bluff Shale properties on the Windsor block of Nova Scotia at 69 Tcf.

Later company releases and update didn't even mention the Fayetteville, but Triangle and Kerogen attended the North American Prospect Expo in January 2009, with Fayetteville properties on the sale block. ■

Unit Corp.

Unit Corp. brought its considerable experience in the Arkoma Basin of Oklahoma and its rig fleet to bear as it drilled its first Woodford Shale wells in 2008.

It completed its first horizontal well in the second quarter of 2008 and followed up with additional wells. A November company presentation said it planned to complete 15 Woodford wells in the Arkoma for US \$13 million during the year.

The company held 514.6 Bcfe of proved reserves company wide in 2008, and 22% of those reserves were in the Arkoma Basin.

It held 97,000 gross, 18,100 net, acres of leases in the Woodford Shale in the Arkoma Basin and most of that property was help by the company's production from other zones in the basin's stacked pay opportunities. For comparison, Unit held 31,360 gross, 6,556 net, acres in the Woodford play in the Anadarko Basin; 30,300 gross, 15,500 net, acres in the Haynesville

Shale play; 200,000 gross, 55,000 net, acres in the Marcellus shale; 27,000 gross, 5,400 net, acres in the Bakken Shale and 23,000 gross, 11,500 net, acres in the Mowry Shale in northern Wyoming.

Most of the Arkoma leases were in Pittsburg and Latimer counties, but it had minor interests in Coal and Atoka counties. ■

Whitmar Exploration Co.

Whitmar Exploration Co. generates and develops gas and oil prospects and has partnered with some of the most successful companies in the industry on its generated play.

Currently, it holds properties in the Appalachian Basin in the northeastern US, the Uinta and Paradox basins in Utah, the Piceance Basin of Colorado, west central Louisiana, east central Texas, the Big Horn Basin of northern Wyoming, and the Anadarko and Arkoma basins in Oklahoma and Arkansas.

Among those properties, it holds 75,000 acres of leases in the Arkoma Basin, more than any other program area except Appalachia where it holds 160,000 acres. It even started the Arkoma Compression Co. to rent compressors in the Arkoma Basin in 1986 and later sold that company after building it into one of the Mid-Continent's largest compression companies.

The Fayetteville Shale in Arkansas isn't a major project area for the company, but it did take out a permit to drill four horizontal Fayetteville wells from a single pad in northern Franklin County, Ark.

At that point, it planned to reach the Fayetteville at a vertical depth of 1,800 ft and drill horizontally to a measured depth of 3,000 ft, according to IHS Inc. ■

XTO Energy Inc.

The Woodford Shale and the Fayetteville Shale in the Arkoma Basin played important roles in XTO Energy Inc.'s "Year of Acquisitions" in 2008, and they will play important parts in the company's "Year of Drilling" in 2009.

In a 2009 investor presentation, XTO claimed 160,000 net acres in the Woodford Shale with 40 MMcfg/d of production from wells that range from 2.6 Bcf to 5 Bcf in reserves per well.

The industry-wide Woodford Shale play in the Arkoma Basin produced about 550 MMcfg/d at the end of 2008.

During 2009, XTO plans to work five or six rigs in the

play to drill 40 to 45 wells at a cost of US \$4.5 million to \$5.5 million per well.

Among significant recent wells in the play, the company's Pale Moon 1-31 and the McClung 8-15H each showed an initial potential of 6 MMcfg/d. The Churchill 1-26 came in at 4.5 MMcfg/d, the Churchill 1-26 gaged an initial potential of 4.5 MMcfg/d, and the Black 2H-17 recorded in initial production rate of 4 MMcfg/d.

On the Arkansas side of the Arkoma Basin, the industry produced about 800 MMcfg/d at the end of 2008. XTO, with 380,000 net acres in the Fayetteville, produced 30 MMcfg/d from wells with ultimate recoveries from 1.5 Bcfg to 4 Bcfg per well.

The company plans 115 to 125 wells in the Fayetteville in 2009 using seven to eight operated rigs. Wells cost between \$2.5 million and \$3 million.

Significant initial potential for recent wells in the play include the Johnson for 3.5 MMcfg/d, the McFalls for 3 MMcfg/d, the Thomas for 2.7 MMcfg/d, the Deltic for 2.5 MMcfg/d, the Neiheisel for 2.2 MMcfg/d, and the Black for 2 MMcfg/d.

The Woodford and Fayetteville, along with the company's 280,000 net acres in the Marcellus Shale, its 450,000 net acres in the Bakken Shale and 280,000 net acres in the Barnett Shale will make major contributions to the company's goal of doubling reserves to 22 Tcfe and doubling production to 3.6 Bcfg/d by the end of 2011.

"If you look at the overall production number, this would be the greatest natural gas company ever built in America," said Bob Simpson, chairman and chief executive officer of XTO, during a conference call discussing the company's second-quarter results.

It will spend \$1 billion in its Eastern Region in 2009, \$800 million in the Barnett Shale and \$500 million in the Arkoma Basin and its other Mid-Continent properties. Another \$350 million will go into the Bakken Shale, Gulf Coast, and offshore. Its Permian Basin projects will take \$300 million, and the San Juan, Raton, Uinta, and Piceance basins will use \$250 million, and it will direct the remaining \$100 million to exploration.

The activity is stronger than XTO's drilling pace in 2008. For example, the company had 120,000 acres in the Woodford at the end of the third quarter. At that time, it had six rigs working and completed nine wells in the play.

At the same time, it worked seven rigs in the Fayetteville and drilled 18 wells during the quarter. ■

Figure 1. A BJ Services engineer holds a handful of LiteProp beads. The uniform light-weight beads “float” into place in slickwater fracs to extend fracture length.



Photo courtesy of BJ Services



Technology Rules Arkoma Successes

Operators build vast knowledge bases, then apply the right technical solutions to maximize productivity.

By Dick Ghiselin
Contributing Editor

The Arkoma Basin of southeastern Oklahoma and north central Arkansas is home to three prolific shale plays — the Woodford, the Caney, and the Fayetteville. Although there are some similarities, most players agree that each should be studied in its own right to determine the possible effect of the differences between them. There is no “Arkoma Solution.”

However, experience has led to the development of some trends that seem to prevail in most Arkoma wells. In a recent report, Constellation Energy recognized the dramatic growth of horizontal drilling as applied to natural gas wells. It cites several sources that support this contention. For example, compared to a total rig count growth of 70% since 2000, the number of horizontal rigs has grown by 377% during the same period. Another source says that horizontal well drilling is growing 96% year-on-year. And it’s a good thing. According to Simmons & Company, absent the development of applicable technology, overall gas production would have declined 40% to 50%, but instead it remained essentially flat.

Notwithstanding the positive effect of new technology development on gas well drilling and production, Wood Mackenzie warns that operators should not expect overnight results in their unconventional

Figure 2. Massive hydraulic frac jobs are required to stimulate multiple stages in the Woodford Shale.



gas plays. There is no panacea or magic elixir that works on all shale gas wells. Each must be treated according to the challenges it presents – on a reservoir-by-reservoir basis or even on a well-by-well basis (Figure 2).

Measure before cutting

The ancient carpenter’s rule applies. Experienced service providers are unanimous in this regard. Knowledge is the key to the development of effective solutions. BJ Services has gone so far as to trademark its “Understand the Reservoir First” philosophy, demonstrating to all its commitment to excellence through the development of local knowledge along with the capture and application of learnings from each project to guide future recommendations to its customers.

Operators too, have recognized the benefit of superior measurements to guide strategic and operational decision-making. In its Fayetteville play, Southwestern Energy (SEECO) has taken a high-tech approach to get the best well placement and maximum reservoir contact. The company uses state-of-the-art formation evaluation and completion technology to maximize its reservoir knowledge before undertaking a project. The result is that it can produce more gas from fewer, but better, wells.

If there is a consensus among Arkoma operators, it is to achieve maximum effective reservoir contact with the objective of achieving the lowest cost per Mcf while getting the gas to market as quickly as possible. There are two ways to achieve this objective: possess a good deal of blind luck, or take the time to develop the reservoir understanding necessary to make the right decisions. In short, measure before cutting.

Successful technology applications

Much of the success in drilling and completing the Arkoma Shales is the result of good hard work in applying proven drilling and completion techniques. There are many ways to drill and complete a well, and with foreknowledge, operators and their service providers can usually find the best technique for the well under consideration. A few stand out as being particularly useful. In the realm of formation evaluation, microresistivity imaging, acoustic imaging, elemental capture spectroscopy and nuclear magnetic resonance are mentioned most frequently. It’s useful to take a closer look at each.

- Microresistivity imaging provides a 360-degree image of the borehole wall in such detail as to allow users to identify, measure, and determine

the orientation of microfractures intersected by the borehole. Lithological texture can be observed, as well as formation dip, and fracture apertures can be quantified. One microresistivity imaging device that is available in logging-while-drilling (LWD) tools is the Schlumberger geoVISION service. Some prefer to drill and log vertical pilot holes to get the information, while others use LWD, drillpipe-conveyed wireline techniques, or tractors to log horizontal sections. Another limitation is oil-based mud, which is used to drill most Woodford wells. While several providers offer oil-based mud microresistivity imagers, often they are unable to provide the fine detail of the water-based mud versions. Microresistivity imaging is used primarily to detect and discriminate drilling-induced fractures from natural fractures, detect lithology changes, identify geologic features such as sub-seismic faults, and evaluate qualitative stress variations along lateral sections.

- Acoustic logs enable resolution of another piece of the formation evaluation puzzle. This is the ability to perform geomechanical analyses and 3-D anisotropy determinations including the magnitude of hydraulic fracture closure stress and orientation of the prevailing stress profile. An advanced tool, the Sonic Scanner service from Schlumberger gives compressional, shear, and Stoneley velocities, along with the orientation of maximum horizontal shear velocity. The accuracy of stress profile calculations is enhanced by taking both horizontal and vertical measurements in complex, highly laminated rocks such as gas saturated shales. The equipment can be run in both cased and openhole. When run in cased holes, an added benefit of the tool is provision of a high-quality cement bond log. The primary benefit of these measurements is the ability to make recommendations for landing and orienting laterals for maximum effective reservoir contact as well as guiding the engineers responsible for hydraulic fracture design.
- Elemental capture spectroscopy logging provides detailed understanding of shale mineralogy as well as total organic carbon content, and volume of adsorbed and free gas in place. It can help identify reservoir “sweet spots” and can be used to “chemically steer” the well into the best reservoir zones.

- Nuclear magnetic resonance imaging has been characterized as the only direct logging measurement of permeability. It yields lithology-independent measurements of effective porosity, free fluid porosity, clay-bound water, and capillary-bound water. Advanced versions, such as the XMRI tool from Halliburton, help to discriminate open fractures that can actually flow gas from drilling induced fractures that pose leak-off problems.

Breakthrough technology

Recommended by all hydraulic fracturing providers, the use of microseismic imaging to track fracture propagation represents technology that is making a major difference in the Arkoma as well as in other shale plays. Generally, the technique involves hanging an array of geophones in a nearby well to monitor the progression of the microseisms that occur as a hydraulic fracture propagates through the rock. Previously, the seismic arrays were placed in the vertical sections of offset wells, but recently, tractors have been used to place the arrays in lateral sections, paralleling the well being treated. For its dramatic effect on hydraulic fracture quality and placement, microseismic imaging is recognized as today’s hot new technology. In some cases, results are made available at the well site in real time, and can be used to guide the fracturing job, helping to prevent a fracture from propagating into an aquifer or communicating with offset producing wells. Perhaps the biggest benefit of real-time fracture monitoring is the ability to make on-the-fly changes to plans for subsequent stages of multistage fracture programs based on observations from the stage being treated.

Barry Dean of Schlumberger provided insight into the value of StimMAP Live, the company’s real-time microseismic log presentation. “We are able to map the propagation of the fractures we make using StimMAP Live,” he said. “This prevents treating sections of lateral that have already been effectively treated, or helps identify sections not taking treatment in time to take remedial action. There are isolation issues, and without StimMAP you might be treating a section of a horizontal well and find that all the treatment is going into the same reservoir volume as treated in the previous stage. You should not assume that the entire horizontal lateral is being treated based on the location of isolation plugs and perforations.

Images courtesy of Schlumberger

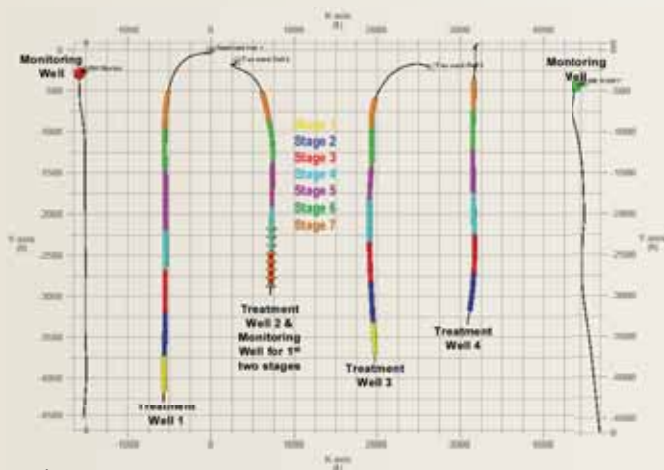


Figure 3

Above: Figure 3. A seven-stage Simul-Frac targeted 25 zones in the Woodford. Four wells were treated with microseismic images made from two vertical observation wells on the perimeter and one lateral combination observation/treatment well in the middle. Figure 4. Composite microseismic activity for all 25 zones of seven stages is shown. Fracture growth toward the outlying well bores was seen once the fractures from offset wells began to interact with each other.

“We use the Plug n’ Perf technique most of the time,” Dean said. “This system gives us the flexibility we need.” According to Dean, while other multistage techniques may be more efficient, it is important to know in advance exactly where you want to treat, and it is much preferable to get many fractures distributed along the lateral. “I would rather have dozens of 500-ft- to 800-ft-long closely spaced transverse fractures than five widely spaced 2,000-ft-long fractures,” he said.

Learnings from the application of microseismic technology have led to a new technique called “Simul-Frac.” Particularly appropriate in the Arkoma, where it’s desirable to produce multiple closely spaced fractures to maximize recovery rates and ultimate recovery factors, the technique has been pioneered by Continental Resources on its Woodford Shale acreage in eastern Oklahoma. Basically, geophone arrays were deployed in vertical and/or horizontal sections of offset wells then multistage hydraulic fracturing was conducted in two or more wells simultaneously with excellent results (Figure 3). Overall reservoir volume treated was improved along with well productivity.

Sequential fracturing of adjacent well bores often resulted in fracture stimulation treatment fluids, moving along the path of least resistance, to intersect producing well fracture networks. This flooded producing well fracture networks, interrupting production, and reduced the efficiency of fracture treatments on the new wells. In collaboration with Schlumberger, Continental Resources engineers determined that fracture propagation from a well was dependent on the local

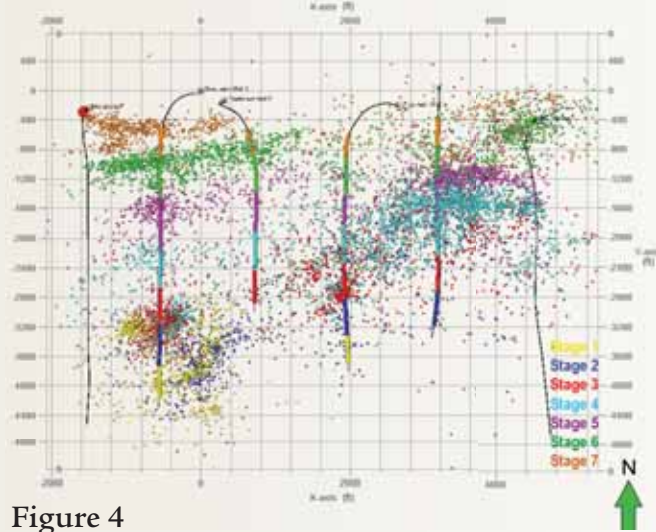


Figure 4

stress fields that it encountered as it radiated out from the well being treated. As induced fractures neared previously fractured reservoir it communicated with that drainage volume due to the lower post-frac stress level. Why not avoid this communication by pre-stressing the earlier-treated wells?

At first, they tried pumping adjacent stages on parallel wells simultaneously. Results were encouraging. Another technique used a batch process where adjacent stages were left pressured-up until treatment of the nearby wells were completed, then all wells were allowed to flow back and clean up at once. By leaving a stage under pressure, higher reservoir stress was created that would, in some cases verified by StimMAP Live, divert fracture propagation away from the pressured region to untreated parts of the reservoir (Figure 4).

Further experimentation resulted in a number of variations of the Simul-Frac technique with similar results:

- Vertical staggering takes advantage of the tensile region surrounding the tops and bottoms of fractures to allow close spacing of fractures;
- More than two laterals can be stimulated at once — in some cases up to four laterals were simultaneously pumped; and
- In shales, since there is essentially no leak-off, the fractures remain pressured up until they flow back during the cleanup phase. Accordingly, treatments can be sequential as long as the wells are left pressured up until the conclusion of all treatments.

With the Zipper-Frac technique, adjacent stages are treated sequentially without pressure bleed-off.

After treating the toe of the first well, the frac crew moves to the adjacent well. While the frac crew is treating the toe of the second well, the plugging and perforating crew is setting the frac plug and perforating the next stage of the original well. The crews swap back and forth between wells until all stages have been treated. The plugs hold pressure on previously treated zones while adjacent stages are being treated.

If fewer crews are available than wells, a system is designed whereby perimeter wells are treated first, then held under pressure while the inner wells are treated. This prevents fractures from the inner wells from communicating with the fractures from the perimeter wells. This allows a more dense fracture pattern to be created. The combinations are endless, and they are a function of the actual well spacing, the structural geology, logistics, and the desire for fracture density over fracture length. The multiwell technique is very efficient when all wells share a single drilling pad. However, efficiencies may still be realized even if crews have to move between adjacent locations.

Another benefit, and perhaps the most important, is you only load the wells once with fluid when simultaneously completing closely spaced horizontal wells. You avoid the costs associated with having to workover wells or install artificial lift due to fracturing into producing well fracture systems from new well stimulations.

In preparing for the simultaneous stimulation technique, the appropriate logs were run to gain as much reservoir and geomechanical foreknowledge as possible. The Sonic Scanner service was run in cased hole to ascertain that a good cement bond existed and hydraulic isolation of the annulus was assured. The service helped estimate stress variation along the laterals and pick optimum perforation points.

In a test series, three Simul-Frac projects were run by Continental Resources. Several valuable conclusions were reached. There was a clear potential to increase production rates. Two of the projects resulted in increased rates, and a third, which did not, was constrained by pipeline capacity. Subsequently, three additional projects have been completed. Early data indicates that the production rate improvement will last. Frequency of workover and intervention of producing wells is reduced.

Building better fracs

Armed with reservoir understanding obtained from logs, cores, and offset well data, BJ Services' engineers have designed ways to improve productivity from the multistage fracs they make in shale gas plays. Simply fracturing the rock was not enough. They wanted to ensure their client got the maximum gas flowrate from the resulting fracture. To do that, they had to ensure that the entire frac was propped from top to bottom. To overcome the tendency for sand proppant to slump to the bottom of the frac due to the effects of gravity, BJ Services introduced its LiteProp technology, an ultra-lightweight proppant bead that is almost perfectly spherical and light enough to float in most carrier fluids, even those used in slickwater fracs.

"We use 40/100 mesh LiteProp 108 ULWP to fill in the tops of the fracture wings," said Scott Nelson of BJ Services' Oklahoma City region. Rocky Freeman, also of the Oklahoma City region, added, "The LiteProp proppant is added late in the pumping schedule, and we have evidence that not only does it help prop the entire fracture open, but it is actually creating new fractures due to diversion, so it's improving reservoir contact too."

The technique follows the philosophy of partial monolayers, which is particularly effective in low-permeability reservoirs. Essentially, the idea is to improve fracture length more than width. In low-permeability reservoirs, a single proppant layer may be enough to sustain the fracture. By removing proppant, less horsepower is required to create and propagate the fracture to achieve the desired conductivity. The lightweight proppant floats to the fracture tip instead of slumping to the bottom of the wing. At the same time, the new proppant has a high compressive strength and heat resistance. But the biggest advantage is its weight-to-volume ratio.

For example, LiteProp 108 ULWP occupies a 250% greater volume than an equivalent weight of Ottawa sand (Figure 1). Tony Martin, BJ Services' international stimulation development manager, said, "The concept of near-buoyant proppant can revolutionize the industry."

BJ Services also likes having the ability to use microseismic monitoring to aid in making both on-location treatment decisions and to improve

treatment designs in future wells. To take advantage of this information, the company performs mostly Plug n' Perf type multistage fracs. "The advantage of the flexible Plug n' Perf technique is that you're not locked in to a predetermined perforating interval," said BJ Services' Mike Stockard. Terry Hardwick added, "We watch the pumping pressures from our frac van and make decisions on-the-fly to get the best results. We also like to pump all the specified fluid even if we get a screenout on the sand. We think that getting all the fluid pumped is important in extending the frac to its limit," he concluded.

The company averages five to 10 stages per well, spaced out along the horizontal lateral. Each stage may contain several perforated zones, so more than one frac can be created per stage.

Giving a plug to the cementers, BJ Services' Curtis Huff said, "It should be noted that the key to a successful frac job is a successful cement job. We've found that the natural fractures tend to take drilling mud and cement. The result is that you lose all the conductivity the natural fractures provided."

To combat this problem, the company has developed special cement blends such as foamed cement,

acid soluble cement, and foamed acid-soluble cement to provide good hydraulic isolation without damaging potential pay zones. "Later we can dissolve the cement using acid," Huff explained. "Or in the case of foamed cement, we can usually get the fractures to propagate out through any cement that may be present. We've had near 100% success since we started engineering our cement jobs according to log and well parameters, and completing the job using foamed and acid-soluble systems."

Foamed cement is key in the Woodford

According to Halliburton, operators completing wells in the Woodford Shale had cemented 116 horizontal production strings using conventional cement before switching over to lightweight foamed cement. As of early 2008, 229 lateral production strings had been isolated using cement foamed with nitrogen. Results were dramatic, and fell into at least one of three categories:

- Improved gas production;
- Improved fracture stage stimulation; and
- More complete hydraulic isolation.

Most importantly, operators released production data on almost half the wells stimulated using foamed cement. On average, the 30-day gas production from those wells averaged 28.1% better gas volumes than wells cemented conventionally.

In the case of stimulation design improvement, Halliburton statistics show improved fracture initiation and placement on 96.4% of the wells isolated using foamed cement compared to 79.9% success on conventionally cemented wells.

A major contributor to problems cementing long lateral sections is uniform cement distribution around the pipe. Azimuthal bond logs showed that conventionally cemented wells often had an uncemented channel running along the top of the casing. This was caused by heavy slurry cement slumping to the low side of the hole leaving a fluid-filled gap at the top. When stimulation commenced, the channel robbed frac fluid and pressure from the treatment zone, resulting in sub-optimal performance. On the other hand, the nature of foamed cement is to completely fill the annulus, leaving no channels due to gravity slumping. According to Halliburton, cement compressive strength is secondary in importance to complete hydraulic isolation. The

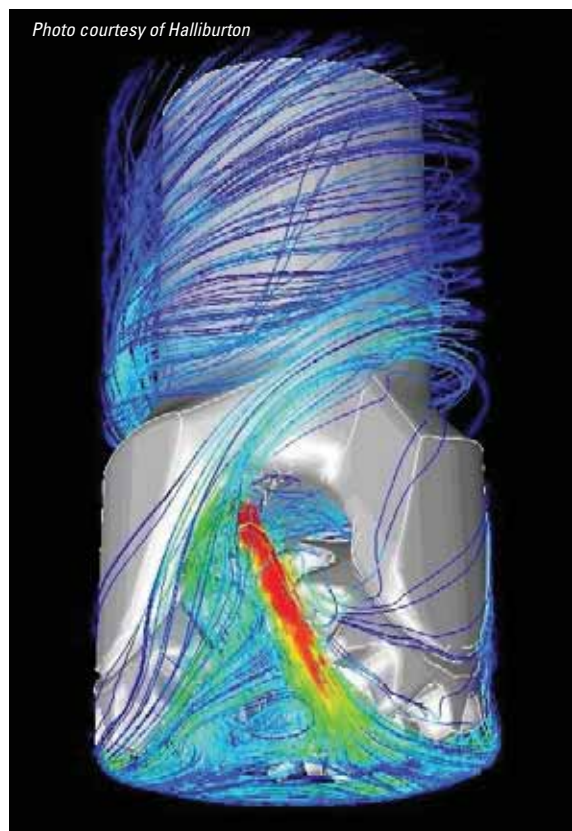


Figure 5. Designed for drilling shale, the unique hydraulics of the Security DBS Quad-pack drill bit are illustrated by blue streamlines. The bit features high rate of penetration with excellent wear and bore-hole quality characteristics.

cement sheath should exhibit both ductile and elastic characteristics along with increased tensile strength.

The desired characteristics are achieved by designing a cement slurry that is fully engineered to meet each well's requirements. The generalized objectives include 360-degree uniform coverage around the casing; an expandable sheath that achieves 100% cement-to-formation bond as well as cement-to-casing bond; a life-of-the-well solution that will provide complete hydraulic isolation for both the stimulation and completion phases as well as the subsequent production phase; maintaining positive hydrostatic pressure during the entire cementing operation to prevent borehole wall caving; and providing a positive mud-cleaning displacement action to optimize the hole to accept the cement.

Newfield Exploration benefited from the use of foamed cement in several of its Woodford Shale wells. Typically, the company has been drilling 8 3/4-in. diameter laterals using 8.5 lb/gal to 10.0 lb/gal oil-based mud. Production casing was centralized 5 1/2-in. diameter pipe. Borehole stability and hole quality have been good, and, as a result, there have been few problems getting casing set to total depth. Completions are multistage, high-volume slickwater fracs. Treatments are generally pumped at 80 bbl/min to 100 bbl/min, and wellhead treatment pressures range from 5,000 psi to 9,000 psi. The favored technique is Plug n' Perf. It has been hypothesized that the application of pressure cycles as each stage is broken down and treated may have overstressed the cement sheath in the past. This is one key reason that ductile foamed cement is ideal for multistage shale play fracturing. Halliburton engineers developed a generalized technique for application of foamed cement, then customized the mixture to optimize it to each well's parameters and the planned fracturing schedule before pumping it. To help it reach the desired level of design optimization, the company uses proprietary software like its ShaleEval program to match the proposed completion design to the geological and geomechanical conditions of the formation to be treated. It employs its ShaleStim technology that is specifically designed to optimize stimulation treatments from pre-job evaluation and planning through clean-up and recovery.

Shale drilling can be tricky. As a result, Halliburton's Security DBS Division has addressed the technology of

purpose-built drillbit design with its QuadPack drill bits (Figure 5). These roller cone tungsten carbide insert bits were specifically designed for shales like the Woodford, and they deliver increased penetration rates through long intermediate sections and subsequent laterals. Key features of the bits include larger, tougher bearings, improved bearing seal capabilities, and better bit hydraulics and steerability.

Location, location, location

As the saying goes, the top three reasons given for the success or failure of a business are location, location, and location. This is true in drilling the nation's shale plays as well. While the maps imply broad swaths of shale crossing the country from sea to sea and from north to south, bringing in a commercially viable producer is not a slam dunk.

The Arkoma Basin in particular has seen its share of successes and also-rans. According to a report published by PetroQuest Energy in January 2009, in addition to itself, the most successful players in the Woodford appear to be Newfield Exploration, Devon Energy, XTO, Continental Resources, and St. Mary Land & Exploration, with a total of 575,000 acres leased. To the east in the Fayetteville trend, the players include SEECO, Chesapeake, XTO, and Petro-Hawk Energy in addition to PetroQuest. Between them, they have 1.83 million acres under lease.

For every successful venture in the Arkoma, the news is full of less impressive performances. Obviously, location plays a major role in the success of a project, but it's possible that overlooking successful technology could play an equally important role. If you listen to the major service providers, simply drilling a well in the right place is no assurance that it will produce high volumes of gas at commercially viable rates. There is a lot of technology between simply fracturing the rock and producing successful fractures that maximize reservoir contact, conductivity, and longevity. Famous oilman George H. Mitchell has been honored as the "Father of the Barnett," testifying to his dogged persistence of two decades that finally resulted in a "solution" for making profitable wells in the famous north Texas play. The gas was always there, and George Mitchell knew it, but it took years for technology to catch up to his dreams. Now the technology is available, and successful players are using it to their everlasting advantage.

Arkoma Basin Activity Spurs Pipeline Expansion

Operators are working to insure that transportation capacity is available for growing oil and gas production.

By Bruce Beaubouef, Ph.D.

Editor, *PipeLine and Gas Technology*

Growing natural gas production from the Woodford Shale play in Oklahoma's Arkoma Basin has prompted several operators to build new pipeline systems as a means of increasing takeaway capacity in the region. One of the key players in the region is MarkWest Energy Partners, which last year announced that it had submitted a pre-filing application with the FERC to construct a new interstate natural gas transmission pipeline for this purpose.

The new Arkoma Connector Pipeline would provide needed pipeline capacity to transport Woodford Shale production to new markets. It would consist of approximately 50 miles of 24-in. pipe running through Coal, Atoka, and Bryan counties in southeastern Oklahoma. As planned, the line would originate at MarkWest's gathering system in the Woodford Shale production area in southeastern Oklahoma, north-northeast of Coalgate, then extend south to where it would interconnect with both the Midcontinent Express Pipeline and the Gulf Crossing Pipeline. MarkWest also says it plans to construct a new compressor station approximately eight miles north-northeast of Coalgate, Okla., and a mid-line compressor station. The new system would have a capacity of up to approximately 625,000 dekatherms per day. Newfield and Chesapeake are two major producers in the Woodford Shale that plan to ship natural gas on the Arkoma Connector Pipeline. The new system will provide significant additional outlets for producers in the Woodford Shale as volumes continue to rap-

idly increase. MarkWest recently executed agreements with significant Woodford producers, including Newfield Exploration Co., to provide transportation capacity in excess of 500,000 MMcf/d on the Arkoma Connector Pipeline.

In conjunction with the Arkoma Connector transportation agreements, MarkWest and Midcontinent Express Pipeline LLC (MEP) have also entered into an option agreement that provides MarkWest with a one-time right to acquire 10% of the equity of MEP after construction is complete on the Midcontinent Express Pipeline and it is placed into service. MEP is a 50/50 joint venture between Kinder Morgan Energy Partners LP and Energy Transfer Partners LP. If the option is exercised, Kinder Morgan and Energy Transfer Partners will each own 45% of the equity in the project, while MarkWest will own 10%. The Midcontinent Express Pipeline, connecting Bennington, Okla., and Perryville, La., will have initial capacity of 1.4 Bcf/d. Kinder Morgan is managing the construction of and will operate the pipeline. The approximately US \$1.3 billion project will extend from southeast Oklahoma, across northeast Texas, northern Louisiana and central Mississippi, to reach an interconnection with the Transco Pipeline near Butler, Ala.. The approximately 500-mile pipeline will consist of 262 miles of 42-in., 197 miles of 36-in., and 40 miles of 30-in. pipe, and have up to 13 receipt and/or delivery interconnections. The delivery interconnections will provide access to numerous downstream markets, including those served by the



Chesapeake Energy is installing compressors like this near Albion, Ark., to handle Fayetteville gas production.

Photo courtesy of Lowell Georgia

NGPL, Transco, Texas Eastern, Tennessee, Columbia Gulf, Texas Gas, Southern Natural, Destin, and ANR pipelines. Midcontinent Express is scheduled to be in service by March 2009.

“The Woodford Shale is one of the fastest-growing resource plays in the United States, and we are very pleased to announce these significant projects that will support the continued success of our producer customers,” said Frank Semple, president and chief executive officer of MarkWest. “In these rapidly growing resource plays, we believe it is critical to ensure that the produced gas has a clear path to liquid markets. The Arkoma Connector Pipeline and MEP are critical links to providing market access for Mid-Continent producers.”

There are a number of existing systems to help Arkoma Basin producers market their gas.



This recent announcement follows a previous announcement by MarkWest of its plans to invest up to \$350 million in the 2006-2010 time frame to build a significant amount of gathering pipelines in the Arkoma Basin of Southeastern Oklahoma. This infrastructure is designed to support expanded drilling plans by Newfield Exploration Co. The gathering pipelines and related facilities will serve about 200 sq miles in four counties. MarkWest will operate the pipeline.

Newfield has allocated an additional \$150 million in capital expenditures for expanded exploration this year in the Arkoma basin. “Our growth requires the installation of significant midstream infrastructure,” said Lee K. Boothby, president of Newfield Mid-Continent. “Partnering with MarkWest allows us to benefit from their proven expertise in gathering and transportation and allows Newfield to focus its efforts on drilling and production.” The gathering system being constructed by MarkWest will support Newfield’s Woodford shale operations. The gathering system will include 400 miles of pipeline with capacity of more than 500 MMcf/d. Newfield has drilled more than 100 vertical wells and 30 horizontal wells in the Woodford shale play. Average production from the last five wells totaled 3.7 MMcf/d.

In addition to these new construction projects, there are a number of existing systems to help Arkoma Basin producers market their gas. These include Crosstex Energy’s Arkoma gathering system, an approximately 140-mile, low-pressure gathering system in southeastern Oklahoma. It delivers gathered gas into a mainline transmission system. In 2007, throughput on the system averaged approximately 18,000 MMBtu/d. Another existing system is owned by Penn Virginia Resource Partners LP. Its Arkoma System is a stand-alone gathering operation in southeastern Oklahoma’s Arkoma Basin, and is comprised of three separate gathering systems, two of which are 100% owned with the third system being 49% owned. The company operates and maintains all three systems. The Arkoma System consists of a total of approximately 78 miles of natural gas gathering pipelines, ranging in size from 3-in. to 12-in. diameter. Three compressor stations are operating across the Arkoma System. ■

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The Economics of the Arkoma Shales

Lean times will not last forever.

By Steve Berman
Senior Research Analyst
Pritchard Capital

The Mid-Continent Arkoma Basin includes the Woodford Shale in eastern and southeastern Oklahoma, and the Fayetteville shale in western Arkansas. While there is production from shallower formations such as the Hartshorne Coal, Cromwell Sandstone, Atoka Sands, and the Caney Shale, the main activity in the Arkoma Basin and focus of this article is on the Woodford and Fayetteville shales.

Located on the Arkansas side of the Arkoma Basin, the Fayetteville Shale is a Mississippian-age formation ranging in thickness from 50 ft to 550 ft and depth from 1,500 ft to 6,500 ft. Thickness

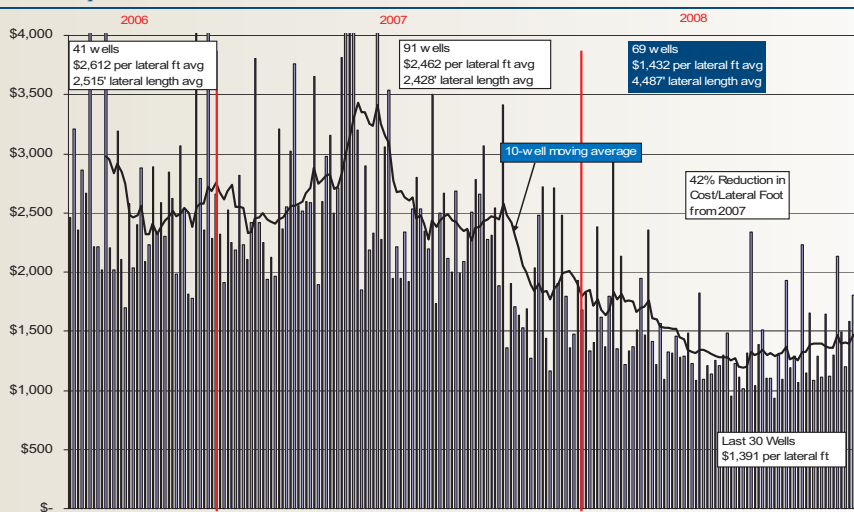
increases going from west to east in the Basin. The Fayetteville is found in multiple eastern and central Arkansas counties, including Cleburne, Conway, Faulkner, Franklin, Jackson, St. Francis, Pope, Prairie, Van Buren, White, and Woodruff counties. The Fayetteville is about the same age and is seen as a geologic equivalent to the Barnett Shale. As with other shale gas plays, the Fayetteville was previously known to be a gas-bearing formation, but only started producing in a meaningful way when horizontal drilling and fracture stimulation were introduced.

The dominant player in the Fayetteville Shale is

Southwestern Energy, with 875,000 net acres. Southwestern's gross operated Fayetteville shale production as of mid-February was 750 MMcfe/d, up from nothing three years ago. The company drilled its first Fayetteville horizontal well in the first quarter of 2005. Improving well performance has resulted from longer laterals, slickwater completions, and larger frac jobs. Average completed well costs are ~US \$3 million, and estimated ultimate recoveries (EURs) are in the 3.0 Bcfe range. Petrohawk Energy, another large Fayetteville operator with 157,000 net acres, has an average well cost of \$1.75 million to \$2.25 million with EURs of 1 Bcfe to 4 Bcfe per well. Two other major players in the Fayetteville are Chesapeake Energy with 420,000 net acres and XTO Energy with 380,000 net acres.

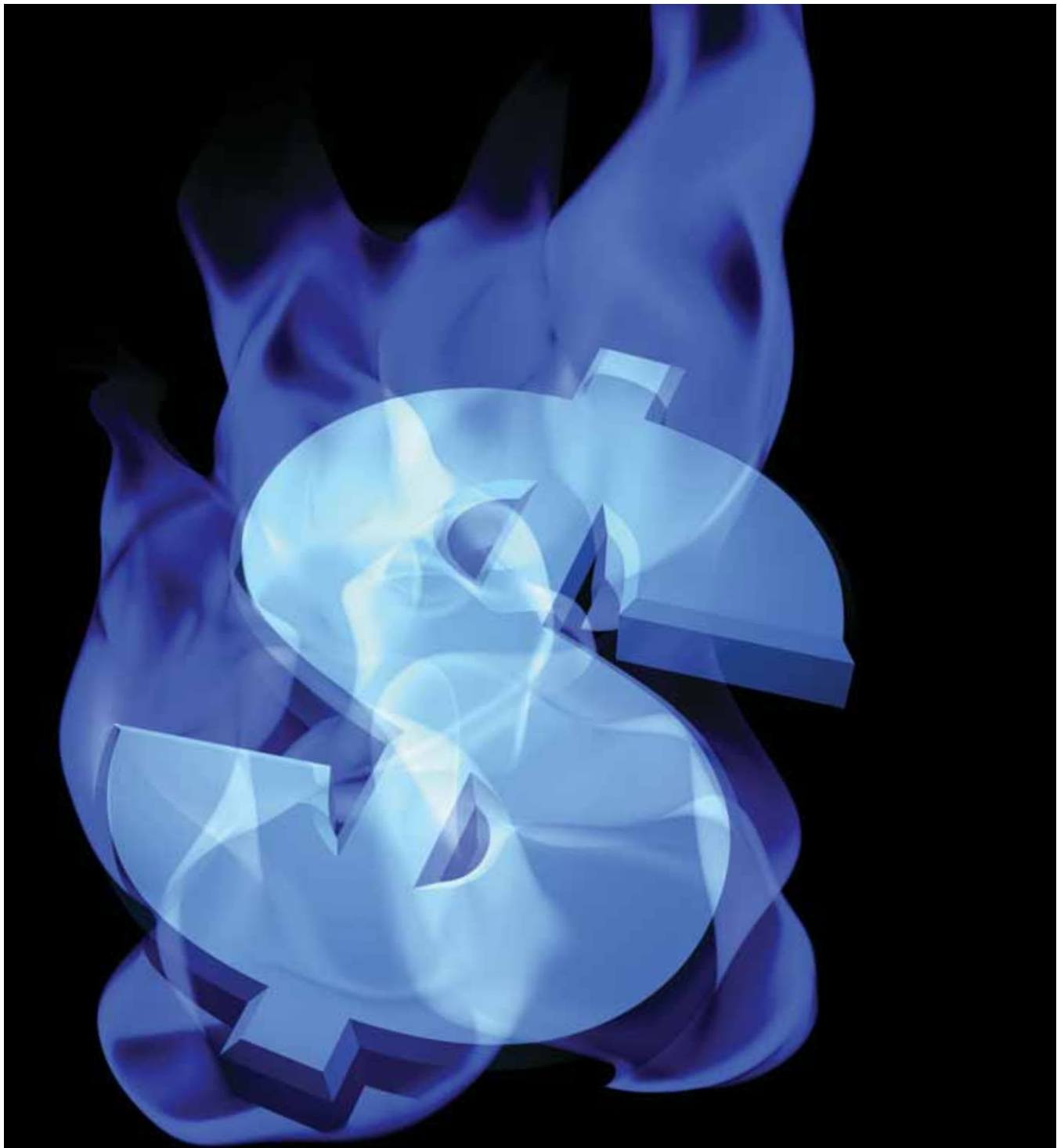
Woodford Drill & Complete Cost

Total Cost per Lateral Ft



Note: 11 wells not shown due to mechanical failure

Image courtesy of Newfield Exploration Co.



IN RESPONSE TO LOW PRICES, high differentials, and in an effort to drive down service costs that have not matched the decline in commodity prices, virtually every company has slowed drilling and completion activity.

The Woodford and Fayetteville Shale Trends



- Approximately 48,000 net acres in the Woodford Shale
- Over 18,000 net acres in the Fayetteville Shale
- Current production in excess of 46,000 Mcf/day net

BP got into the play last year with 135,000 net acres through a joint venture with Chesapeake.

The Woodford Shale, a Devonian-age formation, generally ranges from 100 ft to 220 ft thick at depths of 6,000 ft to 11,000 ft. Although the first gas production was recorded in 1939, the play did not really develop until 2003-2004, first through vertical drilling. High gas prices and better completion techniques unlocked the potential of the Woodford as a horizontal play in 2005-2006. The Woodford is mostly in the Arkoma Basin of southeast Oklahoma, but drilling has extended the play west into the Anadarko Basin with Devon Energy and Cimarex Energy recently showing promising early results.

Our discussion here centers on the Arkoma Woodford. Approximately 750 horizontal wells have been drilled in the play to date. The largest producer from the Woodford is Newfield Exploration. Other main operators in the play include PetroQuest Energy, St. Mary Land & Exploration, Continental Resources, XTO, and Devon. The core of the play centers in Pittsburg, Coal, Atoka, and Hughes counties.

Newfield's Woodford reserves grew 40% in 2008,

gross operated production was up 65% and is expected to be up 30% in 2009. Ninety percent of its 165,000 net acres are held by production. Laterals at 4,500 ft headed to 5,000 ft. NFX expects to be able to add Woodford reserves in 2009 at an efficient F&D cost of \$1.50/Mcfe to \$1.75/Mcfe, down from \$1.75 to \$2.00/Mcfe in 2008. Recent wells for PetroQuest have averaged slightly under \$5 million to drill and complete with EURs in the 3.5 Bcfe to 4.0 Bcfe range. St. Mary cites a \$4.5 million to \$5.5 million cost and a 4 Bcfe EUR, while XTO also has a \$4.5 million to \$5.5 million cost with EURs of 2.5 Bcfe to 5.0 Bcfe.

As of the writing of this article, economics in the Arkoma Basin, particularly the Woodford, are underwhelming. A combination of low benchmark (Henry Hub) natural gas prices, differentials, transportation, and handling charges running as high as 20% to 30% of Henry Hub prices, and stubbornly high service costs have created the perfect storm of tough operating conditions. At flat \$5 gas and a well cost of \$5 million in the Woodford, the IRR would be 10% to 15%, but differentials have crushed the economics. The numbers are slightly better in the

Fayetteville, but not by much. Bottom line, at current well costs and differentials, the Woodford needs Henry Hub prices of ~\$6.50/Mcfe and the Fayetteville \$5.75/Mcfe to \$6.00/Mcfe to generate 20% type IRRs.

In response to low prices, high differentials, and in an effort to drive down service costs that have not matched the decline in commodity prices, virtually every company has slowed drilling and completion activity in both the Fayetteville and Woodford. For example, one Woodford player has laid down all of its operated rigs including one that remains under contract, waiting for service costs to come down. Several of its wells that were drilled will not be completed until service costs such as pressure pumping and frac jobs come down another 10% to 20%.

Insufficient takeaway capacity has caused bottlenecks for Arkoma Basin gas and led to oversized basis differentials. This should be alleviated by several pipeline projects expected to come into service starting in the second quarter of this year. With more capacity coming into service, such as the Gulf Crossing, Midcontinent Express, and Boardwalk (Phase 2) Pipelines, differentials are expected to be cut in half or more, a big uplift for economics in the play. Boardwalk Pipeline Partners' Gulf South pipeline expansion and Gulf Crossing pipeline, the MidContinent Express pipeline, and other projects will add 6.6 Bcf/d of capacity, moving Arkoma Basin and other gas into higher-priced southeast and eastern markets.

One aspect an individual company can control in the economic hierarchy is drilling an efficient well. Southwestern, for example, has reduced Fayetteville spud to spud time from 16 days at the beginning of 2008 to 13 days in fourth-quarter 2008. As can be seen in the chart on the previous page, driving costs down can be a big boost for the economics of a play. Newfield's average cost to drill and complete a lateral foot in the Woodford has fallen 42% since 2007. Driving the cost reductions have been faster drilling times, the increased use of more efficient pad drilling, completion advances such as requiring less frac fluids, and increased lateral lengths. Although longer lateral wells cost more on an absolute basis, the F&D cost on a unit basis (per Mcf/e) is lower. ■

DRIVING COSTS DOWN

can be a big boost for the economics of a play.



Photo courtesy of Newfield Exploration Co.

Additional Information on the Arkoma

For more details on the Caney, Fayetteville, and Woodford plays, consult the selected sources (2000-2008) below as well as the expanded Arkoma Reference Section available at UGcenter.com.

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Caney Wells

Operator	Completion Date	Field Name	County	Shale Formation/ Member	#Wells	Depth	Initial Potential (MCFD)
Alda Oil & Gas Corporation	10/9/2002	Vernon NW	McIntosh	Caney	1	3872	62
Brower Oil & Gas	8/10/2004	Hoffman	Okmulgee	Caney; Mayes	1	2532	15
Brower Oil & Gas	12/18/2003	Pierce	McIntosh	Caney	1	2953	34
Brower Oil & Gas	1/14/2005	Salem N	Okmulgee	Caney	1	3192	10
Centrex Operating	5/20/2004	Hoffman	McIntosh	Caney	2	2445	57
Chaparral Energy	8/25/1999	Enville W	Love	Caney	1	3612	500
Chesapeake Operating	4/29/2005	Reams NW	Pittsburg	Caney; Woodford	1	6453	97
Chesapeake Operating	3/1/2005	Stidham	McIntosh	Caney	1	2823	47
Citris Energy	10/29/2004	Raiford SE	McIntosh	Caney	1	3965	200
Citrus Energy	3/4/2005	Hanna NW	McIntosh	Caney	1		86
Citrus Energy	4/24/2004	Raiford W	McIntosh	Caney	2	3978	45
Citrus Energy	2/8/2005	unnamed	McIntosh	Caney	1		235
Citrus Energy	3/8/2004	Vernon NW	McIntosh	Caney	4	3802	1125
Crown Energy	4/8/2008	Beland	Muskogee	Caney		2580	112
D & J Oil Company	8/4/2004	Checotah NW	McIntosh	Caney	1	2576	240
D & J Oil Company	9/3/2004	Keefeton	Muskogee	Caney	2	1800	30
Dave Holke Consulting	8/7/2002	Stidham S	McIntosh	Caney	1	3838	58
Devon Energy	4/4/2006	Dustin	Okfuskee	Caney	2	3764	221
Dyne Exploration	6/12/2006	Stidham S	McIntosh	Caney	1	3620	32
Enterprise Energy Expl	2/1/2005	Checotah NW	McIntosh	Caney	1	2905	140
Enterprise Energy Expl	10/18/2004	Weleetka	Okfuskee	Caney	1	3237	50
EXOK	5/1/2004	Dustin	Hughes	Caney	1	4104	85
EXOK	4/8/2004	unnamed	Hughes	Caney	2	4138	55
EXXON Corporation	1/7/1984	Sho-Vel-Tum	Stephens	Caney	1	4784	135
Finley Resources	6/22/2007	Enville W	Love	Caney	1	4090	272
Fortuna Energy	5/19/1984	unnamed	McIntosh	Caney	1	4046	150
Gruy Petroleum Management	6/20/2006	Cumberland	Marshall	Caney	1	2442	5
Gruy Petroleum Management	7/24/2006	Madill	Marshall	Caney	1	3918	1
K.G. Landrum	11/6/2001	Stidham SE	McIntosh	Caney	1	3122	64
Landmark Energy	12/18/2004	Raiford SE	McIntosh	Caney	2	3979	100
Larron Energy Corporation	3/1/2005	Wewoka	Seminole	Caney	1		
Mack Energy	9/13/2000	Enville W	Love	Caney; Sycamore	1	3490	296
Mack Energy	8/31/2005	Marietta N	Love	Caney	1	4772	162
Metro Energy Group	9/4/2004	Lyons-Quinn	Okfuskee	Caney	4	3492	120
New Dominion LLC	2/10/2004	Adams	Hughes	Caney	1	3740	30
New Dominion LLC	3/27/2003	Hanna N	McIntosh	Caney	1	3982	88
New Dominion LLC	5/17/2004	Raiford SE	McIntosh	Caney	1	3986	30
New Dominion LLC	9/4/2003	unnamed	McIntosh	Caney	1	3874	80
Newfield Exploration	12/8/2004	Asher N	Pittsburg	Caney; Woodford	1	6144	34
Newfield Exploration	9/8/2007	Scipio NW	Pittsburg	Caney	1	5823	307
Newfield Exploration	9/22/2005	Sho-Vel-Tum	Stephens	Caney	1	2766	743
Newfield Exploration	11/14/2006	unnamed	Hughes	Caney; Woodford	1	6922	4662
Newfield Exploration	7/6/2008	unnamed	Hughes	Caney; Woodford	1	7633	2100
Newfield Exploration	3/3/2007	unnamed	Pittsburg	Caney	1	6286	824
Parsons Engineering	5/2/2006	Choska NW	Wagoner	Caney	1	1157	7
Pawnee Petroleum	12/26/1982	Bethel N	Seminole	Caney	1	3826	186
Pawnee Petroleum	2/4/1983	Bethel N	Seminole	Caney	1	3920	184
Porter Oil & Gas	8/11/2004	unnamed	McIntosh	Caney	2	3865	
R K R Exploration	12/10/2004	Carson	Hughes	Caney; Woodford	1	3902	165
Sedna Energy	12/17/2007	unnamed	Pittsburg	Caney; Woodford	1	11303	2586
Southstar Oil & Gas	3/26/2004	Dustin	Okfuskee	Caney	1	3338	40
Southstar Oil & Gsa	8/9/2004	Lyons-Quinn	Okfuskee	Caney	1	3520	120
Star Resources	12/6/2001	Overbrook S	Love	Caney	1	4471	180
Tack Operating	7/30/2004	Keefeton	Muskogee	Caney	1	2250	50
Thompson, Joe L.	7/6/2005	Sho-Vel-Tum	Stephens	Caney	1	2901	10
Williams Production	3/25/2005	Raiford N	McIntosh	Caney	1	4200	349
Williams Production	12/17/2005	Raiford SE	McIntosh	Caney	1	4356	200
Williams Production	5/12/2005	Stidham S	McIntosh	Caney	2	3905	450
Williams Production	7/22/2005	unnamed	McIntosh	Caney	2	4294	500
Williford Petroleum	2/10/1998	Sho-Vel-Tum	Stephens	Caney	1	2668	149

Source: Oklahoma Geological Society

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Fayetteville Shale B-43 Field

Operator	County	#Wells	Mo. Yr.	MCF
Chesapeake Operating Inc.	CLEBURNE	2	Nov-08	101,631
	CONWAY	5	Nov-08	166,849
	FAULKNER	18	Nov-08	591,762
	VAN BUREN	8	Nov-08	116,126
	WHITE	218	Nov-08	5,518,432
Edge Petroleum Operating Company, Inc.	WHITE	5	Nov-08	4,227
Hallwood Petroleum LLC	WHITE	16	Nov-08	119,278
Hawk Field Services, LLC	VAN BUREN	1	Nov-08	0
KCS Resources Inc.	CONWAY	1	Nov-08	7,084
	POPE	2	Nov-08	0
	VAN BUREN	36	Nov-08	975,214
L & L Energy Company, Inc.	WHITE	1	Nov-09	580
Lawco Exploration Inc.	JOHNSON	1	Nov-08	4,334
OneTEC Operating, LLC	CLEBURNE	6	Nov-08	47,961
	VAN BUREN	57	Nov-08	998,406
Penn Virginia MC Energy, LLC	POPE	5	Nov-09	26,048
Petrohawk Operating Company	CLEBURNE	5	Nov-08	83,822
	CONWAY	11	Nov-08	134,476
	FAULKNER	2	Nov-08	21,298
	VAN BUREN	36	Nov-08	1,049,579
Sedna Energy Inc.	POPE	1	Nov-08	1,533
SEECO, Inc.	CLEBURNE	22	Nov-08	693,859
	CONWAY	276	Nov-08	7,840,372
	FAULKNER	59	Nov-08	791,398
	FRANKLIN	10	Nov-08	12,938
	POPE	15	Nov-08	240,523
	VAN BUREN	256	Nov-08	6,919,198
	WHITE	78	Nov-08	1,711,896
SH Exploration, LLC	VAN BUREN	2	Nov-08	31,334
Storm Cat Energy (USA) Operating Corp.	VAN BUREN	9	Nov-08	90,297
XTO Energy, Inc.	CLEBURNE	11	Nov-08	36,893
	FAULKNER	2	Nov-08	37,628
	INDEPENDENCE	6	Nov-08	5,215
	JACKSON	3	Nov-08	25,878
	VAN BUREN	4	Nov-08	179,226
Yale Oil Association Inc.	WHITE	28	Nov-08	507,817
	CONWAY	1	Nov-08	664

Source: Arkansas Oil and Gas Commission 2/2/2009

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2008 Woodford Wells

Operator	Completion Date	Field Name	County	Shale Formation/ Member	#Wells	Depth	Initial Potential (MCFD)
Antero Resources	3/1/2008	Ashland S	Pittsburg	Woodford	1	9021	2778
	5/26/2008	Cabaniss NW	Pittsburg	Woodford	1	6967	1824
	2/10/2008	D&A	Coal	Woodford	1	8292	
	5/6/2008	McAlester E	Pittsburg	Woodford	1	9613	515
	1/31/2008	Mekko	Pittsburg	Woodford	1	9187	1523
	2/21/2008	Reams	Pittsburg	Woodford	1	8729	2380
	2/18/2008	Reams SE	Pittsburg	Woodford	2	8767	3357
	6/20/2008	unnamed	Atoka	Woodford	10	9506	375
	1/11/2008	unnamed	Coal	Woodford	6	7541	1853
	2/7/2008	unnamed	Pittsburg	Woodford	4	9405	2090
BNK Petroleum US	2/24/2008	unnamed	Johnston	Woodford	2	9072	1800
CBL Resources LLC	4/15/2008	Harrah E	Lincoln	Woodford	1	5605	200
Chesapeake Operating	6/12/2008	Arpelar N	Pittsburg	Woodford	1	6798	2010
	4/10/2008	Ashland	Pittsburg	Woodford	1	9642	3510
	3/6/2008	Ashland N	Hughes	Woodford	6	8029	3224
	10/3/2008	Ashland S	Pittsburg	Woodford	1	9489	3004
	3/25/2008	Coalgate NE	Coal	Woodford	2	10449	2553
	9/1/2008	Gerty E	Hughes	Woodford	1	7123	5520
	1/3/2008	Hill Top	Hughes	Woodford	4	6736	1437
	2/29/2008	Legal N	Hughes	Woodford	1	8177	2009
	1/31/2008	Pine Hollow S	Pittsburg	Woodford	1	7306	778
	4/3/2008	Springer	Carter	Woodford	1	6485	1866
	6/5/2008	Tandy E	Hughes	Woodford	1	6160	4296
	6/7/2008	unnamed	Coal	Woodford	1	11308	2615
	1/9/2008	unnamed	Pittsburg	Woodford	5	9450	2379
	5/29/2008	Ashland S	Coal	Woodford	1	8653	2330
	Cimarex Energy	1/7/2008	Ashland S	Pittsburg	Woodford	1	8990
2/7/2008		Watonga-Chickasha	Canadian	Woodford	4	12486	2760
3/20/2008		Calvin	Hughes	Woodford	2	5505	1387
Continental Resources	2/6/2008	Calvin N	Hughes	Woodford	1	5472	684
	4/3/2008	Citra	Hughes	Woodford	1	5609	588
	2/29/2008	Citra NE	Hughes	Woodford	2	5998	2007
	6/1/2008	Gerty West	Hughes	Woodford	1	6038	2443
	2/27/2008	Horns Corner	Hughes	Woodford	3	5082	214
	2/1/2008	unnamed	Hughes	Woodford	9	7625	5423
	4/5/2008	Allen	Hughes	Woodford	1	5363	42
Cornerstone E & P Company Coronado Great Plains	10/1/2008	Green NW	Mayes	Woodford	1	0526	2
	10/1/2008	Porter District	Wagoner	Woodford	1	1788	19
	10/1/2008	Porter SE	Wagoner	Woodford	5	1186	15
	10/1/2008	Tulahassee District	Wagoner	Woodford	35	0778	313
	10/1/2008	Wagoner District NW	Wagoner	Woodford	1	0820	10
	10/1/2008	Wagoner District SW	Wagoner	Woodford	2	0810	20
	2/21/2008	Ashland	Coal	Woodford	7	8252	1934
Devon Energy	4/16/2008	Calvin SE	Hughes	Woodford	1	7710	520
	5/10/2008	Chiles Dome	Coal	Woodford	1	7076	4253
	3/14/2008	Citra	Hughes	Woodford	1	5607	796
	3/4/2008	Gerty E	Hughes	Woodford	3	7055	395
	3/9/2008	Gerty N	Hughes	Woodford	1	5681	911
	1/2/2008	Iona NE	Coal	Woodford	1	6475	764
	9/7/2008	unnamed	Canadian	Woodford	1	12613	3660
	1/12/2008	unnamed	Coal	Woodford	10	6758	626
	1/9/2008	unnamed	Hughes	Woodford	6	7758	3503
	2/4/2008	Watonga-Chickasha	Canadian	Woodford	5	12702	3607
	2/21/2008	unnamed	Cleveland	Woodford	1	5643	20
GLB Exploration	2/22/2008	unnamed	Marshall	Woodford	1	7770	70
Judd Investment Company	4/16/2008	Fox-Graham	Carter	Woodford	1	5046	120
Newfield Exploration	1/15/2008	Ashland N	Hughes	Woodford	9	8083	2174
	2/7/2008	Gerty E	Hughes	Woodford	1	7036	3379
	4/30/2008	Hill Top	Hughes	Woodford	1	6518	2337
	5/17/2008	Hill Top SW	Hughes	Woodford	3	6817	1538
	2/20/2008	Pine Hollow S	Hughes	Woodford	3	7275	3114
	2/10/2008	Pine Hollow S	Pittsburg	Woodford	14	7351	1382
	2/24/2008	Stuart SW	Hughes	Woodford	1	6820	2660
1/9/2008	unnamed	Atoka	Woodford	1	12570	2395	

2008 Woodford Wells Continued

Operator	Completion Date	Field Name	County	Shale Formation/Member	#Wells	Depth	Initial Potential (MCFD)
Newfield Exploration	1/26/2008	unnamed	Coal	Woodford	2	6832	1651
	2/4/2008	unnamed	Hughes	Woodford	14	7270	1179
	1/25/2008	unnamed	Pittsburg	Woodford	2	12729	1628
Pablo Energy II LLC	9/6/2008	Wardville S	Atoka	Woodford	1	11780	6123
	5/10/2008	Centrahoma	Coal	Woodford	2	7204	3000
	7/20/2008	Coalgate	Coal	Woodford	2	6846	3700
	5/3/2008	Olney NE	Coal	Woodford	1	6621	2389
	1/31/2008	TA	Atoka	Woodford	1	7322	
Petroquest Energy	1/22/2008	unnamed	Atoka	Woodford	8	7097	759
	3/14/2008	Mekko	Pittsburg	Woodford	3	8308	4354
	1/23/2008	Pine Hollow S	Pittsburg	Woodford	6	8878	2099
	5/22/2008	Reams NW	Pittsburg	Woodford	2	8898	3134
	8/11/2008	Reams SE	Pittsburg	Woodford	1	7924	2125
Range Production	1/27/2008	unnamed	Marshall	Woodford	2	8005	103
Resource Development Tech	7/26/2008	Wagoner District NW	Wagoner	Woodford	1	0655	24
RKR Exploration	6/17/2008	Carson	Hughes	Woodford	1	4160	110
Short Oil	3/11/2008	Domes-Pond Creek	Osage	Woodford	1	2204	1
St. Mary Land & Exploration	3/3/2008	Centrahoma	Coal	Woodford	1	7610	636
	8/6/2008	Coalgate	Coal	Woodford	2	7583	2105
	1/3/2008	Coalgate N	Coal	Woodford	4	8662	1198
	3/10/2008	unnamed	Coal	Woodford	3	10475	1800
	9/10/2008	Baum N	Carter	Woodford	1	9523	738
Wagner & Brown	1/20/2008	unnamed	Marshall	Woodford	1	6169	781
Walter Oil & Gas	3/15/2008	unnamed	Wagoner	Woodford	1	1034	20
WCT Operating	7/29/2008	Wagoner District	Wagoner	Woodford	9	0982	85
	3/28/2008	Wagoner District NW	Wagoner	Woodford	19	0740	50
	4/22/2008	Wagoner District W	Wagoner	Woodford	2	0954	30
	6/2/2008	Watonga-Chickasha	Canadian	Woodford	1	12567	3066
Western Oil & Gas Develop XTO Energy	7/29/2008	Ashland S	Atoka	Woodford	1	11917	2050
	1/27/2008	Ashland S	Coal	Woodford	2	8781	1984
	1/16/2008	Ashland S	Pittsburg	Woodford	6	10180	3009
	6/21/2008	Cabaniss NW	Pittsburg	Woodford	1	7898	474
	7/7/2008	Hill Top N	Hughes	Woodford	1	6198	921
	3/30/2008	Pine Hollow S	Pittsburg	Woodford	3	8443	1509
	10/5/2008	Shady Grove SW	Hughes	Woodford	1	6268	1366
7/16/2008	unnamed	Pittsburg	Woodford	1	9526	350	

Source: Oklahoma Geological Society

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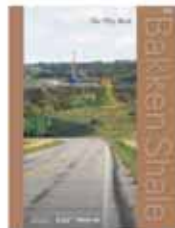
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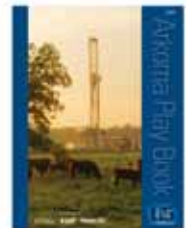
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