

HARTENERGY

# Permian Basin

*The 2013 Playbook - featuring Wolfcamp, Bone Spring and Cline*

A supplement to

Oil and Gas  
Investor

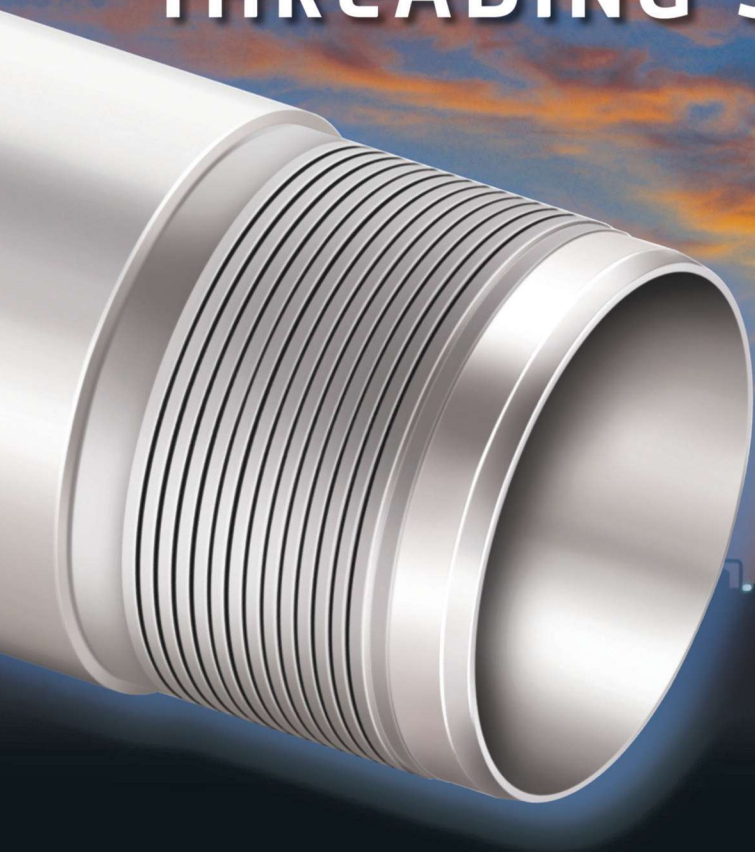
E&P

MIDSTREAM  
Business



*TUBULAR PRODUCTS & SERVICES ACROSS THE PERMIAN BASIN*

# PATRIOT PREMIUM THREADING SERVICES



Located in the heart of the Permian Basin, Patriot Premium Threading Services provides quality premium connections, repairs, accessories and rig site services. A U. S. Steel Tubular Products licensee, we offer full-length threading of USS-LIBERTY FJM™ premium connections as well as repair and accessory machining of other USS proprietary connections. Our state-of-the-art facility, local management team, short lead times and superior customer service help keep you on the job and turning to the right.

For more information or a quote call 432-250-6001 or visit [www.patriotthreading.com](http://www.patriotthreading.com) today.



*A joint venture with  
U. S. Steel Tubular Products*







## Permian Basin: The Playbook

A supplement to *Oil and Gas Investor, E&P,*  
and *Midstream Business*

### HART ENERGY

1616 S. Voss, Suite 1000 | Houston, Texas 77057

Tel: +1 (713) 260-6400 | Fax: +1 (713) 840-8585

[www.hartenergy.com](http://www.hartenergy.com)

Group Managing Editor **JO ANN DAVY**  
*E&P*

Editors **RHONDA DUEY**  
*E&P*

**LESLIE HAINES**  
*Oil and Gas Investor*

**PAUL HART**  
*Midstream Business*

Contributing Editors **RAPHAEL HUDSON**

**DON LYLE**

**GLENN R. MEYERS**

**JENNIFER PRESLEY**

**STEVE THORNHILL**

Associate Managing Editor **MARY HOGAN**

Assistant Editor **CODY ÖZCAN**

Corporate Art Director **ALEXA SANDERS**

Senior Graphic Designer **ROBERT D. AVILA**

Art Director

*Oil and Gas Investor* **MARC CONLY**

Production Director **JO LYNNE POOL**

Marketing Director **GREG SALERNO**

For additional copies of this publication,  
contact Customer Service +1 (713) 260-6442.

Group Publisher, *E&P* **RUSSELL LAAS**

Group Publisher  
*Oil and Gas Investor* **SHELLEY LAMB**

Group Publisher  
*Midstream Business* **DAVID PARKER**

Director of  
Business Development **ERIC ROTH**

## HART ENERGY

Editorial Director **PEGGY WILLIAMS**

President &

Chief Operating Officer **KEVIN F. HIGGINS**

Chief Executive Officer **RICHARD A. EICHLER**

## 2013 Unconventional Playbook Series

The Permian Basin Playbook is the 17<sup>th</sup> in Hart Energy's exclusive series of comprehensive reports delving into North America's most compelling unconventional resource plays. Our lineup of topics addresses the plays everyone is talking about and delivers answers to essential questions on reservoirs, active operators, economics, key technologies, and infrastructure issues. Some playbooks also feature a full-color map highlighting fields, drilling activity, and significant wells.

To learn more, visit [www.ugcenter.com/subscribe](http://www.ugcenter.com/subscribe)

# Table of Contents

## OVERVIEW The Prolific Permian Basin Still Pays

4

*Almost 100 years after an initial completion in Mitchell County, the West Texas giant continues to offer potential.*

## KEY PLAYERS Big Pay Attracts Big Money

18

*Multiple stacked pay zones featuring shale combinations promise long-life returns.*

## TECHNOLOGY Investigating New Tools, Technologies for the Permian Basin

60

*While challenges have driven some companies away from West Texas, others have found success through innovation.*

## MIDSTREAM Building, Rearranging, and Reconfiguring

88

*Midstream constraints have been causing bottlenecks in the Permian Basin oil transportation system recently, but a surge of new projects promises relief in short order.*

## ECONOMICS Oil, Oil Everywhere

94

*The Permian Basin offers a mélange of conventional, tight oil, and shale plays, and has a cast of operators to match. Here is a look at the economic underpinnings of the resource plays most popular today.*

## REFERENCES Additional Information on the Permian Basin

100

*For more details on the Permian Basin, consult the selected sources below.*

On the cover: A rig works one of LINN Energy's 400 oil-prone locations in the Wolfberry trend in the Midland Basin. (Photo courtesy of LINN Energy LLC)



# WORK SMARTER in Any Play

Magnum's complete line of composite frac plugs improve well completion economics in any downhole environment.

---

Magnum tools have been deployed across some of the nation's hottest shale plays, helping countless companies work smarter and maximize profits.

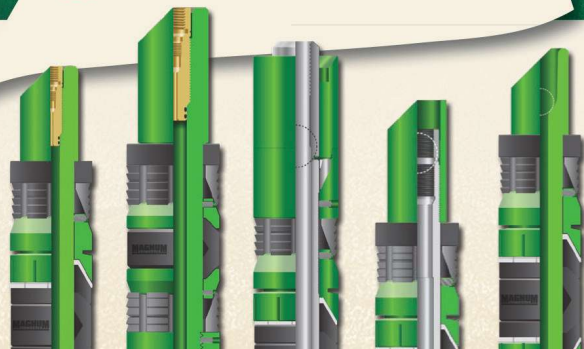
Better designs. Solid construction. Proven performance. Our completion tools make sense both at the wellsite and on the balance sheet.

Find out how Magnum Oil Tools can help you work smarter on your next well.

**[magnumoiltools.com](http://magnumoiltools.com)**

**361.299.6333**

*See the complete line  
at [magnumoiltools.com](http://magnumoiltools.com)*



★ WORK SMARTER ★



## WEB EXCLUSIVES

### MARKET DYNAMICS FAVOR PRIVATE INDEPENDENTS

Meanwhile, investors in offshore contractors are calling for a return of cash to shareholders in 2013.

[UGcenter.com](http://UGcenter.com)

### MACQUARIE: NATURAL GAS LIKELY A LOST CAUSE IN 2013

Oil may beat expectations, especially domestically, analyst says.

[UGcenter.com](http://UGcenter.com)

### OPERATORS ARE FINDING THE CLINE JUST FINE

One of the challenges surrounding how fast operators move in the Cline during 2013 stems from the abundance of Permian Basin horizontal opportunities competing for capital.

[UGcenter.com](http://UGcenter.com)

### BERNSTEIN RESEARCH: WELL-KNOWN RESOURCE PLAYS DOMINATE THE 'THOUSAND CLUB'

The Eagle Ford, Haynesville, Bakken and Marcellus plays are at the top of Bernstein's 2012 Thousand Club, which counts wells that have peak rates greater than 1,000 BOE per day.

[UGcenter.com](http://UGcenter.com)



## MOST READ ON THE WEB

1. Special Report:  
The Michigan Basin
2. Blue Racer Steps  
On The Gas
3. Dug East 2012: DUG  
Out With Ambridge
4. Market Dynamics  
Favor Private  
Independents
5. Devon Offers  
Permian Acreage

## SPECIAL REPORTS AND RESOURCES

### The Michigan Basin

The new Special Report on the Michigan Basin provides an in-depth look at the geologic elements of conventional and unconventional total petroleum systems from Ordovician- to Pennsylvanian-aged formations that produce oil and gas in central Michigan. [UGcenter.com/library/monthly/newsletters](http://UGcenter.com/library/monthly/newsletters)

### Top 12 I.P. Wells

Access information on the top producing wells in the major North American unconventional plays, including the Eagle Ford, Marcellus, the Bakken and more. The tables are broken down by play and include information on well location, production, operators and date of completion

[UGcenter.com/events/webinars](http://UGcenter.com/events/webinars)

### Rig Counts

Hart Energy's exclusive rig counts measure drilling intensity. Our counts exclude units classified as rigging up or rigging down, and also exclude rigs drilling injection wells, disposal wells or geothermal wells. The result is our most accurate assessment of rigs on location working on oil or gas programs as of the sample date. While our process results in a rig tally that is lower than the published numbers from the non-proprietary rig-tracking agencies, Hart Energy believes our product presents the most accurate picture of what is actually occurring in the field. [UGcenter.com](http://UGcenter.com)

## Full Access to Premium Content at UGcenter.com is available to Unconventional Gas Center subscribers.

Three convenient ways to become an Unconventional Gas Center subscriber:

- 1 Go to [UGcenter.com/subscribe](http://UGcenter.com/subscribe).
- 2 Complete and return one of the enclosed subscription cards in this publication.
- 3 Call Tim Kallmerten at +1 (713) 260-6413 or [tkallmerten@hartenergy.com](mailto:tkallmerten@hartenergy.com).



An Aermotor windmill stands ready on a Greenwood-area ranch outside of Midland, Texas. (Photo by Jennifer Presley)



# The Prolific Permian Basin Still Pays

Almost 100 years after an initial completion in Mitchell County, the West Texas giant continues to offer potential.

**By Steve Thornhill**  
Contributing Editor

**T**he West Texas Permian Basin covers an area about 300 miles long north to south and between 250 miles to 300 miles wide, or more than 86,000 sq miles. It includes 52 Texas and New Mexico counties. The oil industry got its start in the Permian Basin in 1921 with the completion of a 2,498-ft-deep well located in Mitchell County on the Permian Basin's east side. More discoveries quickly followed so that by the mid-1920s the Permian Basin drilling boom was well under way. Today the Permian Basin is responsible for approximately 17% of the total US petroleum production.

While the oil industry and America are excited about the potential of the current shale gas/oil plays, the producing formations are not new to geologists. Geologists have been aware of them for decades. They are a basic part of the standard petroleum system. There have been a number of "petroleum systems" proposed over the years; they all have these three major lithologic components:

- A petroleum source rock, often an organic-rich shale, which is the petroleum system's hydrocarbon source. However, it does not have to be shale. Source rock can be any number of rock types including shale, mudstone, limestone, or siltstone, and the list goes on. The actual lithology does not matter as much as the fact that it is rich in organic matter and has been buried to a sufficient depth, heat, and pressure to generate mobile hydrocarbons. The one thing that all source rock has in common is that it was typically deposited

in a low oxygen (hypoxic or dysoxic) or an oxygen-free (anoxic) freshwater or saltwater basin environment;

- A petroleum reservoir rock, typically a porous clastic or carbonate rock with sufficient permeability to allow hydrocarbons contained in the rock to readily flow through the rock to the wellbore; and
- A petroleum reservoir seal rock, normally a low porosity/permeability rock such as shale, overlying the petroleum reservoir, entrapping the hydrocarbons within the reservoir rock. Quite often, such as with the Eagle Ford Shale and Woodbine sandstone duo, the Eagle Ford Shale overlying the Woodbine sandstone is not only the reservoir seal; it is also the reservoir source rock.

Given the right source rock lithology combined with accurate horizontal drilling via geosteering and modern hydraulic fracturing, oilmen are finally able to coax economic hydrocarbon riches from this long-known resource.

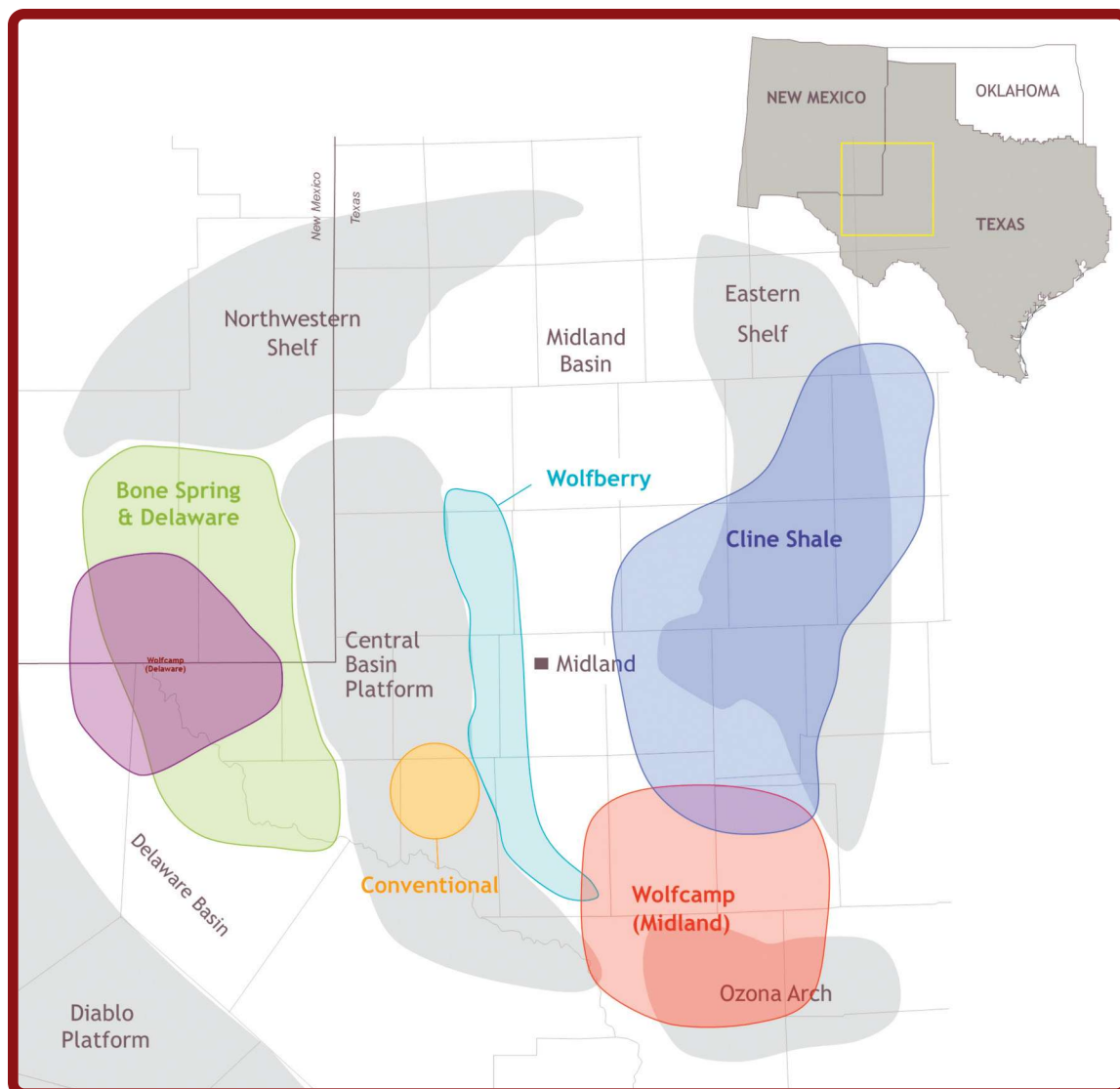
This report will focus on the Cline, Wolfcamp, and Bone Spring shale plays, although the Permian Basin is an outstanding petroleum province comprising much more than just these three plays – a whole lot more.

## In the beginning

At the end of the Upper Paleozoic Mississippian Period (325 million years ago), the North American land mass, part of an early supercontinent known as Euramerica, was located just below the

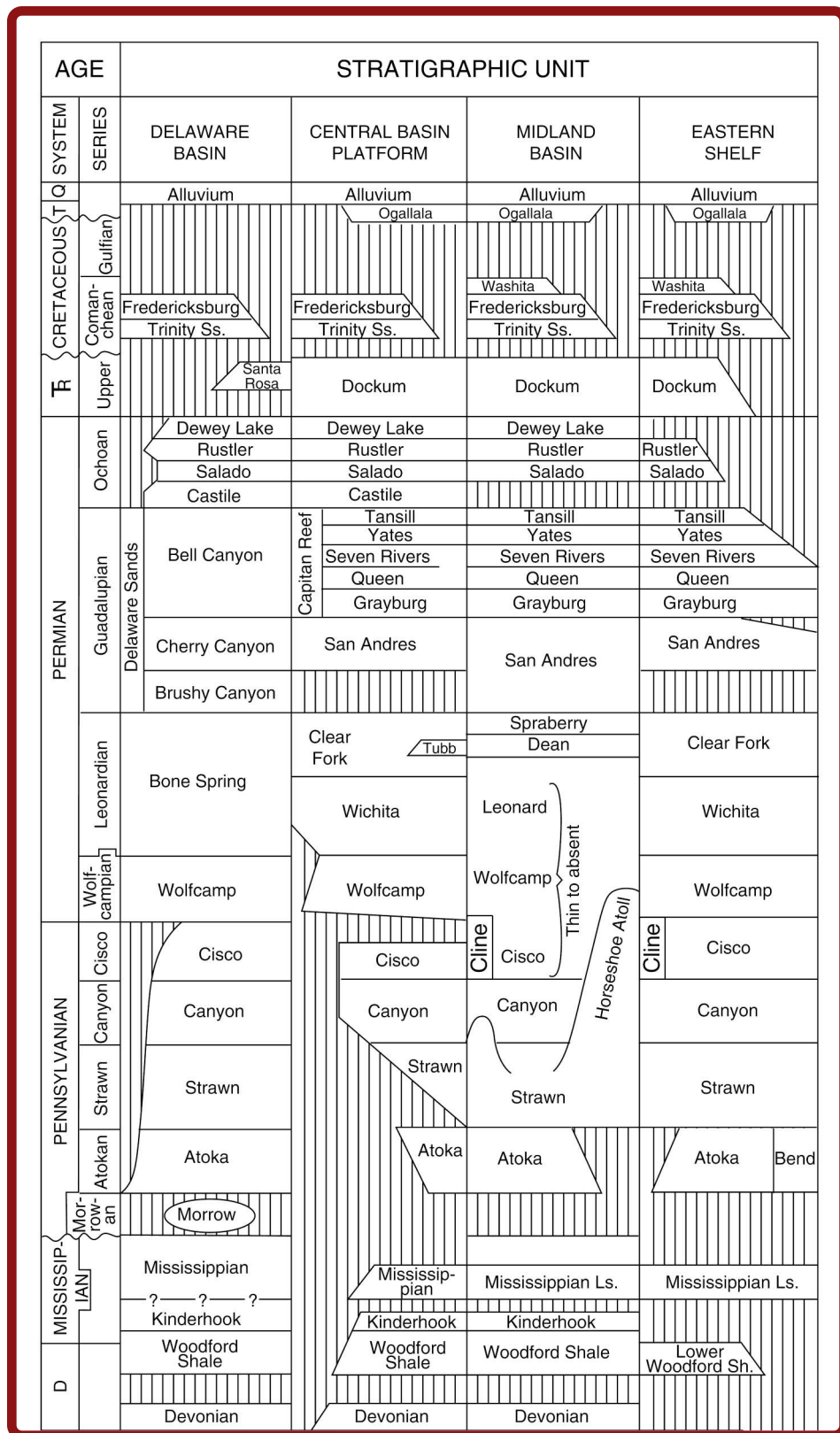
equator. Paleozoic strata making up today's Permian Basin, mainly carbonates, were being deposited on the western coast of Euramerica on a broad shallow continental shelf. The shelf had a slowly subsiding area that geologists named the Tobosa Basin. This early basinal area was not tectonically active. However, it had a central basin high area and underwent several periods of sub-aerial exposure and erosion, between periods of submergence and renewed deposition. These sub-aerial exposure periods were due to global sea-level fluctuations caused by continental glaciation. Another supercontinent, Gondwana,

was located in the South Pole region, and during this period it became a platform for numerous continental glaciation episodes resulting in many significant sea-level changes. This movement caused the subsequent Tobosa Basin erosion and deposition. As time marched forward 25 million years through the Pennsylvanian Period, plate tectonics caused Gondwana to break apart into many of today's continental landmasses. The South American and African plates separated from Gondwana, moving northward toward the North American Plate section of Euramerica. This movement caused the broad continental shelf



The petroleum-rich Permian Basin in West Texas and southeastern New Mexico includes the Wolfcamp, Bone Spring, and Cline plays, among others. *(Used with permission from Devon Energy)*





and the Tobosa Basin to buckle, retiring the Tobosa Basin and causing the Permian Basin to form in its place. As plate movement continued, the Permian Basin buckled further into three smaller basins, the Delaware Basin, the adjoining Midland Basin, and the southeast Val Verde Basin. In between the Delaware and Midland Basins, tectonic uplift was forming the Central Basin Platform, while north of the three basins was the Matador Uplift and Northwestern Shelf, a less tectonically involved area remaining from the earlier Tobosa Basin. West of the Delaware Basin was the Diablo Platform. South of the Permian Basin the collision between the South American and African plates with the North American Plate created the Marathon-Ouachita Fold Belt.

Mountain rain shadows blocking precipitation were formed, causing desertification in adjoining land areas. Because there was only sparse rainfall, much of the basin's sand, silt, and shale (clastic) deposition was from wind-blown or eolian sources. In addition, surficial erosion from infrequent rains falling on nearby uplifted areas supplied a limited amount of clastic and redeposited carbonate sediments as well. This lack of clastic sediment deposition allowed the building of vast carbonate reef systems. The oldest oil play focused on in this report, the Cline Formation, was deposited during the Late Pennsylvanian Period.

By the beginning of the Upper Paleozoic Early Permian Period,

Stratigraphic columns describe the extensive Permian Basin. (Source: modified from M.M. Ball, 1995, USGS)



# Stinger

CONICAL DIAMOND ELEMENT



## Beyond shear-based cutting performance— Unique, central conical element increases ROP.

Cutters on conventional PDC bits shear rock at the center of a borehole inefficiently at low velocities, thereby limiting ROP and introducing unwanted drilling vibration. The Stinger conical diamond element is a unique cutting enhancement at the center of the bit that significantly increases drilling efficiency. Using a PDC bit with a Stinger element to drill in the hard and abrasive formations of the Bakken basin, one customer increased average ROP 46%.

Find out more at  
[slb.com/Stinger](http://slb.com/Stinger)

**SMITH BITS**  
A Schlumberger Company



tectonic activities were ending with the continued thrusting of the Marathon-Ouachita Fold Belt forming the Marathon Mountains located adjacent to and south of the Delaware Basin. The Wolfcamp and Bone Spring formations were deposited during the early to middle Permian Period. By mid-Permian the area had become tectonically inactive, with periodic sea-level changes, probably from polar glaciation, continuing to cause alternating periods of subaerial erosion and deposition. From the late Permian through the Triassic, the Permian Basin slowly filled with sediments and its seawater sources became cut off. The remaining basinal seawater, as well as periodic seawater replenishments from sea-level highstand periods, evaporated leaving vast evaporite deposits. Ultimately, the sediment-starved basins gradually filled with carbonate, evaporate, and red bed clastic sediments.

The Mesozoic Era from the Jurassic through the Cretaceous was a period of global tectonic change, the ancestral Gulf of Mexico was formed and with it the Tethys Seaway opened up between the North American Plate and the South American and African Plates. However, the Permian Basin remained inactive becoming a broad continental shelf with no additional tectonic uplift or subsidence.

### **Sub-basins and platforms: Midland and Delaware basins**

The Midland Basin covers an area approximately 240 miles north to south and 90 miles wide. The basin subsided at a vastly different rate from east to west with more subsidence occurring in the southwestern basin area. Because of the differing east to west subsidence rates, the Midland Basin is an asymmetrical basin that deepens to the west and southwest with complex folds and faults along its arbitrary eastern boundary. The Midland Basin did not have nearly as much tectonic subsidence as did the Delaware Basin to the west.

The Delaware Basin covers an area approximately 200 miles north to south and 100 miles wide. With a sedimentary thickness of over 30,000 ft, of which 20,000 ft were Pennsylvanian and Permian sediments, the Delaware Basin has the

deepest and thickest sedimentary deposits of the two sub-basins.

Throughout the Permian Basin carbonate reef deposition predominates on the shelf edges surrounding the deep basins. During the late Pennsylvanian and Permian periods the deeper basinal areas became stagnant and hypoxic or anoxic. Much of the sedimentary deposition during this period was organic-rich lime mud redeposited from shallow water shelf reef systems. While the Midland and Delaware basins underwent active subsidence during the Pennsylvanian and Permian periods, the Central Basin Platform, located between the two basins, was uplifted thousands of feet above sea level. As a result of this uplift and subsequent erosion, numerous sand and silt layers were deposited across the basins. Since much of the uplifted strata was carbonate rock, a good deal of carbonate sediments were eroded, carried basin-ward by clastic debris flows, distributary channels, and finally redeposited in the deep basins. Active subsidence caused the Delaware Basin to reach a water depth of 1,500 ft; the Midland Basin water depth is thought to have been shallower. Algae and planktonic organisms thrived in the shallower depths of the two basins, creating a constant rain of organic detritus into the deeper hypoxic and anoxic basin areas. The lack of deep basin oxygen caused the organic material to be preserved in the bottom sediments.

Clastic debris from nearby mountainous areas around the Delaware Basin and the Central Basin Platform between the Delaware and Midland Basins was carried out onto the basins edges through near shore channels, building arkosic clastic sediment platforms out into the deeper basin areas. When a channel would become abandoned limestone reefs would form over the remaining platform. In many shelf edge areas the clastic platforms became unstable with the weight of the overlying reef, causing the underlying platform to fail and slump, dropping the overlying platform and reef down-slope into the deep basin. Because the eastern edge of the Midland Basin was not undergoing the rapid subsidence like the western side of the basin, and there weren't the mountainous sediment sources, the eastern side of the Midland Basin had a greater amount of reef building extending out into the basin.

# \$58,000,000 and 755 days of rig time saved in unconventional plays

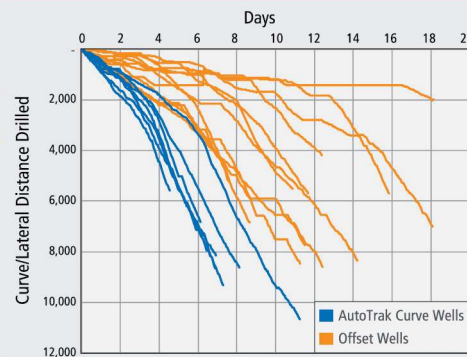
On recent Marcellus shale wells, the AutoTrak Curve system outpaced the field's average drilling time by six days.


## The AutoTrak™ Curve system drills 3 million feet in 22 months... and keeps on drilling.

Save time and money on unconventional wells by safely and efficiently kicking off from vertical and drilling a high buildup curve and the lateral section in one smooth, fast run.

Maximize ultimate reserve recovery by exposing more of the reservoir with a rotary steerable system with a build-rate of 15°/100 ft (30.48 m). Three-pad steering capabilities keep the well in the target payzone and deliver a smooth, high-quality wellbore.

*Advancing Reservoir Performance.*



 [bakerhughes.com/autotrakcurve](http://bakerhughes.com/autotrakcurve)



### Val Verde Basin

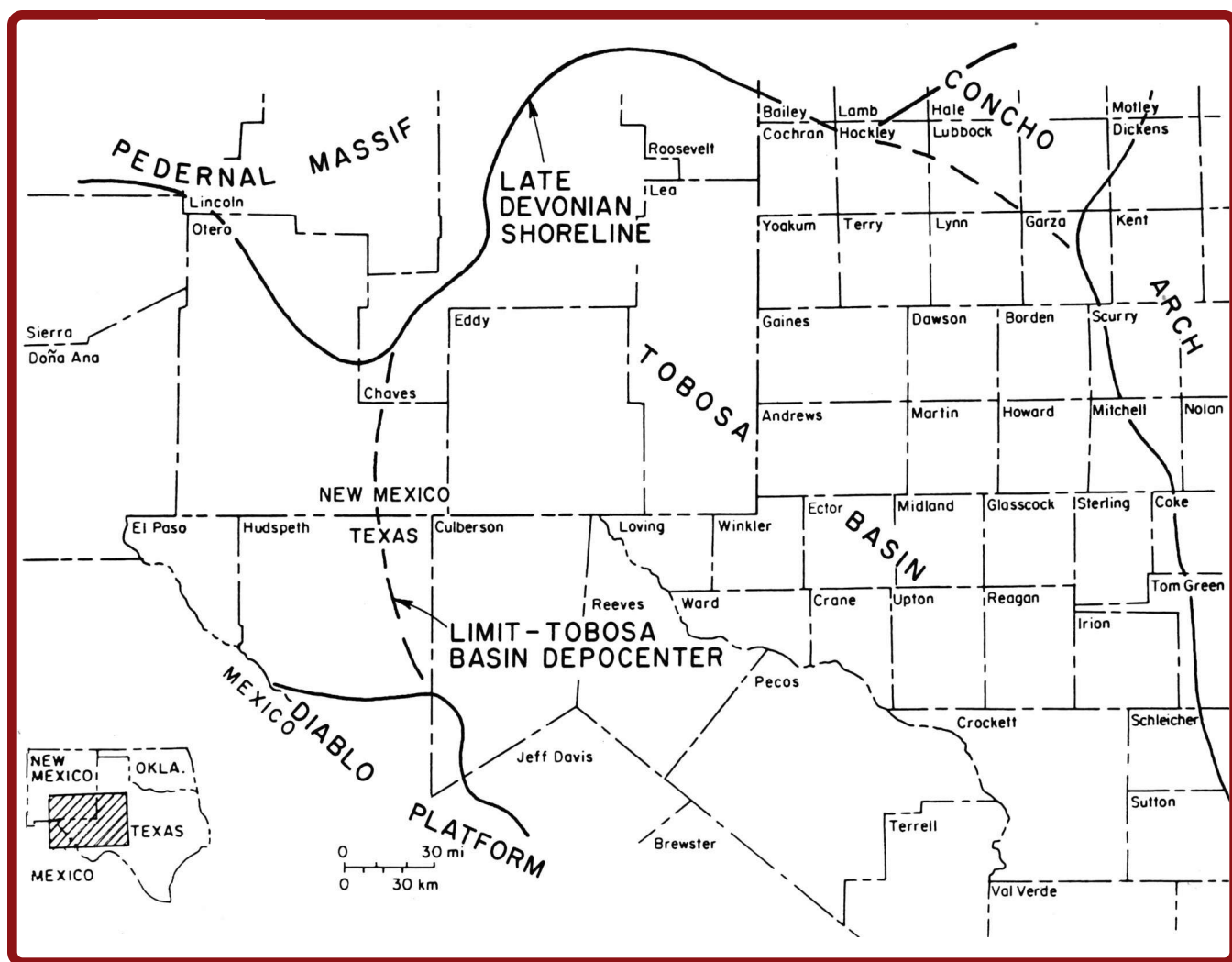
The Val Verde Basin is the smallest of the Permian Basin sub-basins. The Val Verde Basin is an extension of the Delaware and Midland basins that was separated by a small tectonic uplift called the Ozona Arch. The basin is a late Paleozoic foredeep basin formed in front of the Marathon-Ouachita Fold Belt. The southern Val Verde Basin shelf is filled with more than 15,000 ft of granite wash and related arkosic clastic sediments shed from the adjacent Marathon Mountains created by the advancing South American and African plates.

As in both of the Delaware and Midland basins, carbonate sediments predominate. Depo-

sition and organic sediment preservation in the hypoxic/anoxic Val Verde Basin depths is similar to that in the Delaware and Midland basins.

### Central Basin Platform

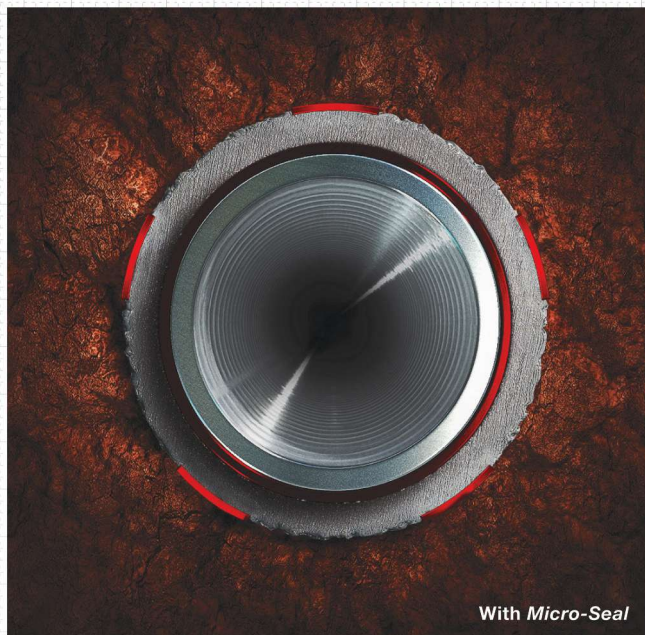
The Central Basin Platform, positioned between the Delaware and Midland basins, is the location of some of the most prolific oil fields in the US. This platform represents an area that was being uplifted as the Midland and Delaware basins on either side were subsiding. Huge nearly vertical faults with throws in excess of 1,000 ft bounded the Central Basin Platform on either side. In addition, geologists have found evidence of strike-



The Tobosa Basin (Source: with modifications; Comer, J. B., 1991, *Stratigraphic analysis of the Upper Devonian Woodford Formation, Permian Basin, West Texas and southeastern New Mexico: The University of Texas at Austin, Bureau of Economic Geology Report of Investigations No. 201, 63 p. + 7 plates in pocket.*)

# Channel Zero

Get zero gas channeling and avoid annular pressure with one-of-a-kind swellable isolation technology



Weatherford offers the world's only centralizers that integrate swellable technology. With over 1,000 runs, **Micro-Seal™ systems** are economical, simple solutions for improving wellbore isolation and overall well integrity. The elements conform to annular irregularities to seal against microannulus pressure between the casing string and the cement sheath.

For applications that require zonal isolation, our **high-strength packers** offer the reliability and cost benefits of conventional swellable packers with the advantages of customized swelling performance and a unique extrusion-control back-up system to achieve high differential pressures with shorter packer elements.

All of our swellable isolation technologies are designed with one of Weatherford's standard oil or water swell elastomers or our proprietary hybrid blends which have the unique capability to expand in oil, water or both. We call it applied versatility. You'll call it well worth it. Contact your Weatherford representative or visit [weatherford.com/micro-seal](http://weatherford.com/micro-seal).



[weatherford.com](http://weatherford.com)



slip faulting as well. Because this area was uplifted above sea level, it was subject not only to surface erosion, but much of the areas limestone layers became karsted as well as dolomitized. Cavernous porosity is not uncommon in conventional Central Basin Platform oil fields.

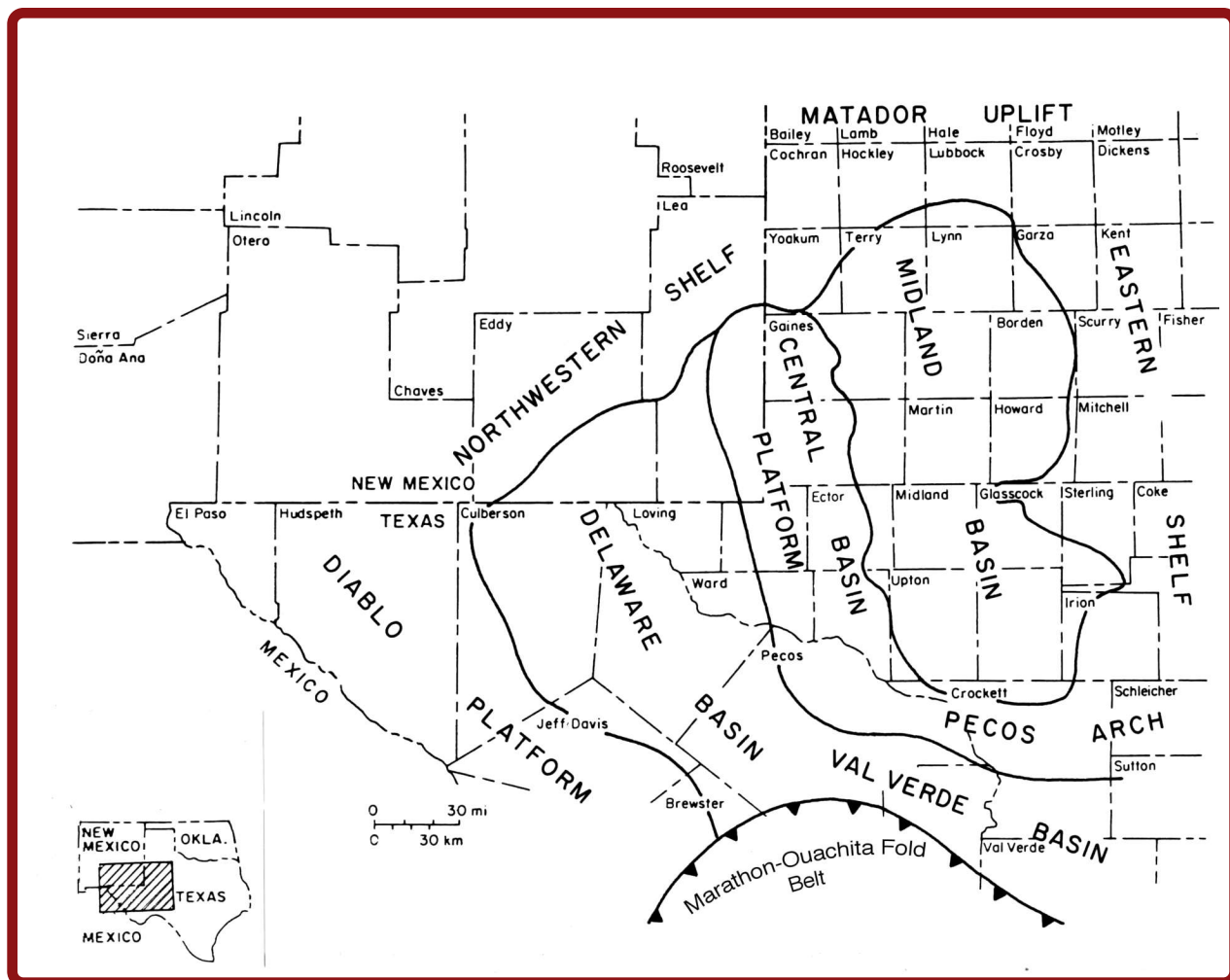
### Northwest and Eastern shelves

The Northwest and Eastern shelves are remnants of the former pre-Pennsylvanian Tobosa Basin. Because these areas were without subsidence or uplift they were subject to periodic erosion and redeposition as the late Paleozoic sea levels changed due to periodic continental polar glaciation occurrences.

### The Midland Basin Cline (Canyon/Cisco) – Late Pennsylvanian

The Midland Basin Cline Formation also is called the Canyon/Cisco formations, not only in the Midland Basin, but in other Permian Basin areas as well. Though listed as late Pennsylvanian, the Cline Formation is thought by some researchers to be a lower part of the Permian age Wolfcamp Formation. The Cline Formation is found in an area that is approximately 140 miles north to south and 70 miles wide, located east of Midland along the eastern flank of the Midland Basin and on the Eastern Shelf at depths of around 9,000 ft or more.

Underlying the Permian age Wolfcamp Formation, the Cline Formation was deposited dur-



The Permian Basin (Source: with modifications; Comer, J. B., 1991, *Stratigraphic analysis of the Upper Devonian Woodford Formation, Permian Basin, West Texas and southeastern New Mexico: The University of Texas at Austin, Bureau of Economic Geology Report of Investigations No. 201, 63 p. + 7 plates in pocket.*)



# Fracturing

## With Purpose



## Experienced Innovative Horizontal Hydraulic Fracturing

### Fracturing Cementing Acidizing

*Hydraulic Fracturing is a large investment. We strive to provide you the best return on this investment by being safe, timely, innovative, and cost-effective.*

*Our local knowledge & experience allow us to overcome the many challenges our customers face, such as logistics, water quality and green additives.*

*Let's work together to maximize your hydrocarbon production.*

Director of Sales  
Jeff Wilkinson  
817.688.8738  
Jeff.Wilkinson@univpp.com

West Texas - Midland  
Mark Acklin, Sales Manager  
432.238.6880  
Mark.Acklin@univpp.com

North Texas & South Texas  
Harry Littleton, Sales Manager  
940.389.4999  
Harry.Littleton@univpp.com





ing a marine transgressive phase. Because much of the Permian Basin was in a subsidence phase, and with the generally elevated sea levels, the deeper basin areas received little clastic sediment during this time. Because of changing sea levels, dominated by overall high sea levels and the ongoing eastern basin downwarping, carbonate reef development was hampered and subject to backstepping creating many small platforms as the eastern Midland Basin continued to warp downward. Cline sediment deposition was made up of grain-dominated, multilithological, organic-rich source rocks consisting of redeposited carbonates interspersed with sand, silt, and shale (siliclastic) layers. Siliclastic sediments in the northern and eastern Midland Basin probably originated from the Llano and Matador Uplifts located to the northeast and east respectively. Siliclastic sedimentation tended to dominate the Midland Basin's Eastern Shelf except along the basin margins where carbonate reefs formed. In general, the Cline Formation is from 200 ft to 350 ft thick, with 8% to 12% porosity and 2% to 8% total organic hydrocarbons (TOC). Horizontal wells completed in the Cline Shale have been attaining a 30-day initial production (IP) of 575 boe/d with 75% lightweight 38° to 42° API oil. The Cline Shale has a pressure gradient of 0.55 to 0.65 psi/ft and an Ro of 0.85% to 1.1%.

### **The Delaware Basin Wolfcamp – Early Permian**

Even though the Wolfcamp Formation is found throughout the Permian Basin, the significance of the Wolfcamp in the Delaware Basin is its thickness. While the Central Basin Platform uplift was taking place the adjoining Delaware Basin was rapidly subsiding. This rapid subsidence resulted in large sediment buildup. The Delaware Basin Wolfcamp Formation alone achieved thicknesses in excess of 2,000 ft. The Delaware Basin Wolfcamp is a carbonate-rich multilithological source rock. While much of the siliclastic sediments supplied to the formation arrived from windblown sources and erosion of nearby uplifted areas, much of the carbonate sediments were eroded from adjacent uplifted shelf and platform areas and redeposited in the deep

basin. In addition, as sediments accumulated along the basin margins, they formed clastic platforms. Carbonate reefs formed on top of the clastic platforms. The weight of the overlying reefs often destabilized the underlying clastic sediments, resulting in structural failure with the clastic sediments and overlying reefs slumping into the deeper basin. Submarine fans and basin bottom turbidite flows carried the sediments into deeper basin areas. While surface waters were well oxygenated and rich in algae and bacteria, the basin bottom was hypoxic or anoxic. This lack of oxygen preserved organic debris raining into the basin from shallower depths. The Delaware Basin Wolfcamp is divided into upper and lower zones and is found at subsurface depths from 11,000 ft to 12,000 ft. The complete Delaware Basin Wolfcamp Formation is approximately 2,000 ft thick, with the oilier upper zone being 1,000 ft thick. The Delaware Basin Wolfcamp Formation is overpressured. Hydrocarbons produced from the Wolfcamp tend to be consistent across the Delaware Basin with 60% crude, 20% NGL, and 20% dry gas. Delaware Basin operators have been comingling the Wolfcamp with the overlying Bone Spring Formation; the result is the Wolfbone play. The Wolfbone, at a depth of approximately 11,000 ft, is a vertical well play that simultaneously produces both the Wolfcamp and the overlying Bone Spring Formation. The Wolfbone is composed mainly of quartz and carbonate sediments, with very little clay, and has a completion zone thickness of approximately 1,250 ft, 2% to 5% TOC, and a reservoir pressure gradient of 0.7 psi/ft.

### **The Midland Basin Wolfcamp**

While the Central Basin Platform uplift was taking place the adjoining Midland Basin, like the nearby Delaware Basin, was subsiding – but at not nearly as high a rate. However, this subsidence did result in sediment buildup. The Midland Basin Wolfcamp Formation achieved thicknesses of 1,000 ft. Like the Delaware Basin Wolfcamp, it is a carbonate-rich multilithological source rock, having much the same sedimentary history as the Delaware Basin Wolfcamp, with clastic and redeposited carbonate erosional sediments, supplemented by windblown sediments.

# MADE FROM THE GREENEST STUFF ON EARTH

Many of you have experienced outstanding production results through the use of Flotek's Complex nano-Fluid™ technology in your hydraulic fracturing operations.

You may have recognized the benefits that **CnF**® fracturing additives provide including lower surface tension, lower interfacial tension, lower adhesion properties, better fluid mobility, increased flowback recovery and better productivity.

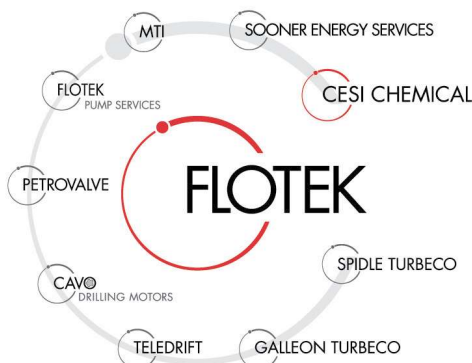
But have you seen what our citrus-based, environmentally friendly **CnF**® fluids do not include?

Here's a short list of what is NOT in Flotek's **CnF**® fluids:

- No Persistent Bioaccumulative Toxic agents (PBT) per EPA
- No Safe Drinking Water Act Regulated Contaminants
- No Clean Water Act Priority Pollutants
- No Hazardous Air Pollutants
- No Halogenated Compounds
- No Carcinogens, Mutagens, and Teratogens
- No Reportable Quantity (RQ) chemicals per SARA Section 304
- No SARA Section 313, Toxic Release Inventory (TRI) Chemicals
- No Extremely Hazardous Substances per SARA Section 302
- No Clean Air Act, Section 112(r), Risk Management Program (RMP) Chemicals
- No OSHA Highly Hazardous Chemicals, Process Safety Management (PSM) Chemicals
- No OSHA Toxic Air Contaminant Chemicals
- No Department of Homeland Security (DHS) Chemicals of Interest
- No Petroleum Products per EPA Oil Pollution Act
- No BTEX
- No diesels, kerosene, mineral oils or petroleum distillates



**"NO" can be a good thing...**



For more information contact  
[cesimkt@flotekind.com](mailto:cesimkt@flotekind.com)  
or call  
832-308-CESI (2374)



As in the Delaware Basin, carbonate reefs formed on top of the clastic platforms with the same result: structural failure with the clastic sediments and overlying reefs slumping into the deeper basin with sediments carried into deeper basin areas via submarine fans and turbidite flows. Like the Delaware Basin the waters at the basin floor were hypoxic or anoxic, preserving organic debris that rained onto the deep basin floor from shallower depths. The Wolfcamp Formation in the northern Midland Basin is generally found from 7,700 ft to 9,800 ft in depth. The southern Midland Basin Wolfcamp play, at depths from 9,500 ft to 11,700 ft, is a horizontal play. The southern Midland Basin Wolfcamp is a brittle rock with equal amounts of silica and carbonate. It has a thickness of approximately 1,000 ft, with 9.4% to 12% porosity, 4% to 8.2% TOC, an Ro of 0.7% to 0.9%, and a reservoir pressure gradient from 0.46 psi/ft to 0.52 psi/ft. In the northern Midland Basin operators are comingling the overlying Spraberry Formation with the Wolfcamp. The resulting Wolfberry play, at depths from 9,500 ft to 9,800 ft, is a vertical well play that produces simultaneously from both the Wolfcamp and the overlying Spraberry Formation. The Midland Basin Spraberry is equivalent to the Delaware Basin Bone Spring Formation.

### **The Val Verde Basin Wolfcamp**

The Val Verde Basin formed when tectonic thrusting from the adjoining Marathon-Ouachita Thrust Belt caused the Ozona Arch uplift on the south end of the Midland Basin, separating the Val Verde Basin from the Midland Basin to the north. Though a relatively small basin, the Val Verde Basin received huge amounts of sediment, much of which can be loosely classified as arkosic granite wash, from the adjacent Marathon Mountains, formed by the thrust belt. The Wolfcamp Formation is present in the northwest portion of the Val Verde Basin, adjacent to the bottom end of the Central Basin Platform. Wolfcamp gas production in the Val Verde Basin typically is obtained from horizontal wells at depths of approximately 9,000 ft.

### **The Delaware Basin Bone Spring (Spraberry) – Lower to Middle Permian**

The Bone Spring Formation, located just above the Wolfcamp Formation with a similar depositional history, is a multilithological source rock unit made up of brownish gray, crystalline limestone, interspersed with dark brown to black shale, dark brown limestone, and brownish gray fine-grained sandstone. The Bone Spring Formation comprises the first, second, and third Bone Spring members. The formation is encountered in the Delaware Basin at depths from 6,000 ft to 13,000 ft with the formation becoming deeper toward the basin's south end. The entire formation is approximately 2,500 ft to 3,500 ft thick.

The Bone Spring play is a horizontal play with most attention being given to the second and third members. However, some operators have been drilling what they call the Leonard Shale, which is a combination of the first Bone Spring member and the overlying Avalon Shale. Many consider the Avalon Shale as the top member of the Bone Spring Formation. Porosities in the Avalon and Bone Spring formations are between 7% and 18% with permeabilities in the 0.5 md to 7.2 md range. The lower third Bone Spring member is overpressured. Recent research has determined that the Bone Spring Formation has a TOC of 4% to 10%, Type II kerogen, and an Ro of 1.1%. Hydrocarbons produced from the Bone Spring are comparable to the underlying Wolfcamp and consistent across the trend with 60% crude, 20% NGL, and 20% dry gas. Several sweet spots were reported in the Bone Spring with 30-day IP averages of 500 boe/d to 700 boe/d.

In summary, today's mature Permian Basin remains a geological bonanza for the creative petroleum geologist. Not only are there significant new hydrocarbons yet to be found, both in conventional and unconventional plays, but the Permian Basin offers a plethora of opportunities for creative secondary and tertiary recovery opportunities as well. Indeed, much of today's worldwide secondary and tertiary recovery understanding comes directly from earlier lessons learned in the Permian Basin. ■

*References available.*

# NABORS COMPLETION & PRODUCTION SERVICES



## Meeting All Your Permian Basin Servicing Needs

Nabors provides wellsite manufacturing from construction to completion, offering unparalleled service throughout the life of your well. Our commitment to safety, efficiency, versatility, and environmentally friendly quality is what you have come to expect.

Our completion services include pressure pumping equipment for hydraulic fracturing, acidizing, and cementing; mobile coiled tubing for well intervention; wireline formation evaluation and logging; and tubing-conveyed perforating.

Our production services include manufacturing, hauling, transport, transfer, storage, and disposal of various completion fluids. Our workover and well servicing rigs provide for routine repair and maintenance, recompletion, redrilling, and plugging and abandonment.





# Big Pay Attracts Big Money

Multiple stacked pay zones featuring shale combinations promise long-life returns.

**By Don Lyle**  
Contributing Editor

**O**ily shales and shale combinations draw record rig activity, big lease bids, and high production opportunities to the Delaware and Midland basin segments of the Permian Basin.

The Avalon, Cline, and, in some places, Wolfcamp shales offer growing opportunities for profit, particularly when the Wolfcamp combines with conventional formations to provide Wolfberry (Wolfcamp, Dean, Spraberry), Wolfbone (Wolfcamp, Bone Spring) and Wolffork (Wolfcamp, Clearfork) blanket pay zones across wide areas of the Permian Basin.

Approach Resources drew publicity to the Wolfcamp when it described a 1,200-ft thick pay zone and recommended adding the Clearfork for 2,500 ft of potential pay in the Midland Basin.

Cimarex paid \$5,586 an acre for a tract in Ward County in the Delaware Basin at the July 2012 Texas Land Office sale.

Rig activity in the basin topped 500 according to a May 2012 Concho Resources report, a higher rig count than the previous peak in the oil boom of the 1980s.

Estimated ultimate recoveries from a Wolfcamp horizontal well with a 7,000-ft lateral have been calculated as high as 500,000 boe.

Those figures have tempted international players, including BHP Billiton Petroleum and Sumitomo Corp., to invest in Permian Basin unconventional plays, and they have provided a sharp boost in potential profits for independents with land held by production in the basin.

This compilation of profiles of companies working the unconventional zones of the Permian Basin attempts to catalog the larger and more significant operators in the area and to outline the reasons they like their positions in this growing oily resource.

## Key Players



### **Abraxas Petroleum Corp.**

- *Land: 41,131 net acres*
- *Permian rates minor emphasis*

Abraxas Petroleum Corp. ranks its Permian Basin properties below the Williston, Maverick, and Powder River basins, but company executives like their Permian leases.

In a November 2012 presentation, the company said the Bakken/Three Forks play in the Williston Basin, with one working rig, and the Eagle Ford Shale in South Texas, with 10 rigs at work, offer its highest returns and rate the highest investment.

It holds both conventional and unconventional properties in the Permian Basin, with conventional production led by its Spires Ranch

horizontal Strawn wells and dry gas wells in the Delaware Basin. Approximately 29% of its 30.8 MMboe in proved reserves and 4,170 boe/d of production come from the Permian Basin.

The company's holdings in the Midland Basin and Eastern Shelf offer stacked pay zones and potential for production from Wolfcamp and Cline shales, and the Delaware Basin gives the company access to Bone Spring and Wolfcamp production.

An acquisition in Ward County, Texas, gave the company 1.44 MMcf/d of gas production and 7.6 Bcf of gas reserves along with exposure to emerging unconventional horizontal plays in that section of the Permian Basin.

Its leases include unconventional properties in the Wolfberry trend, the Wolfbone, and the Barnett and Woodford shales.

Abraxas planned three net wells in the Permian Basin during 2012 at a cost of \$6.3 million and another 1.9 net wells in 2013 at a cost of \$7 million.

It has logged shales at its Spires Ranch leases in Nolan County but is watching industry activity in that area and around the Millican Reef play in Coke County.

### **American Standard Energy Corp.**

- *Land: 29,000 net acres*
- *Recent wells target Wolffork*

American Standard Energy Corp. actively works unconventional resources in the Permian Basin and counts the basin as a key area along with the Bakken/Three Forks combination in the Williston Basin and the Eagle Ford Shale in South Texas.

The company drilled five net wells in Crockett and Schleicher counties in Texas to the Wolfcamp and Clearfork zones in 2Q 2012. Overall, according to an April 2012 presentation, it holds 38,800 gross (29,000 net) acres in the basin with operations focuses on the Wolfcamp, Wolfberry, and Wolffork plays. It has properties in Lea County, N.M., and in the Yoakum, Gaines, Andrews, Borden, Scurry, Midland, Glasscock, Upton, Reagan, Crockett, and Schleicher counties of Texas.

It owns 226 gross (182.8 net) wells, and it plans to drill and operate its properties through other operating companies.

Among its properties with unconventional prospects are 2,500 net acres with 25.4 net locations in Upton County, 500 net acres with 4.8 net locations in Reagan County, 3,700 net acres with 37.3 net locations in Crane County, 5,700 net acres with 57.3 net locations in Crockett County, and 1,600 net acres with 16.4 net locations in Schleicher County.

According to a July 2011 release, American Standard brought in a second drilling rig to help conduct a 10-well program in Andrews County, Texas, with Strawn, Wolfcamp, Spraberry, and Lower Clearfork as targets. It called that effort Phase 1 of its Permian Basin development program.

### **Anadarko Petroleum Corp.**

- *Land: 170,000 net acres*
- *Concentrating on the Delaware Basin*

Anadarko Petroleum Corp. controls 13.2 Bboe in net risked resources worldwide, and it counts its Permian Basin properties as a small but active part of its activity.

It operated five drilling rigs in the basin in 3Q 2012 and sold 18,000 boe/d, a gain of 35% from the same quarter in 2011. The 3Q production represented an increase of 300 boe/d from 2Q 2012. At the time, the company said, “The growth was highlighted by an increase of more than 85% in high-margin oil sales volumes from the Bone Spring and Avalon Shale plays.” It added production with three operated and five non-operated rigs in the Bone Spring and two operated and one nonoperated rig in the Avalon Shale. Those rigs started drilling 24 wells and completed 16 in 2Q 2012.

It also started operations at a 26 MMcf/d of gas refrigeration plant in the quarter and said a 100 MMcf/d cryogenic processing plant would come online in early 2013.

According to a December 2012 operations update, “Anadarko also continues to achieve production records in its liquids-rich East Texas horizontal program and in the Permian Basin’s Avalon Shale and Bone Spring plays.”

At one point, Anadarko partnered with Chesapeake Energy Co. in the companies’ Delaware Basin properties, which included the Avalon and Bone Spring formations. At that time, Chesapeake held some 1.5 million acres in the Permian Basin, and Anadarko considered buying those properties in May 2012, particularly in the areas where the partnership existed.

Chesapeake later sold its southern Permian Basin properties to Royal Dutch Shell, its Midland Basin properties to EnerVest, and its Delaware Basin assets to Chevron.

Anadarko held a much larger position in the Permian Basin, but sold controlling interests in 28 oil and gas fields under 218,000 gross acres of land to Apache Corp. for \$1 billion in 2007.

In late 2011, Anadarko said recent Bone Spring wells came in with initial production rates of 1,600 boe/d to 2,000 boe/d. It planned to drill 130 wells to the Bone Spring and Avalon in 2012.

The company’s principal Bone Spring property is Haley Field at the corner of Texas and New Mexico.



## Apache Corp.

- *Land: 1.8 million net acres*
- *Largest US production area*

Approximately 14% of Apache Corp.'s US production, onshore and offshore, comes from the Permian Basin, making the basin the company's largest production area, according to a December 2012 presentation.

In a November 2012 presentation, Apache said its Permian region delivered 18% year-on-year growth in 3Q 2012 and production had increased more than 200% in the past two years.

It drilled 201 wells in the basin in 3Q 2012, including 26 horizontal wells, and it increased its horizontal drilling activity from 20 in 2010 to 40 in 2011 to 124 in 2012.

That drilling activity resulted in 263 total wells in 2010, 507 wells in 2011, and 760 wells in 2012.

Apache planned to invest \$2.1 billion in the Permian Basin in 2012 to keep 33 rigs at work. That rig count increased from five in 2010 to 25 in 2011, while investment rose from \$40 million in 2010 to \$1.2 billion in 2011. It anticipated \$1.8 billion in cash flow from its Permian operations.

That sharp growth started when the company established its Permian region in 2010 with the acquisition of major properties from BP and later Mariner Energy.

Apache said its rig count made it the most active operator in the Permian Basin, followed by Pioneer Natural Resources with 31 operated rigs, Concho with 25, Occidental Petroleum with 21, and Devon and Energen with 20 each.

The company has plenty of room for growth. In May 2012 it had 34,518 drilling locations with 3.79 Bboe in potential recovery from Permian zones. That included 2,321 locations with an estimated net 642 MMboe in the Cline Shale in the southern Permian Basin, 971 locations with a net 347 MMboe potential in the Wolfcamp Shale, and 1,823 locations with 284 MMboe in potential in the Delaware Basin.

It held 1.1 million gross (625,000 net) acres in the Midland Basin with potential production from unconventional zones from vertical Wolfberry to horizontal Cline and Wolfcamp shales. It had 17,816 locations with 1.714 Bboe in production potential from that area and drilled 396 wells in 2012. The Midland Basin was Apache's most active drilling area in 2012 as the company targeted more than 3,000 ft of productive pay zones from Spraberry through Fusselman.

The area also offered predictable drilling results, and Apache has successfully tested 20-acre spacing as it sought to double its drilling locations from the typical 40-acre spacing.

One active area in 2012 was the company's Deadwood area where production increased 7.5 times to 23,000 boe/d in the 23 months since Apache took over operations. Production comes primarily from Wolf-Wood (Deadwood and Lower Wolfcamp shales) and Fusselman. The area contains 5,900 future vertical locations plus upside in the Wolfcamp, Lower Cline, and Atoka/Barnett shales.

Apache held 650,000 gross (520,000 net) acres in the Cline Shale in September 2012 and planned six new wells during 2012. It ran two rigs targeting the formation in the second half of the year. It also is looking at the Deadwood and Atoka/Barnett in the same area.

The company said it is still in the learning curve for the Cline, and newer wells drilled with longer lateral legs are finding higher estimated ultimate recoveries (EURs) with additional fracture stages, modified fracture designs, and optimized landing points.

The company held 450,000 gross (345,000 net) acres with production of 2,200 boe/d in the Wolfcamp Shale in September. It drilled 25 wells to the



Equipment at a Permian Basin field location separates rich gas from oil.  
(Photo courtesy of Apache Corp.)



# Strong Foundations

Chevron has been demonstrating its commitment to the Permian Basin every day for 90 years – and we continue to build on that strong foundation.

We do it through jobs, growth and investment in the community.

We do it in partnership with everyone who calls the region home.

We do it because it's our home, too.

And we're here to stay.



## Neighbor of Choice, Partner of Choice, Employer of Choice

Chevron has remained committed to the Permian Basin for nearly a century and plans to be here for decades to come. Chevron and its predecessor companies began operating in the Permian Basin in the early 1920s. When other majors left the Permian in the 1980s and 1990s, Chevron bucked the trend, growing to become the largest leaseholder and second largest producer in the region. Today, Chevron builds on these strong foundations through continued investment in acreage, assets, technology, people and communities.

To learn more about Chevron and career opportunities, please visit [chevron.com](http://chevron.com).



formation in 2012 among its 971 locations with 347 MMboe in net production potential. The company ran three rigs in Irion County on a small portion of its acreage.

Its best Wolfcamp well in the first three quarters of the year was the Bennie No. 2H at an initial potential of 1,260 boe/d and average production of 499 boe/d over 30 days. The well had an EUR of 794,000 boe from a 9,300-ft lateral with 30 frac stages.

Apache called its 609,000 gross (287,000 net) acres in the Delaware Basin an area with emerging opportunities. It produced a net 3,300 boe/d in September 2012. It drilled 18 wells in 2012 from an inventory of 1,823 locations. Targets in that area include the Bone Spring, Avalon, and Wolfbone.

### Approach Resources Inc.

- *Land: 148,000 net acres*
- *First mover in southern Midland Basin shales*

Approach Resources Inc. earned credit as the father of the southern Midland Basin's Wolfcamp and Wolf-

camp combination plays when it reported a 1,200-ft oil-saturated Wolfcamp layer in late 2010.

Add the Clearfork zone and the pay interval stretches to some 2,500 ft.

That announcement extended the Midland Basin pay potential south into Crockett and Schleicher counties, as well.

Approach has a history in that area with drilling operations since 2004 and some 525 wells to its credit. By the time of a November 2012 presentation, it held 83.7 MMboe in proved reserves with 99% of those reserves in the Permian Basin. It produced 8,100 boe/d in 3Q 2012 with a 65% oil and NGL cut.

It has drilled pilot wells to the Wolfcamp A and C benches and is shifting gears from evaluation to development mode in the B bench. It planned to add a third drilling rig to operations in January 2013.

Its core Permian area also offers more than 500 MMboe of gross unrisks resource potential from more than 2,900 drilling and recompletion locations, and it has derisks 100,000 gross acres of land.

## REPUTATION. EXPERTISE. SERVICE.



The #1 Choice for SEC Reserves Reporting  
(based on public filing data)

### NSAI CERTIFIED

Netherland, Sewell & Associates, Inc. is one of the most respected names in independent reserves reporting. We provide petroleum engineering and geoscience consulting services to clients worldwide. Each evaluation is based on technical expertise, sound professional judgment, and years of experience.

With NSAI, you get our team of experts and a reliable, respected report.



**NETHERLAND, SEWELL & ASSOCIATES, INC.**

**Serving Our Clients For Over 50 Years**

Dallas 214.969.5401 Houston 713.654.4950  
www.netherlandsewell.com  
info@nsai-petro.com



# EXPERIENCE MATTERS.

## TRUST YOUR INVESTMENT TO A PROVEN LEADER.

Cudd Energy Services (CES) approaches each challenge with experience, reliability and a commitment to helping you achieve the maximum production from your reservoir. We have extensive experience in conventional and unconventional oil and gas fields, and understand the challenges that may arise. With CES, you get a partner who works with you to develop the optimal plan to ensure your investment produces the maximum return, safely and efficiently.



A recent A bench well tested for 689 boe/d and a B bench well at 922 boe/d.

The company breaks down its 500 MMboe potential into four segments. It has 225 MMboe in resource potential from 500 potential drilling locations in horizontal Wolfcamp wells. It holds another potential 200 MMboe from 1,825 potential vertical locations in new wells in the Wolfcamp (Wolfcamp-Clearfork) combination. Approach controls another 190 vertical recompletion opportunities for more than 17 MMboe, and it has 440 potential Canyon Wolfcamp vertical well locations with the potential to produce 85 MMboe.

It spent \$295 million in 2012 to operate two rigs in the horizontal Wolfcamp and one vertical rig to

drill vertical Clearfork and Wolfcamp wells. For 2013 it plans to spend \$260 million on three rigs with horizontal capability to drill 35 to 40 Wolfcamp wells and one vertical rig to drill 12 wells and continue its recompletion program in the Clearfork and Wolfcamp.

Approach expects strong returns from its shale and shale combination wells.

In the Wolfcamp horizontal segment it expects 450,000 boe estimated ultimate recovery (EUR) per well at a targeted cost of \$5.5 million for a well with a 7,000-ft lateral. That should give the company a before-tax internal rate of return (BT-IRR) of about 42% with \$100/bbl.

Wolfcamp vertical wells offer a 110,000 boe EUR, a well cost of \$1.2 million, and a 27% BT-IRR with \$100/bbl.

A Wolfcamp recompletion can give the company a 93,000 boe EUR at a cost of \$750,000 and a BT-IRR of 52% with \$100/bbl.

### **BHP Billiton Ltd.**

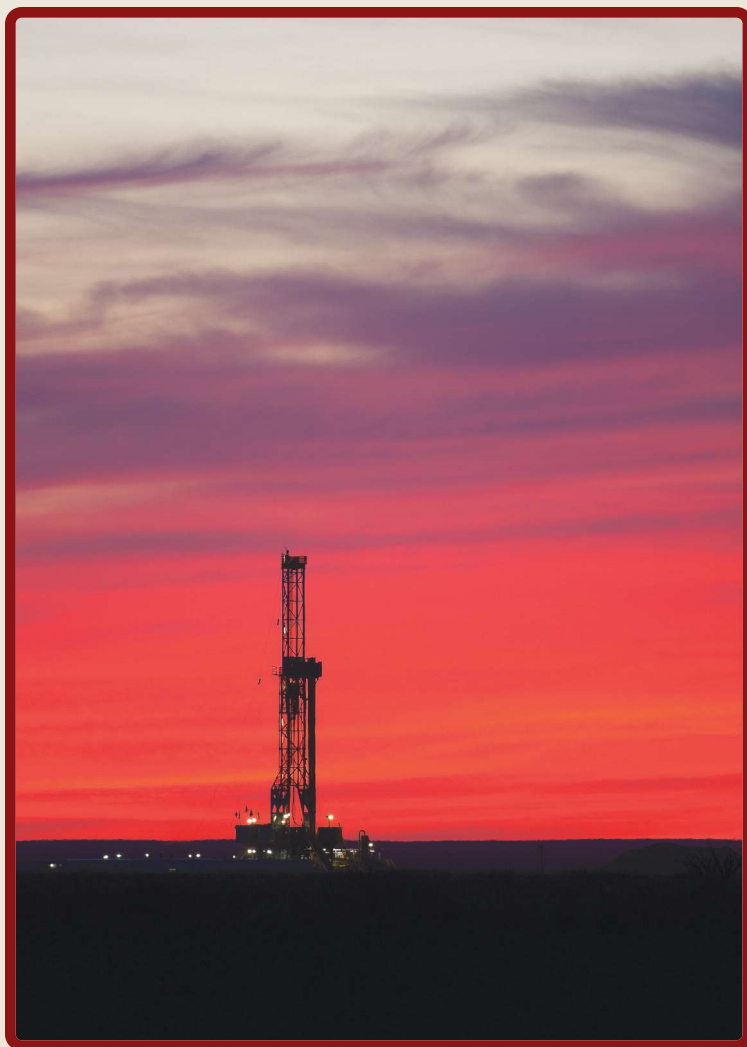
- *Land: 440,000 gross acres*
- *Shales drive petroleum growth*

The BHP Billiton Petroleum division of Australian mining giant BHP Billiton Ltd. used US shale acquisitions to grow from the world's 21st largest independent oil and gas company, slightly larger than Marathon Oil, to the world's seventh largest independent behind Anadarko Petroleum.

Those acquisitions included a Fayetteville Shale purchase from Chesapeake and a \$15.1 billion purchase, including debt, of Haynesville, Eagle Ford, and Permian shale properties from Petrohawk.

At the time of the Petrohawk acquisition in 2011, Petrohawk had budgeted \$2.84 billion in capex from the three shale areas. BHP said it planned to spend between \$3.8 billion and \$5 billion in fiscal year 2015 – ending June 30 – and \$5 billion to \$6.5 billion in fiscal year 2020 with simultaneous development in all three areas.

Sagging natural gas prices later forced the company to write down \$2.85 billion in its Fayetteville and Haynesville gas assets, but it is still going strong in the Eagle Ford and Permian properties. It planned to return to active gas development after gas prices climbed back above \$3.50/Mcf, according to J. Michael Yeagar,



The sun may be setting on this rig, but the highlights are getting brighter for BHP Billiton Petroleum's operations in the Permian Basin. (Photo courtesy of BHP Billiton Petroleum)

petroleum CEO at a Barclay's presentation in September 2012.

BHP still is evaluating the Permian Basin properties and buying more acreage. Its property position grew from an 86% interest in 325,000 gross acres in November 2011 to 440,000 acres in late 2012, and it planned to drill more than 60 wells to the Permian Basin's stacked conventional and unconventional pay zones, including the Wolfcamp Shale, by the end of June 2013.

In the six months ended Dec. 31, 2012, the first half of the company's 2013 fiscal year, the company had 31 rigs working the Eagle Ford Shale, eight rigs in the Permian Basin, four rigs in the Haynesville Shale, and two rigs in the Fayetteville Shale as part of its \$2.1 billion US onshore drilling and development budget.

In a May 2012 report the company said its Permian acreage could produce another 100,000 boe/d within three years.

When BHP and Petrohawk announced the acquisition in 2011, BHP said the new properties would help the company deliver a compound annual production growth rate of more than 10% for the rest of the decade. At that point it had strong production from the Eagle Ford, and the liquids-rich properties in the Permian Basin were "highly prospective," and early drilling results showed strong potential.

Those Permian Basin assets are in the north and south Midland basins and the Delaware Basin in Texas.

Although the company did not specifically identify unconventional targets, typical production comes from Wolfcamp and Wolfberry in the North Midland Basin, Wolfcamp and Cline in the South Permian Basin, and Wolfbone and Avalon in the Delaware Basin.

### **Blacksands Petroleum Inc.**

- *Land: 5,050 net acres*
- *Completed first operated well*

Blacksands Petroleum Inc. works a drilling program on its properties in the Permian Basin and, in 2012, transitioned from being a nondrilling operator to one of the basin's drilling independents through its NRG Assets Management LLC subsidiary.

Its first operated well, the BVR No. 6-1 in Borden County, Texas, reached a total vertical depth of 7,970 ft with perforations in the Spraberry and Wolfcamp zones in a field that previously produced from the Spraberry. It called its results encouraging.

The company also said it planned to drill two more vertical wells in the field to evaluate deeper potential and assess the feasibility of horizontal drilling.

Previously, the company participated in wells drilled by other operators, including the Everett No. 3 in its Apclark Field project, in which the company held a 70% gross working interest. That 9,200-ft well tested Spraberry, Wolfcamp, Strawn, and Upper Mississippian formations.

### **BreitBurn Energy Partners LP**

- *Land: 4,600 net acres*
- *Starting Permian campaign*

BreitBurn Energy Partners, a master limited part-

## **Sun Coast** RESOURCES, INC. *Quality Fuels & Lubricants*

- |                        |               |
|------------------------|---------------|
| • Frac Site Fueling    | • Chevron     |
| • Crude Hauling        | • Mystik      |
| • Condensate Hauling   | • Citgo       |
| • Rig Fueling services | • Phillips 66 |
| • Fuel Tanks available | • Total       |
| • Frac Tanks           | • Havoline    |
| • Vacuum Services      |               |

 **1<sup>st</sup> SOURCE** ELITE



**www.suncoastresources.com**  
**(800) 677-FUEL (3835)**



## Bone Spring Play Economics\*

Formation	EUR MBOE	EUR MBO	EUR BCFG	NPV 10%	ROR (M)	DISC. RETURN ON INVEST.	PAYOUT	LIFE YEARS
AVALON SHALE	346.7	126.5	1.32	\$2,640	26.17%	1.42	3.1	24.9
1ST BONE SPRING SD	378.8	203.8	1.05	\$5,080	46.80%	1.85	2.0	30.0
2ND BONE SPRING SD	339.4	243.1	0.58	\$4,464	37.93%	1.75	2.8	34.8
3RD BONE SPRING SD	466.6	354.8	0.67	\$8,337	55.45%	2.16	1.8	35.7
WOLFCAMP SHALE	442.8	130.8	1.87	\$2,782	22.32%	1.39	3.7	33.3
AVERAGE	394.9	211.8	1.10	\$4,661	37.73%	1.71	2.7	31.7

NYMEX Strip 9/24/2012

### Bone Spring Price Estimate (1) Mcf Processing

GAS SALES MCF Basis					GAS SALES ON PROCESSING BASIS				
Wellhead BTU/Mcf	Gas Price 1000 BTU EXAMPLE	Gas Value / Mcf	BTU/Mcf	42% Shrinkage, Line loss and flared	Gas value post shrink/fees/ comp @ \$2.83	Oper share Gallons product Recovered/mcf	Liquid average value/gal.	Processing value/Liquid/ Mcf	Total (\$/Mcf) value Caza Gas after processing
1.322	\$3.75	\$4.96	1.150	0.637	\$2.19	5.016	0.797	\$3.90	\$6.09

Caza Ridge 3rd Bone Spring Sample  
11/09/12 - 1322 BTU

Assumed : 7.8 GPM \* plant efficiency \* 0.86

\*Caza Internal Estimate of EUR oil equivalent from type curves for Avalon(Lennox Prospect), 1st BS (Forehand Ranch Prospect), 2nd BS (Forehand Ranch), 3rd BS (Copperline Prospect), Wolfcamp (Forehand Ranch)



The unconventional Avalon and Wolfcamp shales in the Delaware Basin may offer nice returns, but the Bone Spring sands take precedence in rewards for development. (Table courtesy of Caza Oil & Gas Inc.)

nership, closed two deals in July 2012 that gave the Los Angeles company an operating position in Permian Basin shales.

The company bought properties from Element Petroleum for \$148 million and from CrownQuest Operating LLC for \$70 million that gave it 13.6 MMboe in proved reserves and some 4,600 net acres in the Wolfberry play's Martin and Howard counties in West Texas.

Production from the properties averages 65% oil and 35% liquids-rich gas.

That deal also gave BreitBurn a strong operating partner in CrownRock LP.

The properties produced an average 1,850 boe/d in November 2012 with approximately 48 producing wells and more than 200 potential drilling loca-

tions. It holds hydrocarbons with an estimated production life of 18 years.

BreitBurn operates the properties with a working interest of more than 70%.

### Caza Oil & Gas Inc.

- Land: 3,312 net acres
- Sees Avalon and Wolfcamp potential

Caza Oil & Gas Inc. concentrates its activity on the Bone Spring sands in southeastern New Mexico, but its properties also contain unconventional potential in the Avalon and Wolfcamp shales.

After selling its San Jacinto Wolfberry properties in the Midland Basin for \$6.1 million in mid-2012, Caza looked to southeastern New Mexico for its growth.

# WE'RE SURGING INTO THE SHALE.



FLOW EQUIPMENT LEADERSHIP

## Deploying a complete fleet of Flowback and Well Testing units to major shale plays.

From the Bakken Shale and Eagle Ford Shale to the Marcellus Shale and every shale play in between, we are putting the full force of our Flowback and Well Testing fleet to work for you. A vital link in our comprehensive range of integrated CAMSHALE™ products and services, our portfolio of Galaxy™ Flowback and Well Testing equipment is customized to meet the pressure, temperature and liquid content specifications of each basin. Through our suite of Galaxy products, you benefit from proven technology that delivers seamless flow control from completion to production. Maximizing efficiency for the life of the field. In every shale gas environment.

Visit us at [www.camshale.com](http://www.camshale.com)



COMPLETION



FRAC SUPPORT SERVICES



FLUID MANAGEMENT



COMPRESSION



AD00400DRL

RAISING PERFORMANCE. TOGETHER™

 **CAMERON**



In a December 2012 presentation the company said it had four producing wells in the Delaware Basin, all pumping from the Bone Spring zones. As of January 2012, it has 117 drilling locations including 10 in the Wolfcamp and potential from the Avalon Shale overlying the three Bone Spring producing segments.

According to company estimates, the Bone Spring focus is easy to understand. It expects returns ranging from 37.93% to 55.45% from the sands. For contrast the company calculates estimated ultimate recoveries (EURs) of 346,700 boe and a 26.17% rate of return from the Avalon and EURs of 442,800 boe and a 22.32% rate of return from the Wolfcamp.

As the company started drilling the Forehand Ranch 27 State Com No. 1H horizontal well, its first well in the Forehand Ranch prospect in Eddy County, N.M., in October 2012, it said its primary target was the second Bone Spring with secondary targets in the Delaware, Lower Bushy Canyon, Avalon Shale, first and second Bone Spring, and Wolfcamp.

Among drilling and completion impediments for all wells in the area, hydrogen sulfide and carbon dioxide may raise tubular costs and lower economics in the Avalon. In addition, the high rate of activity in the Permian Basin sometimes results in a lack of crew availability and crews that show up late to cement, perforate, and provide other services. "Crew inexperience can inflate drilling and completion costs," the company added.

### **Chevron Corp.**

- *Land: 1.4 million net acres*
- *Ramping up Delaware Basin activity*

Chevron Corp. boasts 87 years of operations in the Permian Basin of West Texas and southeastern New Mexico.

"Through our legacy companies, Chevron has been a fixture in the Permian Basin since the early 1920s and is now the second-largest oil producer in the basin. Our net daily production from the Permian Basin, which is the largest oil-producing basin in the United States representing more than 20% of the total US oil production, is more than 115,000 barrels of oil equivalent," the company said in February 2011 as it celebrated production of more than

5 Bboe from the basin. At that time, it had almost 4 million acres of land in West Texas and southeastern New Mexico with 11,000 wells producing from hundreds of fields.

Most of that production came from conventional zones, but the company plans a larger role for its unconventional resources.

Coming into late 2012 the company held 700,000 net acres of land in the Delaware Basin segment of the Permian Basin. It added another 246,000 net acres in a purchase of Chesapeake Energy's Delaware Basin holdings where production comes from unconventional Avalon and Wolfcamp formations and conventional Bone Spring sands, sometimes commingled for unconventional Wolfbone yields.

"This acquisition in a premier emerging play in the Permian Basin grows our significant leasehold position there," said George Kirkland, vice chairman. "These early-in-life, liquids-rich unconventional assets have the potential to be significant future contributors to Chevron's robust North American operations."

The acquired properties gave Chevron an additional net production of 7,000 boe/d and the potential for higher production in the future.

Chevron announced a goal of 3.3 MMboe/d of company-wide production in 2017. Unconventional production will contribute 175,000 boe/d to that figure with hydrocarbons from the Duvernay Shale in Canada; the Antrim, Collingwood, Marcellus, and Utica shales in northeastern US; the Haynesville and Bossier in Louisiana and East Texas; the Niobrara in Colorado and Wyoming; and the Wolfcamp, Avalon, and Cisco formations in the Delaware Basin, according to a speech at the company's 2012 annual meeting, before the Chesapeake acquisition, by George L. Kirkland, vice chairman and executive vice president of upstream and gas.

In a supplement to the company's 2011 annual report Chevron said it planned to drill four operated wells in the Delaware Basin in mid-2012 and acquire 3-D seismic data to identify potential core areas and refine development strategies.

At that time, it also was drilling vertical wells with multistage frac treatments in the Wolfcamp in more than 320,000 acres it held in the Midland Basin. Those



Permian Basin | Eagle Ford | Bakken | Haynesville | Marcellus | Utica | Woodford | Barnett | Fayetteville

# Rig inspections

Limit downtime and increase safety during drilling operations

**Lloyd's Register Energy - Drilling** rig inspection services can reduce downtime and save money by improving the reliability, safety and environmental impacts of your drilling program.

From a dropped-objects survey to a value assessment of your rig fleet, **Lloyd's Register Energy - Drilling** can help you continue with what really matters: drilling as safely and efficiently as possible. Our rig inspection services can help you optimize your drilling rig and provide you with an in-depth indication of the technical state of the drilling rig you intend to hire.

Contact your **Lloyd's Register Energy - Drilling** representative to get the right solution for your drilling and safety needs. Visit [www.lr.org/drilling](http://www.lr.org/drilling) or e-mail [energyinfo@lr.org](mailto:energyinfo@lr.org)

Integrating ModuSpec and WEST Engineering Services  
to advance excellence in drilling safety, integrity and performance.





properties held potentially recoverable oil-equivalent resources of approximately 1.1 Bboe.

The properties included 75,000 acres where the company had a nonoperated working interest of about 70% in more than 900 wells and average net production of more than 15,000 boe/d. Chevron operated the remaining acreage with a 97% working interest and ran six rigs in the play at year-end 2011.

### **Cimarex Energy Co.**

- *Land: 110,000 to 116,000 net acres*
- *Expanding in liquids-rich shale*

Cimarex Energy Co. counts the Permian Basin as one of its core areas with some 438,000 net acres with conventional and unconventional pay at year-end 2011.

With 31% of corporate proved reserves of 2.05 Tcfe, it may not be the largest property in the company inventory but is getting the most attention. The company's exploration and development budget for 2012 totaled \$1.5 billion, and \$880 million of that is going into the Permian Basin where it holds 620.4 Tcfe in proved reserves, according to a December 2012 presentation. Only a small portion of that investment is going to unconventional development.

The company held 65,000 net acres in the New Mexico segment of the conventional Bone Spring play and 35,000 net acres in the same formation in Culberson County, Texas. It claimed 110,000 to 116,000 net acres in both states with unconventional potential, including the Avalon, Wolfcamp, and Cisco/Canyon formations.

Within that acreage, 100,000 net acres are in the area of White City in Eddy County, N.M., and in Culberson County, Texas.

Through 3Q 2012 Cimarex drilled a cumulative 29 horizontal wells to the Wolfcamp. Those wells averaged 6.4 MMcfe/d during their first 30 days on line. That production consisted of 26% oil, 31% NGL, and 43% gas. Production from the Wolfcamp rose from about 5 MMcfe/month in 1Q 2010 to about 42 MMcfe/month in 3Q 2012.

The company's horizontal wells cost between \$7.6 million and \$8 million to drill to 8,000 ft to 10,000 ft deep with 4,500-ft laterals.

Cimarex drilled 88 net wells in the Permian Basin in the first nine months of 2012 and 24 wells in 3Q with 14 rigs at work. In the third quarter 11 gross (10 net) of those wells were horizontal wells in the Wolfcamp.

### **Clayton Williams Energy Inc.**

- *Land: 141,620 gross acres*
- *Targeting multiple unconventional areas*

Midland, Texas-based Clayton Williams Energy Inc. holds properties from Louisiana to Texas and New Mexico with a strong presence in its home ground in the Permian Basin.

According to the company's 3Q 2012 report to shareholders, it produced 3,115 b/d of oil, nearly 2 MMcf/d of gas, and 241 b/d of NGL from all its shale holdings in the first nine months of 2012.

Overall, it holds 262,000 net acres of land, including 185,000 net acres with 51 MMboe of proved reserves in the Permian Basin, with 141,620 gross acres in the Permian Basin listed with unconventional production potential.

In a September 2012 presentation the company said it held Wolfberry production in Andrews County, Wolfberry and Cline potential in Glasscock and Sterling counties, Wolfberry potential in Upton County, and Wolfbone production in Reeves and Loving counties in the Delaware Basin, all in Texas.

Clayton Williams aims at Spraberry, Wolfcamp, and Strawn zones in Andrews County where a vertical well costs \$2.3 million to drill to find 130,000 boe to 140,000 boe of estimated ultimate recovery (EUR). For 2012 the company worked one drilling rig in the area with plans for 59 wells on 80-acre spacing. It has the potential to drill 100 wells on 40-acre spacing on its 20,120 gross acres in the county.

The company commingles production from the Upper Wolfcamp and Third Bone Spring (Wolfbone) from its vertical wells in the Delaware Basin. That play still is in the early development stage with 65 vertical and 10 horizontal wells spud by September 2012. It has 400 potential locations on 160-acre spacing and works four rigs on its 62,800 acres of leased land and 20,600 acres earned in a deal with Chesapeake.

It costs the company \$4 million to drill a vertical well with expectations of 200,000 boe to 250,000 boe of EUR per well.

Clayton Williams holds 38,100 net acres of land in its Permian Basin East region in Glasscock and Sterling counties in the Midland Basin. That land has potential from Wolfcamp and Cline shales from vertical wells drilled to depths from 7,000 ft to 9,000 ft. It drilled nine wells in that area in the six months ended Sept. 30, 2012, and spud one Cline horizontal well in the third quarter.

### Comstock Resources Inc.

- *Land: 89,882 gross acres*
- *Drilling for Wolfbone oil*

Comstock Resources Inc. entered the Permian Basin unconventional resource plays late in December 2011 and mounted an active drilling program to promote company growth.

It purchased 70,035 gross (43,591 net) acres of

land in the Reeves County, Texas, part of the Delaware Basin and added 19,847 gross (11,875 net) acres in Gaines County, Texas, in the northern Midland Basin with potential for Wolfcamp Shale production.

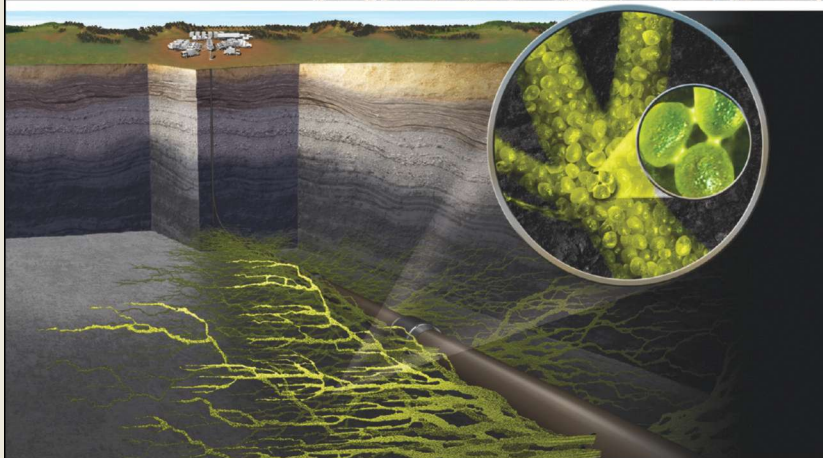
The company bought the Reeves County properties from Eagle Oil & Gas Co. and other parties for \$331.9 million.

According to the company website, it had 151.2 Bcfe in reserves on the Reeves County properties with potential production from the Bone Spring from 10,000 ft to 10,300 ft and Wolfcamp from 10,300 ft to 11,500 ft. Commingled production makes up the Wolfbone play.

In a November 2012 presentation Comstock said it planned 43 vertical and four horizontal Wolfbone wells in 2012 to reach an estimated 151 Bcfe made up of 75% to 80% oil. It had more than 900 locations in the Wolfbone play with a resource potential of 178 MMboe.

## Stop Low Temperature Proppant Flowback

**Black Ultra™**  
PROPPANTS



### Black Ultra™ Proppants Offer the Latest Technology for Low Temperature Wells.

Momentive has designed a new advanced multi-functional resin system, which bonds at low temperatures without the need for our AcTivator™ consolidation aid. This proppant improves well performance while helping to decrease the overall cost to the operator.

Black Ultra proppants provide higher strength in the bonded pack than conventional curable resin coated proppants at low temperatures without the use of a consolidation aid.

**Get the Results You Expect.™**

For more information, contact us at [oilfield@momentive.com](mailto:oilfield@momentive.com).

[momentive.com/oilfield](http://momentive.com/oilfield) • [fracline.com](http://fracline.com)

Momentive Specialty Chemicals Inc., Oilfield Technology Group, Houston, TX USA + 1 281 646 2800  
©2013 Momentive Specialty Chemicals Inc. ®, ™ and SM are trademarks owned or licensed by Momentive Specialty Chemicals Inc.

**MOMENTIVE™**



By the end of 3Q 2012, the company had drilled 29 Wolfbone wells and one horizontal Wolfcamp well to bring its total to 40 operated vertical Wolfbone wells and one operated Wolfcamp horizontal well.

It had budgeted \$178.1 million for 47 gross (29.7 net) wells in the Delaware Basin for 2012.

The Wolfbone wells showed an average initial potential of 370 boe/d, while the Wolfcamp well offered an initial potential of 322 boe/d.

The company's best Wolfbone well came in with an initial potential of 653 boe/d with a 30-day average production rate of 477 boe/d. Average Wolfbone production in 3Q 2012 was 1,900 b/d.

The Reeves County properties also offered potential production from the Avalon Shale overlying the Bone Spring.

### Concho Resources Inc.

- *Land: Less than 750,000 net acres*
- *Third most active operator in the Permian Basin*

Concho Resources Inc. is a relative newcomer in name — formed six years ago — in the Permian Basin, but it is a solid citizen in terms of land and activity.

Its initial acquisitions included Henry Petroleum, generally regarded as the company that established the Wolfberry as a profitable drilling target.

It divested its properties in the Williston Basin in 2011 and brought \$200 million from that sale to its Permian activity.

Since the company was formed, it assembled 1.3 million gross (750,000 net) acres of land in the Midland Basin and Delaware Basin segments of the Permian Basin and the New Mexico shelf. Those properties hold some 10,600 drilling locations.

Among plays the Delaware Basin offers potential from the Avalon, Bone Spring, Wolfbone, Wolfcamp, and Penn Shale.

In January 2013 the company's COG Operating LLC arm reported a horizontal Abo-Wolfcamp success in Chaves County, N.M., on the northwestern shelf of the Permian Basin. The company's #2H Leo 3 Federal Com tested for 500 b/d of oil and 300 Mcf/d of gas from the combined zones.

The northern Midland Basin offers prospects for Wolfberry, Wolfcamp, and Cline/Penn shales.

The southern Midland Basin is prospective for Wolffork (Wolfcamp-Clear Fork) and Wolfcamp.

According to the company's most recent presentation, it plans to run 11 rigs in 2013 to drill 175 wells in the Delaware Basin where it holds 490,000 gross (329,000 net) acres of land with 2,375 north Delaware Basin drilling opportunities.

Wells in the northern Delaware Basin cost \$5 million to \$9 million to drill and complete and offer enhanced ultimate recoveries (EURs) from 300,000 boe to 700,000 boe at depths from 6,500 ft to 11,500 ft from wells with 4,000-ft to 4,500-ft laterals and eight to 13 frac stages. Initial production for the first 30 days online range between 300 boe/d to 1,500 boe/d.

The company holds another 140,000 gross (125,000 net) acres in the southern Delaware Basin with potential production from the Delaware Sand, Avalon, Bone Spring, and Wolfcamp formations. The company drilled 10 wells in 2012 and completed four wells in the area with average initial potentials of 675 boe/d with an 84% oil cut.

It plans to run one or two rigs in the southern Delaware Basin in 2013 to continue to delineate profitable areas of production in Reeves and Pecos counties in Texas.

The Delaware Basin is the company's newest and fastest-growing area with proved reserves of 49.7 MMboe or 13% of Concho's proved reserves.

The company drilled or participated in 42 wells, 22 operated, in the Delaware Basin in 3Q 2012, with successes at all of the six wells completed by the end of the quarter. All were horizontal, including 27 Bone Spring Sand wells, six Avalon Shale wells, six Wolfcamp Shale wells, and three Delaware sand wells.

In the Midland Basin Concho planned to run 14 rigs to drill 265 wells among its 5,772 drilling opportunities during 2013. Those opportunities include 2,064 with 40-acre spacing in the Wolfberry, 2,629 with 20-acre spacing in the Wolfberry, and 927 shallow Wolfcamp sites.

It added 500 Wolfberry locations through acquisitions during 2012 and drilled two horizontal Cline wells in Glasscock County, two horizontal Wolfcamp wells in Upton County, and one horizontal well in Terry County in the first three quarters of

**CASED HOLE  
SOLUTIONS**  
A C&J ENERGY SERVICES COMPANY

# EQUIPPED FOR COMPLEX CHALLENGES

At C&J Energy Services, we bring extraordinary customer service, custom high-specification equipment and exceptional execution to every well.

We believe our customer focus and attention to detail enhances the efficiency and quality of any project, resulting in faster, more effective well completions for our customers.

[www.cjenergy.com](http://www.cjenergy.com)



C&J Energy Services



2012 with another horizontal well planned in Terry County in 4Q 2012.

The company added to its southern Midland Basin holdings with its acquisition of 39,700 gross (29,000 net) acres from Three Rivers. Those properties offer Wolfcamp and Cline shale potential. It drilled its first horizontal well in Irion County in 2012 and planned additional horizontal wells in 2013.

At year-end 2011, the Midland Basin gave the company estimated proved reserves of 126.5 MMboe, or a third of its total proved reserves.

Its primary target in the basin is the Wolfberry combination, and it has drilled more than 1,000 wells and fractured them more than 2,500 ft gross of pay from the top of the Spraberry through the Wolfcamp Shale.

The company drilled or participated in 83 operated wells in its Texas Permian properties in 3Q 2012 with a 100% success rate on the 30 wells that had been completed by the end of September.

In the company's 3Q 2012 report to shareholders, Tim Leach, chairman, president, and CEO, said, "The third quarter was another record quarter in terms of production and cash flow. It also marked a shift for Concho to a drilling program that is now primarily horizontal. The operational and capital efficiencies realized through our horizontal program are real and have expanded our access to new high rate-of-return drilling opportunities. Nowhere is this more evident than in the Delaware Basin, where our results continue to improve. Looking forward to 2013, we are planning to allocate over half of our capital budget to the Delaware Basin and expect this core area to provide a significant source of organic growth. Lastly, we have signed a definitive agreement to sell noncore assets, which will help streamline our business and reduce our overall leverage."

Concho plans to spend \$1.6 billion during 2013, with \$1.4 billion devoted to drilling to operate an average 30 rigs, 15 of which are capable of horizontal drilling. That activity should yield production ranging from 32.9 MMboe to 34.3 MMboe. Some 54% of those funds will go into the Delaware Basin and 25% will support Texas Permian assets.

Overall, the company plans 186 Yeso wells on the

New Mexico Shelf, 175 Delaware Basin wells, and 236 Wolfberry wells.

## ConocoPhillips Co.

- *Land: 1.1 million net acres*
- *Permian offers second highest US production volume*

ConocoPhillips Co., the largest independent US oil company after separating from its downstream segment, counts heavily on US unconventional production, including Permian Basin unconventional resources, to reach set 2016 goals.

The company set a 2013 capital budget of \$15.8 billion. About 40% of that will go into 21 million net acres of legacy assets in the US and Canada, and about two-thirds of that will go to the Lower 48 states, primarily in unconventional targets, including the Eagle Ford, Bakken, Barnett, Niobrara, and both conventional and unconventional resources in the Permian Basin.

The company set a goal of adding 550,000 boe/d of production from five major projects around the world, and the largest part of that is 210,000 boe/d from liquids-rich Lower 48 unconventional production where it estimates a cash margin of more than \$40/boe. That is a higher margin than the \$40/boe it expects from Canadian oil sands, its Australia Pacific LNG operation, and deepwater Malaysia production.

The company added more than 750,000 acres of land in liquids-rich shale plays in the US and Canada since 2011 with targets including the Wolfcamp in the Permian Basin, the Niobrara in Colorado and Wyoming, and the Canol and Duvernay in Alberta.

According to a company fact book, "The Permian Basin in West Texas and southeastern New Mexico is a prime example of increasing existing company resources from legacy assets. We continue to effectively optimize production from its 1.1-million-net-acre lease position. The company drilled 103 wells in 2011 and plans to increase drilling activity in 2012. With resources of approximately 1 Bboe, the basin is expected to remain a high liquids-production asset for years to come."

During 2011 the company produced 48,000 boe/d from the Permian Basin, second only to the San Juan among US basins.

Still, the company is in the early stages in shale activity in the Permian Basin. Its major efforts lie in the Eagle Ford, the Bakken, and the Barnett, but it also is active in the Niobrara and Permian shales.

The company added approximately 240,000 net acres of land in 2011 prospective for the Wolfcamp and Avalon plays in the Permian Basin and the Niobrara in Colorado.

Permian Basin conventional and unconventional properties average about 60% liquids and total more than 1.1 Bboe in resources.

The company claims exposure in every play, including the Yeso on the New Mexico shelf; the Avalon, Bone Spring, and Wolfcamp in the Delaware Basin; and the Clear Fork, Wolfberry, and Wolfcamp in the Midland Basin. Overall, it has identified more than 7,000 drilling locations and reported promising early results from its drilling to the Avalon and Wolfcamp shales.

The company expects production of approximately 84,000 boe/d from the Permian Basin by 2015, up from approximately 55,000 boe/d in 2012.

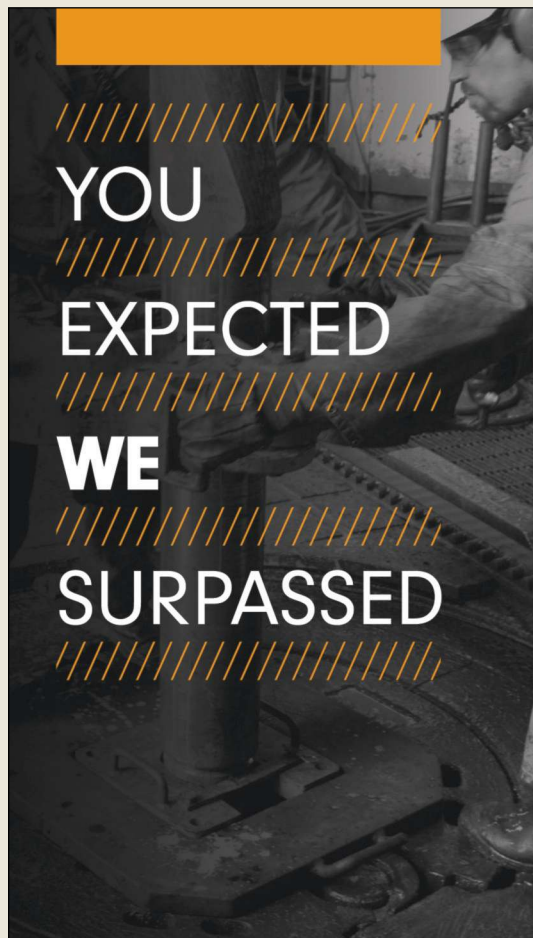
### Endeavor Energy Resources LP

- Operates more than 4,000 wells
- 10th largest oil producer in Texas

Privately owned Endeavor Energy Resources LP runs one of the most active programs in the Permian Basin, not only with producing conventional and unconventional properties but with service activities to back up its drilling and production operations.

Autry Stephens started that activity when he formed Big Dog Drilling Co. in 1996. Currently, the company runs 25 rigs and other servicing activities.

Stevens formed the Endeavor limited partnership in 2005 and acquired Perenco Energy in 2006, changing the name to LCX Energy LLC. He merged that company into Endeavor in 2009.



**LISTENING TO CUSTOMERS IS A GREAT WAY TO REVOLUTIONIZE THINGS. WE TOOK YOUR THOUGHTS AND BUILT THEM INTO OUR NEW PRODUCT LINE.**

WETORQ | WECATT | WEBUCK | WEMOVE | WERUN

GREAT PRODUCTS HAPPEN WHEN GOOD COMPANIES LISTEN TO THEIR CUSTOMERS. THAT'S THE DRIVING FORCE BEHIND OUR REVOLUTIONARY **WE** PRODUCT LINE. BY IGNORING PRECONCEIVED LIMITATIONS, WE MAY HAVE JUST REVOLUTIONIZED THE INDUSTRY. DON'T THANK US. IT'S ALL YOU.



**MORE INFORMATION AVAILABLE AT**  
<http://WE.MCCOYGLOBAL.COM>



**MCCOY** | DRILLING & COMPLETIONS  
MOVING GLOBAL ENERGY FORWARD



Most of the company's production is in Texas and New Mexico.

Current information about the company's activities is not publicly available, but in late 2010 the company ran 11 drilling rigs, nine in the Wolfberry play in the Midland Basin and two in the Wolfbone play in the Delaware Basin. It planned to drill 180 wells that year and the same number in 2011.

A March 2010 report from DI Energy Strategy Partners said the company had brought 380 Wolfberry wells into production.

### Energen Resources Corp.

- Land: 275,000 net acres
- Unconventionals secondary to Bone Spring

The Energen Resources Corp. arm of Energen Corp. picked the Permian Basin as its primary growth engine.

It holds 275,000 net acres in the Delaware and Midland basins with unconventional potential

and conventional production in the Third Bone Spring in the Delaware Basin and on the Central Basin platform. That includes a \$68 million Wolfberry acquisition in February 2012.

Unconventional properties include vertical Wolfberry and horizontal Wolfcamp and Cline shale wells in the Midland Basin and horizontal Wolfcamp and Avalon shale wells and vertical Wolfbone wells in the Delaware Basin.

The company was the sixth most active driller in the basin in September 2012 with 20 working rigs.

In some areas the acreage overlaps, but the company broke down its holdings in a December 2012 presentation.

It has 60,000 net acres, including 32,000 net undeveloped acres in the Wolfberry play with 800 potential locations on 40-acre spacing and 665 potential locations on 20-acre spacing.

Through early December 2012 it drilled 135 gross (130 net) Wolfberry wells with an average initial stabilized rate of 84 boe/d with a 73% oil cut. Wells offer a 155,000 boe estimated ultimate recovery and a 33% pretax rate of return with \$100/bbl oil and \$4/MMBtu gas on \$2.3 million wells with six to eight frac stages.

Also in the Midland Basin, the company has 64,000 net acres in the Wolfcamp horizontal play with 785 potential locations on 160-acre spacing. It plans six net Wolfcamp or Cline wells on its acreage in 2013.

It holds 80,000 net acres with Cline potential with 495 potential locations on 160-acre spacing.

In the Delaware Basin Energen controls approximately 110,000 net acres with Wolfcamp and Avalon potential. It drilled five Wolfcamp wells in 2012 and plans another seven wells in 2013.

Emphasizing its Permian focus, the company devoted \$490 million of its \$1.2 billion in capex for 2012 in the Wolfberry play, and \$70 million in the Wolfcamp in the Delaware Basin. That money powered eight to 10 rigs in the Midland Basin to drill 167 wells and five to seven rigs in the Delaware Basin to drill 46 net wells in 2012.

It planned to produce 5.9 MMboe in the Wolfberry in 2013, up from 3.7 MMboe in 2012 and 2.3 MMboe in 2011.

> FROM THE PLATFORM  
TO THE PRAIRIE....




....QUALITY AND SERVICE TO IMPROVE PERFORMANCE

GENERAL OILFIELD RENTALS AND SERVICES	PUMPING SUPPORT
OFFSHORE MARINE VESSELS	WIRELINE SUPPORT
COILED TUBING SUPPORT	THRU-TUBING SERVICES
PULL TESTING, INSPECTION SERVICES	FRAC ASSIST SERVICES
FLOW BACK	INVENTORY MANAGEMENT CONTROL
	FRAC STACS

WWW.SUPREMESERVICES.COM

ALICE. BROUSSARD. HOUMA. HOUSTON. MINERAL WELLS. ODESSA. REFUGIO, SHREVEPORT



# We Know PVF

Since 1921, we've been doing one thing and one thing only: providing PVF products and solutions to our customers. We create savings well beyond the price of our products.

In December 2012 MRC acquired Permian-based Production Specialty Services (PSS). We welcome PSS customers, suppliers and employees to MRC and look forward to building on our relationship in the years to come.

---

## **MRC Offers PVF Products and Services Globally**

425+ Locations  
24 Automation Facilities  
\$1B+ Inventory

MRO Solutions  
Project Solutions  
Logistics Solutions  
Automation Solutions

Carbon Steel  
Stainless Steel  
Alloys & Duplex

**MRC<sup>®</sup>**  
**McJunkin Red Man Corporation**



[www.mrcglobal.com](http://www.mrcglobal.com)



In a December 2012 release the company said, “... its 2013 consolidated capital budget of \$975 million will focus primarily on the exploration and development of its liquids-rich assets in the Permian Basin of West Texas.” Approximately \$745 million will go into the vertical Wolfberry, horizontal Third Bone Spring, and conventional and waterflood operations on the Central Basin Platform. It will put another \$130 million into the horizontal Wolfcamp and/or Cline in the Midland Basin and the Wolfcamp in the Delaware Basin.

### **EnerVest Ltd.**

- *Land: More than 166,000 acres*
- *Shales represent emerging plays*

EnerVest Ltd. and its EV Energy Partners LP upstream master limited partnership work in some of the most profitable plays in the US. Their standing in the Permian Basin may be a small part of their operations, but it represents a growing opportunity.

Overall, EnerVest has more than 27,000 wells with more than \$6 billion in proved and probable reserves in Arkansas, Colorado, Kansas, Kentucky, Louisiana, Michigan, Montana, New Mexico, New York, North Dakota, Ohio, Oklahoma, Pennsylvania, Texas, Virginia, and West Virginia.

It is the largest producer in the Austin Chalk and in Ohio.

According to an EV Energy Partners presentation in December 2012, the company holds approximately 54.2 Bcfe in proved reserves in the Permian Basin out of a nationwide total of 1.14 Tcfe throughout the nation. In terms of proved reserves the Permian Basin is smaller than any other corporate operating area except Michigan with 44.9 Bcfe.

The company lists the Cline, Wolfbone, and Bone Spring/Avalon combination as emerging plays in its Permian Basin portfolio but ranks horizontal Wolfcamp in the commercial development phase.

Among the company’s recent acquisitions, it picked up a package of properties in the Midland Basin from Chesapeake Energy, reportedly approximately 166,000 acres.

### **EOG Resources Inc.**

- *Land: 239,400 net acres*
- *Permian is third in EOG’s portfolio*

EOG Resources Inc. dominates liquids-rich production activity in the Bakken/Three Forks and Eagle Ford shale plays, and the Permian Basin stacked pay runs a distant third.

The company produced more than 1.4 MMboe/d company-wide in July 2012, led by the Bakken/Three Forks with 623,000 boe/d and the Eagle Ford with 531,000 boe/d.

The company is the nation’s leader in horizontal drilling with more than double the horizontal wells of the next largest company in that ranking.

The Bakken/Three Forks and Eagle Ford will continue to receive the bulk of company funding and attention, but EOG has ramped up its Permian activity since 2011.

It planned to drill 106 net wells in the basin in 2012 and generate after tax returns of 35% to 45%, according to a December 2012 presentation.

The company divides its Permian activities into two areas: the Leonard Shale (also called the Avalon) and the underlying Bone Spring and Wolfcamp zones in the Delaware Basin, and the Wolfcamp formation in the Midland Basin.

It holds 108,000 net acres in the Delaware Basin where it had drilled 42 horizontal wells and completed 39 by the time of the presentation. Its Leonard/Avalon wells offered reserves of 430,000 boe per well gross (340,000 boe per well net) after royalties and cost \$5.5 million to completion.

It also had multiple objectives lying beneath that formation.

EOG runs a two-rig program in the area. Three recent wells in Lea County, N.M., showed initial potentials of 962 b/d to 1,160 b/d, 134 b/d to 188 b/d of NGL, and 941 Mcf/d to 1.04 MMcf/d of gas. It holds a 96% working interest in those Lea County wells.

In the Midland Basin it holds 131,400 net acres of land in the Wolfcamp Shale. The core segment of that area gives the company wells with potential reserves of 430,000 boe per well gross (320 net) after royalties and cost \$5.3 million to completion.

The company has drilled 130 horizontal wells and completed 103 wells to date and is working a four-rig program in the basin. Results from five

# THE SOURCE FOR UNCONVENTIONAL RESERVOIR SOLUTIONS

Spraberry-Dean • Wolfcamp • Cline • Mississippian • Avalon - Bone Spring

## Current Core Lab Joint Industry Projects Include:

Delaware Basin Avalon, Wolfcamp, and Bone Spring  
Tight Oil Reservoirs of the Midland Basin  
Shale Reservoirs of North America

Core Lab's Regional Studies and North American Shale Project are supported by more than 100 companies and include data for more than 300 wells. This database of geological, petrophysical and geomechanical properties is the most comprehensive evaluation of unconventional resources available anywhere in the industry.

GEOLOGICAL ANALYSES

PETROPHYSICAL PROPERTIES

GEOMECHANICAL PROPERTIES

GEOCHEMISTRY

REGIONAL ASSESSMENT

PETROPHYSICAL MODELING

ROCK CATALOGS

COMPLETION OPTIMIZATION

PRODUCTION ANALYSES

FRACTURE STIMULATION



INTEGRATED RESERVOIR SOLUTIONS

[www.corelab.com/irs](http://www.corelab.com/irs)

713-328-2673





recent Lower and Middle Wolfcamp wells in Irion and Crockett counties yielded 840 b/d to 1,290 b/d, 60 b/d to 127 b/d of NGL, and 330 Mcf/d to 726 Mcf/d of gas. It controls those operations with a 75% to 77% working interest in Irion County and an 80% interest in Crockett County.

### EP Energy LP

- *Land: 138,000 net acres*
- *Growing liquids position*

EP Energy LP was created during 2012 when Kinder Morgan acquired El Paso Corp. It kept the midstream assets and sold the upstream activities as EP Energy.

The resulting upstream company held 4 Tcfe and claimed a record of a 100% success rate on 233 gross wells in 2011, including Wolfcamp properties in the Permian Basin.

The company's strongest reserves and production are in the Haynesville and Eagle Ford shales and the tight Altamont Field in Utah, with the Permian Basin in fourth place. The Permian Basin ranked third in the number of drilling locations with 938, behind Altamont with 1,336 and the Eagle Ford with 1,246, but the Permian Basin took second place in the 2012 capital budget. The Eagle Ford, with 58%, got the bulk of that budget, but the Permian Basin followed with 13% as the company turned increasingly to oily plays.

The company added a second rig to the Permian program in 4Q 2012. During the year it budgeted \$104 million to the Wolfcamp to drill 15 wells. By 3Q it had amassed 148 Bcfe in net proved reserves and had 28 net producing wells.

Between its 2011 average and the average for its five latest wells at the time, EP Energy lowered rig spud-to-release days from 28 to 17, increased fracture stages per day from 3.3 to 4.8, and lowered wells costs from \$11 million on a well with a 6,100-ft lateral to \$7.6 million on a well with a 7,300-ft lateral.

The company considers itself in full development of the Upper Wolfcamp and plans to delineate the Lower Wolfcamp during 2013.

### Laredo Petroleum Inc.

- *Land: 196,000 net acres*
- *Focused on Midland Basin shales*

Laredo Petroleum Inc., aided by its 2011 acquisition of Broad Oak Energy in 2011, runs both ver-

tical and horizontal programs as the 10th most active operator in the Permian Basin in September 2012 with six horizontal and four vertical rigs on the job.

The Permian Basin accounted for 65% of the company's reserves and 67% of its 3Q 2012 production. The company supports its operations with 740 sq miles of 3-D seismic, and it operates 97% of its production.

At year-end 2011 it held 156.5 MMboe in reserves in the Permian Basin, 64% gas. The company estimated production at year-end 2012 to be 30,7000 boe/d, 17,600 boe/d oil.

It planned a \$900 million capital budget in 2012 and earmarked \$702 million of that to the Permian Basin.

All six of its vertical rigs are working the Wolfberry zone, which includes the Spraberry, Dean, and Wolfcamp formations.

It has derisked 70,000 net acres for Cline horizontal development and 60,000 net acres for Upper Wolfcamp Shale horizontal development. It is still evaluating the Middle and Lower Wolfcamp shales in the Midland Basin.

Its prime operations area is the Garden City area in the northern Midland Basin, including Glasscock, Reagan, Howard, and Sterling counties in Texas. That area covers 142,000 net acres and represents the heart of the company's horizontal drilling in the Cline and Upper, Middle, and Lower Wolfcamp shales.

In this area the company had more than 700 vertical wells and completed 54 gross horizontal wells, including 33 Cline wells, 16 Upper Wolfcamp wells, two Middle Wolfcamp wells, and one Lower Wolfcamp well at the end of 3Q 2012. It also drilled two Strawn horizontal wells. It planned five more Upper Wolfcamp horizontal wells in 4Q along with one well each in the Middle and Lower Wolfcamp and the Cline Shale.

The company's best Cline well tested for 756 boe/d in the first 30 days of production with 15 frac stages in a 4,582-ft lateral, for an average 30 boe/d per stage.

The best Upper Wolfcamp well tested for 909 boe/d average over 30 days with 23 frac stages in a 6,128-ft lateral, also for an average 30 boe/d per stage.

Complete frac spreads and support  
in every shale play.



Dragon is there.

Frac Pumper Units

Blender Units

Data Van

Hydration Units

Manifold Trailers

Sand Dragons

Vacuum Trailers

Frac Tanks

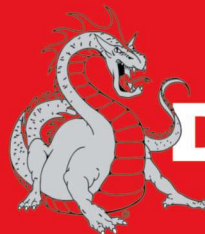
Frac Water Heater

Wherever your frac site is, we're there too, delivering all the quality equipment and support you need to get the job done. Dragon manufactures the full range of frac spread equipment in house. That means every component is severe-duty engineered to perform under the harshest conditions. Each of our field-proven frac spreads is electronically and mechanically integrated end-to-end and precisely managed through our mobile control data unit. Plus we have parts and service centers in every major shale region staffed with frac spread experts, so you always have the backup you need close by to keep your operation running. Complete equipment, support and confidence – delivered on time from one accountable source.

Make it happen.

1-866-875-2665

[www.dragonproductsltd.com](http://www.dragonproductsltd.com)



**DRAGON**  
Make it happen.

U.S. owned and operated. Founded in 1963.

© Copyright 2012 Modern Group Inc. All rights reserved.



Its only Middle Wolfcamp completion tested for 924 boe/d over 30 days with 26 frac stages in a 6,930-ft lateral to give the company 36 boe/d per stage.

The only Lower Wolfcamp well produced an average 715 boe/d for 30 days with 26 frac stages in a 6,933-ft lateral for 28 boe/d per stage.

According to IHS Inc., Laredo tested the deeper Barnett and Woodford zones in at least one well, the 51 Barbee "B" in Glasscock County.

### Legacy Reserves LP

- *Land: More than 130,590 gross acres*
- *Adding production*

Legacy Reserves LP started operations in 2005 as owner and operator of oil and gas properties acquired from founding investors and three charitable foundations. Those properties were in the Permian Basin, Mid-Continent, and Rocky Mountains, but the prime properties are in the Permian Basin.

The company went public in January 2007.

Legacy aimed most of its \$62 million capex budget for 2012 at the Permian Basin, and it directed most of that money to a one-rig vertical well drilling program in the Wolfberry play.

In late December 2012 it closed a \$520 million acquisition of properties in the southern Delaware Basin and northern Midland Basin from Concho Resources. It did not identify the target formations for those properties, but that added an estimated production of 5,230 boe/d in 1Q 2013 from 1,584 wells with proved reserves of 25.6 MMboe.

Before the Concho acquisition Legacy held 3,340 gross acres of land with a 100% interest in the horizontal Wolfbone play in Pecos County in the Delaware Basin.

It also controlled 119 gross locations in the vertical Wolfberry Trend in Midland, Upton, Andrews, Martin, and Glasscock counties with an average 67% working interest.

AREX  
NASDAQ  
LISTED

# INITIATIVE



*Our initiative drives performance.  
We seized the opportunity to be a first-mover  
in the Wolfcamp, understanding the science and  
engineering of the play and then drilling to  
achieve strong results.*



ONE RIDGMAR CENTRE 6500 WEST FREEWAY, SUITE 800 FORT WORTH, TEXAS 76116 WWW.APPROACHRESOURCES.COM

# Labs *to* Wellsite



**Bringing advanced formation evaluation techniques from the lab to your wellsite for optimal development of your assets.**

**Weatherford Labs' Wellsite Geoscience Service** brings advanced, laboratory-based formation evaluation techniques to your wellsite, enabling faster and more informed reservoir development decisions. Our unique service incorporates four innovative technologies to fully characterize cuttings samples for the rock, organic and fluid components of the reservoir in near-real time, while drilling. This coupled with the interpretive expertise of our global network of geologists, geochemists and engineers are used to make more informed drilling and completions decisions, to maximize production, minimize completions costs and increase return on investment.

***We bring the lab to you.***



Elemental Chemostratigraphy



Mineralogy



Advanced Mud Gas Detection



Programmed Pyrolysis



**Weatherford®**  
LABORATORIES

[weatherfordlabs.com](http://weatherfordlabs.com)



It had another 120,000 gross acres with a 5% working interest in the Cline Shale play in Sterling, Mitchell, Nolan, and Coke counties.

Legacy held another 7,250 gross acres with an average 78% working interest in the horizontal Wolfcamp play in Reagan, Crockett, and Upton counties, according to a December 2012 presentation.

The company also had conventional production opportunities in the Yeso and Bone Spring formations in the Delaware Basin and the San Andres and Spraberry formations in the Midland Basin.

### Legend Production Holdings LLC

- *Land: Unspecified*
- *Gathering momentum in shales*

Legend Production Holdings LLC controls Legend Natural Gas II LP, Legend Natural Gas III LP, and Legend Natural Gas IV LP, companies that acquire, develop, and sometimes sell oil and gas properties in the Texas area.

Current properties lie in the Avalon, Bone Spring, and Wolfcamp plays in the Delaware Basin segment of the Permian Basin, the Barnett Shale in North Texas, the Wilcox trend in east-central Texas, the Olmos trend in the Maverick Basin, and the South Texas tight sands.

The first Legend partnership was formed in 2001 by James A. Winne III and Michael Becci with fund-

ing from Riverstone Holdings LLC, Carlyle Global Energy, and Power Funds. The partnership sold its assets in South Texas to Chesapeake Energy in 2004 and formed subsequent partnerships in 2006 and 2009, all under the holding company.

The partnerships currently hold interests in some 800 operated and producing wells in the Fort Worth Basin, Permian Basin, and South Texas. The company's current focus is on the Delaware Basin properties in New Mexico and West Texas.

### LINN Energy LLC

- *Land: 30,000 net acres*
- *Downsizing the Wolfberry*

LINN Energy LLC holds properties throughout the US as it follows its strategy of acquiring, developing, and maximizing cash flow from long-lived oil and gas leases.

That strategy turned the company into the 11th largest domestic independent oil and gas company and the eighth largest public master limited partnership with control over 15,000 gross productive wells.

Among recent acquisitions, it bought the Salt Creek carbon dioxide waterflood in the Powder River Basin of Wyoming from Anadarko Petroleum and the Jonah Field properties in southwestern Wyoming from BP.

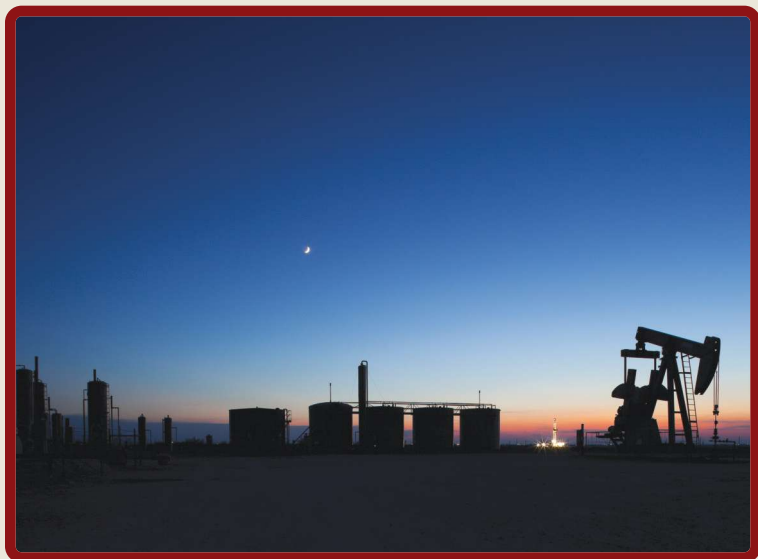
The company held approximately 5.1 Tcfe in proved reserves at year-end 2011, and about 10%, or 527 Tcfe, of those proved reserves were in New Mexico waterfloods and Wolfberry Trend wells in the Midland Basin segment of the Permian Basin.

Those Permian properties provided 79% oil and NGL and were 56% proved developed.

The company has 400 drilling locations in the Wolfberry, making that its smallest operating area in terms of drilling locations, but the 10% proved reserve ranking puts it ahead of the Williston Basin/Powder River Basin with 4% of reserves, California with 4% of reserves, and Michigan/Illinois with 6% of reserves.

The Permian Basin is well behind Jonah Field and the company's Hugoton Basin and Texas/Oklahoma panhandle regions in terms of proved reserves.

According to the company's website, LINN entered the Permian Basin in 2009 with the acqui-



An aggressive acquisition program during 2010 gave LINN Energy a substantial position in the Permian basin. It's now the company's second largest operating area. (Photo courtesy of LINN Energy LLC)

sition of properties in New Mexico and Texas and added bolt-on properties to build it into an asset with 88 MMboe in proved reserves.

“Through year-end 2011 we closed 10 Permian acquisitions for a total of approximately \$1.5 billion. We now have more than 100,000 net acres and operate more than 1,300 producing wells in the region. We increased full-year 2011 production 135% over full-year 2010 production,” the company said.

That acreage includes more than 30,000 net acres in the Wolfberry trend where the company drilled 114 operated wells with six rigs in 2011. Those Wolfberry wells produce from Spraberry, Wolfcamp, and Strawn zones.

The company said it was conducting a 20-acre infill pilot program in the Wolfberry, including microseismic evaluation to guide an infill development program that could double its inventory of Wolfberry locations.

### Lynden Energy Corp.

- *Land: 6,730 net acres*
- *Accelerating Wolfberry development*

Lynden Energy Corp., pushed by favorable results, focused its full drilling resources for 2012 on its Wolfberry development project in the Midland Basin.

The Vancouver, British Columbia, company entered into a participation agreement in October 2009 to acquire interests in 16,500 gross acres of leases in Glasscock, Howard, Martin, Midland, and Sterling counties where Wolfberry was the primary target under five areas of mutual interest.

Lynden's share of production amounts to 43.75% of the seller's interests, which range from 50% to 100% in the leases. In return, Lynden pays half of the drilling and completion costs attributable to those interests and the first \$2 million on any new leases or extensions of existing leases.

In 2010 an independent engineering firm estimated proved and probable reserves of 8.25 mil-



**LARIO OIL & GAS COMPANY**  
ESTABLISHED 1927

**WWW.LARIO.NET**

1-855-GO-LARIO WTXLAND@LARIO.NET

**Lario Oil & Gas Company** has been active in the Permian since the 1940's, so if you need a tried and true partner for your West Texas resource play, *give us a call.*



lion bbl of oil and 22 Bcf of gas for the company, all in the Wolfberry Project.

In November 2012 the company reported in first fiscal quarter 2013, ended Sept. 30, a production of 980 boe/d, all from the Wolfberry.

At that time, Lynden had 53 gross (22.45 net) Wolfberry wells on production, including eight gross (3.41 net) new wells tied in during the quarter. It also had six gross (2.49 net) wells spud or drilled and awaiting completion or hookup. It planned to exit 2012 producing between 900 boe/d and 1,000 boe/d after royalty payments.

The company planned to start drilling 43 gross (18.14 net) Wolfberry wells from July 1, 2012 to June 30, 2013 at a net cost of approximately \$44 million, or about \$2.1 million per well.

In December 2012 Lynden agreed to sell its interest in 16 gross (seven net) Wolfberry Project wells and leases covering 1,440 gross (630 net) acres to BreitBurn Energy Partners LP for \$25 million.

### Molopo Energy Ltd.

- *Land: 26,000 net acres*
- *Sharp production increase*

Proof that Permian Basin shales represent a world-class resource comes from Australia's Molopo Energy Ltd.

The company sold its Queensland, Australia, coalbed methane properties to PetroChina for US \$43 million and downgraded its Saskatchewan Midale prospect to concentrate on its Wolfcamp Shale holdings in the southern Midland Basin. It regards its South Africa and Quebec properties as noncore assets at this time.

In a November 2012 presentation for its annual meeting, the company said it booked its first reserves in the Wolfcamp during 2012 after drilling nine Wolfcamp wells in 2011 and 2012.

Two wells were drilled and are flowing from its 1,400-acre Barnhart property in Irion County, and another well was drilling in November, all to the Wolfcamp B bench.



The advertisement features a large graphic on the left with a red and yellow curved background. It contains several hexagonal images: one showing a coiled tubing rig, another showing a worker in a hard hat, and a third showing a worker in a hard hat. The text 'Key Energy Services' is prominently displayed in blue and red. Below it, 'Coiled Tubing Services' is written in blue. A list of services is provided, including Jet Cut Perforating, Nitrogen Jetting, Fracturing, Fluid Placement, Well Cleanout, Milling and Drilling, Fishing and Rental, and Stiff Wireline/E-coil. The bottom of the ad includes the text 'Save time and money with Key's Coiled Tubing Services.' and 'Learn more about Coiled Tubing Services at keyenergy.com'.

**Key**<sup>®</sup>  
Energy Services

Coiled Tubing Services

Save time and money  
with Key's **Coiled Tubing Services.**

- Jet Cut Perforating
- Nitrogen Jetting
- Fracturing
- Fluid Placement
- Well Cleanout
- Milling and Drilling
- Fishing and Rental
- Stiff Wireline/E-coil

Learn more about  
Coiled Tubing Services at  
**keyenergy.com**

At its 24,600-acre Fiesta property in Crockett County, the company drilled three wells to prove up the oil window. It followed up with two wells to the A bench, which continued to stabilize in November, and its first B bench well still was in the flowback stage.

Results from those wells will determine the company's development budget for calendar year 2013.

Early results from the Wolfcamp prompted Molopo to buy out its partner's 22% interest in the Fiesta property in April 2012.

It posted reserves in the Wolfcamp for the first time during 2012 with 1.8 Bcf of gas and 465,000 bbl of oil in proved and probable reserves.

Molopo plans to fast-track its Texas holdings with an estimate to raise production from 499 boe/d in the quarter ended June 30, 2012 to approximately 2,300 boe/d by year-end.

The combined A, B, and C benches of the Wolfcamp offer 480 well locations at four wells per section and estimated ultimate recovery (EUR) of 216

MMboe, or 720 wells at six wells per section and an EUR of 324 MMboe.

The company also has potential for production from deeper Canyon and Ellenberger sands.

### Nadel and Gussman LLC

- *Wolfcamp and Avalon properties*
- *Going slow, watching other operators*

Nadel and Gussman LLC holds properties with potential unconventional production in the Delaware and Midland basins.

According to a February 2011 article in Oil and Gas Investor magazine by Steve Toon, the company has more than 80 Avalon Shale locations in New Mexico, but it was watching and waiting while others evaluated the shale.

At that time Scott Germann, general manager of Nadel and Gussman Permian LLC, said, "If you look at the decline plots, the gas decline is fine, but the oil portion has a rapid decline. There's no flat-



## Nobody Understands Cleaning Like



**Hotsy has been providing Pressure Washing Equipment to the Oil & Gas Industry since 1970!**

### Hotsy is the brand leader...

- Hotsy manufactures industrial-grade washers - choose from over 100 hot or cold water pressure washers.
- Equipment suitable for oil rigs - electric and diesel fired units that meet safety requirements.
- No open flame - much safer to use than a traditional fired burner
- Very little maintenance required - oil field ready!
- Heavy angle iron frame and chassis with durable powder coat paint resists years of corrosion and rugged use.
- ETL certified to UL-1776 safety standards.
- The best warranties in the industry!

**Hotsy pressure washers are sold exclusively through our dealer network located throughout the Permian Basin. To find your dealer, visit our website at [www.hotsy.com](http://www.hotsy.com)**



Scan to watch our video: Hotsy & the Oil Industry



tening in the oil.” When he made that statement, the first well targeting the Avalon was only 18 months old, and most wells in the play had less than 12 months of data for analysis.

Nadel and Gussman formed a 50:50 joint venture (JV) in 2008 with Harvey E. Yates Co. (HEYCO) called Nadel and Gussman HEYCO LLC, with HEYCO contributing properties with high oil potential.

Germann said the JV planned five or six operated horizontal wells in 2011, and one of those would target the Avalon Shale.

The companies formed the JV primarily to exploit the Bone Spring formations in Eddy, Lea, and Chavez counties in New Mexico.

Under Nadel and Gussman Permian LLC, the company also works the Wolfcamp zone in the Midland Basin.

According to IHS Inc., that company planned to drill the 2 Vaqueros “47” well to the Wolfcamp in

Clyde Reynolds Field in eastern Glasscock County in 2011.

In late 2010, also in Glasscock County, the company tested the 117 Bearkat pumping 72 b/d of oil and 320 Mcf/d of gas from perforations between 7,058 ft and 9,650 ft. Log tops in that well included the Upper Wolfcamp at 6,874 ft, Middle Wolfcamp at 7,204 ft, Lower Wolfcamp at 7,503 ft, Canyon/Cline at 8,979 ft, Strawn/Carbonate at 9,298 ft, and Strawn/Woodford at 9,526 ft.

The company scheduled other wells nearby.

### Otis Energy Ltd.

- *Land: Approximately 24,000 gross acres*
- *Small stakes may grow*

It is a long way from Western Australia to the Lea County, N.M., section of the Delaware Basin, but Otis Energy Ltd. likes the potential.

The company has minor interests in two projects in the county. It has a 5% working interest (3.75% net revenue interest) in the Sombrero Project and a 5.5% working interest (4.79% net revenue interest) in the Charro Project.

Only one well had been drilled at Sombrero by 3Q 2012. The WC 35 State #1 did not meet performance expectations. Otis and the operator were trying to find a completion that would improve production.

The company’s wells in the area will target the Wolfcamp/Cisco shales but offer additional potential from Queen, Grayburg, Paddock, Atoka, and Morrow formations.

Otis acquired its interest in the Charro Project in early 2012. The Paddock/Blinebry conventional zones are the primary target, but the land also holds potential for Abo, Wolfcamp, Cisco, Atoka, and Morrow production.

### Occidental Petroleum Corp.

- *Land: 1.03 million net acres*
- *Searching shales for growth*

Occidental Petroleum Corp. (Oxy), the largest oil producer in the Permian Basin and Texas and the largest operator of CO<sub>2</sub> enhanced recovery projects in the Permian Basin, boasts a huge shale inventory and an aggressive land acquisition program in West Texas and southeastern New Mexico.

## LW Survey Company

Minority Business Enterprise (MBE)

- Pipeline Integrity Surveys
- Well Package Development
- GIS/Data Operations
- Project Cost Analysis
- GPS Network Design
- Civil Survey Automated & Conventional
- 3-D Mapping Laser Scanning Surveys

- Dimensional Survey
- Project Management
- Automated Mapping
- Right of Way
- Inspection
- Route Selection
- Land Survey
- Procurement
- LiDAR



**Locations:**

■ Anchorage, AK	■ Houston, TX
■ Calgary, AB, CAN	■ Minot, ND
■ Cheyenne, WY	■ Pittsburgh, PA
■ Chicago, IL	■ San Antonio, TX
■ Denver, CO	■ Tulsa, OK
■ Duluth, MN	

Coming soon! Ohio

Contact:

www.lwsurvey.com  
businessdevelopment@lwsurvey.com





The company holds properties in Yemen, Iraq, Libya, Bolivia, Colombia, Oklahoma, Kansas, Colorado, Utah, and North Dakota, but its focus areas are in Oman, the United Arab Emirates, Qatar, Bahrain, California, and the Permian Basin.

It produces a net 15% of all Permian oil and holds more than 1 Bbbl of proved reserves in the Permian Basin formation. Its biggest operation lies in high-return CO<sub>2</sub> projects, but it is taking a closer look at shales.

Its capital allocation to the Permian Basin in 2012 was about 75% higher than 2011, the company said on its website.

In a November 2012 presentation the company said it had planned to meaningfully decrease capital spending starting in 3Q, but that “would have resulted in inefficiencies in areas where we have seen positive results, such as the Permian, parts of California, and Oman.”

It did sharply reduce its spending on pure gas projects and even cut back on some liquids-rich projects to focus its activities on oil. It succeeded in increasing production by 6,000 boe/d to 8,000 boe/d from 3Q 2011 to 3Q 2012, but it expected overall production to remain flat between the third and fourth quarters of 2012 as gas production declined from lack of investment while oil production increased.

Among the company’s growth drivers are its CO<sub>2</sub> and non-CO<sub>2</sub> projects in the Permian Basin. It produced 209,000 boe/d from the basin in 3Q 2012 and was the largest among approximately 1,500 operators working in the area.

Significantly, the company’s property position in the basin grew sharply, from approximately 3 million gross (1 million net) acres earlier in 2012 to 4.78 million gross (1.71 million net) by October.

Among non-CO<sub>2</sub> projects with shale in the Delaware Basin, the company held 340,000 gross (120,000 net) acres in the Avalon Shale, 130,000 gross (30,000 net) acres in the Wolfbone play, 570,000 gross (200,000 net) acres in the Wolfcamp Shale, 420,000 gross (160,000 net) acres in the Delaware Shale, and 320,000 gross (120,000 net) acres in the Penn Shale.

In the Midland Basin it held 390,000 gross (160,000 net) acres in the Cline Shale, 400,000 gross (140,000 net) acres in the Wolfcamp Shale, and 280,000 gross (100,000 net) acres in the Wolfberry play.

That means, among Oxy’s 1.71 million net acres in the Permian Basin, 1.03 million net acres are prospective for shales or shale combinations.

According to the presentation, when the company buys properties in the US, it expects returns of at least 15% from its investment.

Oxy called its non-CO<sub>2</sub> projects its fastest-growing assets with production up more than 25% since 2010.

In a May 2010 presentation the company recognized the potential of the Permian Basin and put 10% of its 2010 capex, or \$450 million, into the basin. At that time, it said it would invest 13% of its \$27.5 billion in planned capex in the basin.

At that time, the company controlled more than 550 locations in the Wolfberry play with potential production of more than 70 MMboe. Its largest Wolfberry asset was the 250-well Dora Roberts Field in Midland County. It held Wolfberry properties in Ector County.

It also had interests in Wolfcamp production in Terrell, Glasscock, Pecos, Loving, Reeves, Ector, Andrews, Winkler, and Ward counties.

It also had some Woodford Shale production from Andrews County.

### **Pioneer Natural Resources Co.**

- *Land: 400,000 acres*

- *Massive Wolfcamp potential*

Pioneer Natural Resources Co. works production areas from South Texas to Alaska, but its three prime focus areas lie in Texas with the Eagle Ford in South Texas and the Spraberry and horizontal Wolfcamp plays in West Texas.

According to a December 2012 presentation, it posted strong enough drilling performance in all three areas during 2012 that they drove Pioneer’s production growth.

Pioneer illustrated the importance of the Wolfcamp Shale in its portfolio, a portfolio that already includes the dominant position in the vertical Spraberry play. It held 1.1 Bboe in proved reserves at the end of 2011, including 609 MMboe in the



# Wolfcamp Comparison to Other Plays

**PIONEER**  
NATURAL RESOURCES

Major Oil Shale Play Characteristics

Attribute	Units	Wolfcamp Shale <sup>1</sup>	Eagle Ford <sup>2</sup> (Oil Window)	Barnett Shale <sup>3</sup> (Combo Play)	Niobrara <sup>4</sup>	Bakken <sup>5</sup>
Age		Permian	Cretaceous	Mississippian	Cretaceous	Devonian/Mississippian
Basin		Midland	South Texas	Fort Worth	Denver	Williston
TVD Depth	ft	5,500 - 11,000	7,500 - 11,000	5,000 - 8,000	4,000 - 8,000	9,000 - 11,000
Thickness	ft	1,500 - 2,600	50 - 350	200 - 400	250 - 600	25 - 125
OOIP/Section	MMBO	80 - 220	30 - 90	70 - 90	20 - 40	10 - 20
Porosity	%	2 - 10	4 - 11	4 - 5	4 - 14	5 - 8
Quartz	%	20 - 50	10 - 25	25 - 40		30 - 60
Carbonate	%	10 - 60	60 - 75	6 - 25	~70	30 - 80
Clay	%	10 - 45	10 - 40	25 - 50		25
Permeability	nd	10 - 3,000	40 - 1,300	150 - 200	<10,000	50,000 - 500,000
Pressure Gradient	psi/ft	0.55 - 0.70	0.65 - 0.70	0.54	0.43 - 0.55	0.43 - 0.75
Recovery Factor	%	3 - 15	3 - 10	4	5 - 10	8 - 15

**Wolfcamp compares favorably to other major oil shale plays**

1) Pioneer internal research (modified according to recent core and petrophysical data)

2) EOG Analyst Conference April 2010

3) AAPG Bulletin April 2007, Hart Energy Databank December 2011, HIS, REPSI, EOG February 2010 Investor Presentation

4) Hart Energy Databank December 2011, Oil & Gas Investor June and August 2011

5) Tudor, Pickering, Holt, "The Bakken Momentum Continues" November 2011, Hart Energy Bakken Playbooks 2008 and 2010, Jarvie - AAPG Section Meeting 2008

The Wolfcamp Shale in the southern Midland Basin compares favorable with other prominent US shale plays.  
(Table courtesy of Pioneer Natural Resources Co.)

Spraberry. At that time, it had not booked proved reserves in the Wolfcamp.

In late 2012, it claimed an upside net resource potential of 5.6 Bboe from 35,000 potential drilling locations. Within that number, it estimated 3.5 Bboe in net resource potential in the Wolfcamp Shale from 8,000 potential drilling locations.

Pioneer is willing to share. In the December presentation, the company said it offered a 33% to 50% joint venture interest in the company's working interest in approximately 200,000 net acres of land in Upton, Reagan, Irion, and Crockett counties in the southern Midland Basin prospective for Wolfcamp Shale. That property includes an estimated 4,000 potential locations, not counting downspacing potential. It also contains some 2 Bboe of gross resource potential with a 90% liquids content.

Wells with 7,000-ft laterals in that area offer estimated ultimate recoveries of 575,000 boe and an approximate 45% before-tax internal rate of return with a well cost of \$7 million, an oil price of \$85/bbl, and a gas price of \$4/MMBtu.

In late January 2013, Pioneer signed an agreement to sell 40% of approximately 207,000 net acres in the Wolfcamp Shale play to Sinochem Petroleum USA LLC for \$500 million in cash and \$1.2 billion to cover 75% of drilling and facilities costs in developing the play. Sinochem Petroleum is a US subsidiary of China's Sinochem Group. The companies expected the deal to close in 2Q 2013.

Pioneer will remain operator of the contract area, which covers all formations in the Wolfcamp and deeper formations in portions of Upton, Reagan, Irion, Crockett, and Tom Green counties in Texas.



*Logs Since 1971*

**LOGS LOGS**  
**LOGS**

**OVER 6 MILLION WELL LOGS**  
**FROM THE ARCTIC TO THE GULF OF MEXICO**

**WOLFCAMP**

**THREE FORKS**

**CARDIUM**

**EAGLEFORD**

**HAYNESVILLE**

**BAKKEN**

**MONTNEY**

**WOODFORD**

**FAYETTEVILLE**

**HORN RIVER**

**BARNETT**

**NIOBRARA**

**DUVERNAY**

**[www.mjlogs.com](http://www.mjlogs.com)**

**1-800-310-6451**



The companies plan to drill 86 horizontal Wolfcamp Shale wells in 2013 and increase activity to 120 wells in 2014 and 165 wells in 2015.

The company has experience to calculate the value of its Wolfcamp assets. By the end of January 2013, it had drilled 39 horizontal Wolfcamp wells. It had 22 wells on production and four more flowing back. Of the 22 wells on production, it completed 20 in the B interval and two in the A zone. Production for the Wolfcamp averaged approximately 2,000 boe/d during 2012 and 5,000 boe at year-end.

The company did not slow its Wolfcamp program while awaiting potential joint venture partners. In December, it focused its activities on some 50,000 acres in the southern part of the play where it expected to drill 90 wells by year-end 2013 to hold the acreage after drilling 30 to 35 wells throughout the play in 2012.

It ran five rigs in 3Q 2012 but expected to increase that number to seven late in 4Q and early 1Q 2013. Four of the five rigs were working the southern area in early December. It allocated \$120,000 million in 4Q 2012 to fund that five-rig program.

The company's northern area, with one rig working, includes Midland, Martin, and Gaines county properties.

It completed many of its wells with 7,000-ft laterals, but it drilled one well in 19 days with a 10,000-ft lateral section.

With its opportunities in the Eagle Ford, Spraberry, and Wolfcamp, Pioneer planned to divest its 120,00 net acres in the Barnett Shale play in North Texas and allocate those funds to "higher return" Texas properties.

The company has development plans for the Wolfcamp. It can drill up to 55 wells on a 960-acre segment of land with 20-acre field rules.

That tract would support 41 vertical Spraberry-Wolfcamp (Wolfberry) wells and up to 14 horizontal Wolfcamp wells, seven wells each in the Wolfcamp A and B benches. It could drill additional horizontal wellbores in the C and D benches.

A project of that makeup would require \$180 million and provide the company with a resource potential of approximately 15 MMboe at a \$15/boe finding and development cost.

It would space its vertical wells 900 ft from other vertical wells and 360 ft from horizontal wells. Horizontal wells would be spaced 725 ft from other horizontal wells drilled to the same interval.

## Quicksilver Resources Inc.

- *Land: 155,000 net acres*
- *Testing Permian Basin shale*

Quicksilver Resources Inc. taps a long history of operations in resource plays from coalbed methane (CBM) through shales as it drills its initial wells in the Permian Basin.

In Canada the company finished its first eight-well pad to Klua and Muskwa shales in the Horn River Basin. It also holds property in the Horseshoe Canyon CBM play.

Its anchor program in the US rests in North Texas in the Barnett Shale.

In September 2012 the company signed an acquisition and exploration with the SWEPI LP subsidiary of Royal Dutch Shell to develop more than 850,000 acres in the Sand Wash Basin of northern Colorado and southern Wyoming in search of Niobrara Shale.

It also holds property with Bakken potential in the Montana portion of the Alberta Basin.

In its 3Q 2012 report to shareholders Quicksilver said it recompleted the Price Ranch 31 well in Pecos County, Texas, in the Delaware Basin with a 1,500-ft lateral in the third Bone Spring for 300 boe/d. That is not an unconventional zone, but the area also has potential for shallower Avalon and deeper Wolfcamp shales.

The company also reentered the Vande Ranch State 1H in Upton County in the Midland Basin in 3Q 2012 and was completing the well with a 2,500-ft lateral in the Wolfcamp Shale.

Of the 155,000 net acres the company holds in the Delaware and Midland basins, Quicksilver said approximately 105,000 net acres are in the oil window of the Wolfcamp and Bone Spring formations.

## Royal Dutch Shell plc

- *618,000 net acres*
- *Shell reenters Permian Basin*

Royal Dutch Shell Plc is no stranger to the Permian Basin. In the 1970s it built one of the biggest CO<sub>2</sub> enhanced recovery operations in the world in the

**LUFKIN***Expect More*

*More* **SYSTEMS**  
*More* **SERVICES**  
*More* **LOCATIONS**



Pump jacks with legendary quality and reliability have been the reputation of Lufkin for more than 100 years. In that same tradition, Lufkin now offers more artificial lift systems, more support services and more locations to serve operators around the world. These highly engineered solutions, supported by our experienced staff, deliver optimum production from your oil and gas wells.

Now, more systems and services to meet your requirements:

- **Automation**
- **Beam Pumping Units**
- **Hydraulic Pumping Units**
- **Reciprocating Pumps**
- **Progressing Cavity Pumps**
- **Production Optimization**
- **Well Monitoring**
- **Secure Scada**
- **Plunger Lift**
- **Gas Lift**
- **Completion Products**
- **Maintenance & Repair**
- **Training**

Scan for More Product Information ➤



*The Energy Flows Through Us®*

LUFKIN.COM



Permian Basin. Now it is back in the basin looking for shales.

The company already holds approximately 900,000 gross acres in the Marcellus play in Appalachia, largely due to its acquisition of East Resources. It also runs the Mahogany Project in the Piceance Basin of western Colorado in an effort to hone in situ production of kerogen from shale.

In September 2012 it waded back into the Permian Basin with a US \$1.935 billion purchase of approximately 618,000 acres of land in the Delaware Basin from Chesapeake Energy. That Texas and New Mexico property has potential for production from the unconventional Avalon and Wolfcamp shales and the conventional Third Bone Spring sandwiched between the two shales.

The properties produced 26,000 boe/d and had “significant growth potential” at the time of the sale, Shell said.

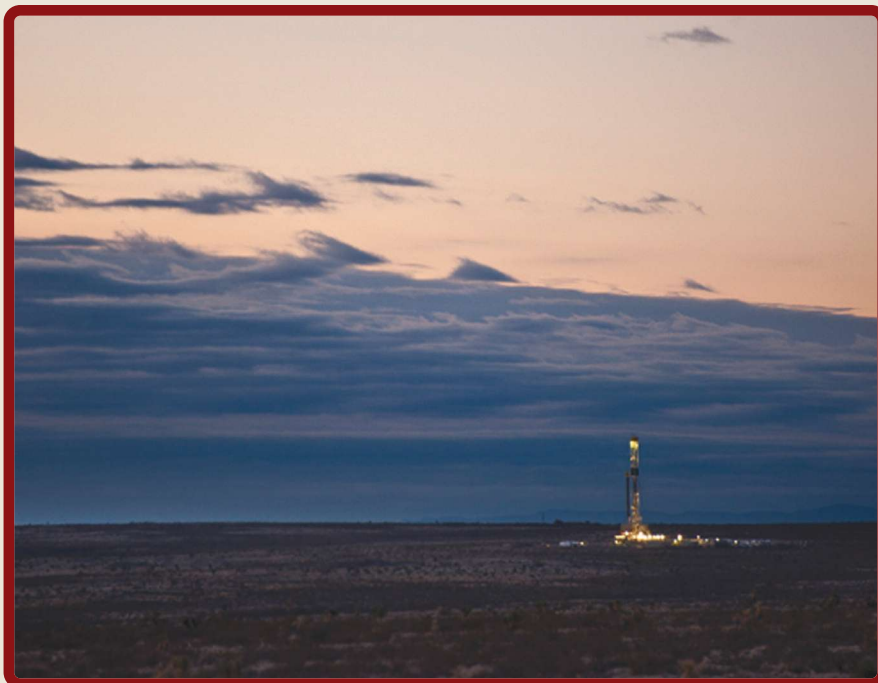
Chesapeake had been involved in a joint venture (JV) with Anadarko Petroleum on Delaware Basin properties, but releases from the company did not say whether those JV properties were involved in the sale.

At the same time, Chevron said it had acquired 246,000 net acres of land in the Delaware Basin from Chesapeake.

### **Resolute Energy Corp.**

- *Land: 8,850 net acres*
- *Production cash flow supports E&P*

Resolute Energy Corp. uses its producing assets in Utah and Wyoming to provide funds to support exploration and development in North Dakota and the Permian Basin in West Texas.



Resolute Energy entered the Permian Basin in early 2011. *(Photo courtesy of Resolute Energy)*

Much of that cash flow comes from the CO<sub>2</sub> flood at giant Aneth Field and nearby McElmo Creek Field in the Paradox Basin of southeastern Utah and from Hilight Field’s Muddy production in the Powder River Basin in northeastern Wyoming.

Those funds provide cash for its developing properties, including those in the Permian Basin.

Before a December 2012 acquisition the company held 6,532 net acres across the Permian Basin. Approximately 44% of reserves in those properties came from the Wolfberry play in Howard County in the Midland Basin of Texas, while another 36% came from conventional production in Lea County, N.M., according to a December 2012 presentation.

Those properties also include Wolfbone properties in Reeves County in the Delaware Basin.

Resolute planned to work two rigs in the Permian Basin through year-end 2012 to work some 90 net locations and drill and complete 19 gross (14.1 net) wells.

The company’s focus during 2012 was the Wolfbone, a combination of the Third Bone Spring and Wolfcamp Shale, where it worked one drilling rig.



*Going the **extra mile** on the road and off*

Thomas Petroleum has been providing top-of-the-line products and services for over three decades. Thomas specializes in products, equipment and programs that provide solutions to all aspects of your business. As a customer and valued business partner, Thomas is your single point of contact for all of your fuel, lubricant & chemical needs.

## SERVICES

- Frac Fueling Services
- On Site Fueling
- Natural Gas Compression Oils
- Gas Treating
- Total Fluids Management
- Product Integrity Programs
- Reliability Based Lubrication Programs
- Extended Drain Programs
- Chemicals and Specialized Amines

[www.thomaspetro.com](http://www.thomaspetro.com) • 1.800.987.7204





The other rig will test Mississippian and Spraberry conventional zones and Cline and Wolfcamp shales. The company holds 11 net locations in that area, completed seven wells in 2012, and has 11 undrilled locations on 40-acre spacing. It held 750 acres in the Midland Basin.

In December 2012 the company said it acquired properties in Howard County, Texas, and Lea County, N.M., for US \$120 million.

The 1,310 net acres in Howard County primarily targeted the Wolfberry play and produced a net 377 boe/d in 3Q 2012.

The Lea County properties produced from 39 wells in conventional fractured carbonates.

### Sumitomo Corp.

- *Land: 650,000 gross acres*
- *Forms joint venture with Devon*

Japan's Sumitomo Corp. joined the parade to the Permian Basin when it formed a joint venture with Devon Energy Corp. for a 30% share of 650,000 net acres in the Cline and Wolfcamp shale plays in the Midland Basin.

Sumitomo agreed to put up US \$340 million in cash and another \$1.025 billion in drilling carries to fund 70% of Devon's capital requirements in the venture properties. In all, Sumitomo will pay 79% of the drilling costs.

The companies planned to drill 40 wells in 2012 and use the entire \$1.025 billion by the middle of 2014, although the companies expect drilling to continue for at least 15 years. Devon will operate the project.

The properties are in the eastern part of the Permian Basin.

Sumitomo also has interests in the Barnett and Marcellus shales.

In November 2012 IHS Inc. reported Devon permitted two horizontal wildcats in an apparent attempt to extend its Wolfcamp and Cline shale programs along the eastern shelf of the Permian Basin. The wells are the 1H and 2H Flat Top Ranch "M" wells, with one in Haskell County and the other in Stonewall County.

### Summit Petroleum LLC

- *Land: More than 6,000 gross acres*
- *From the founders of the Wolfberry play*

Summit Petroleum LLC started under the

direction of Dennis Johnson, one of the people largely responsible for the initiation of the Wolfberry play.

Industry history gives credit for the Wolfberry play idea to Dave Feavel, an employee of Henry Petroleum. Jim Henry and Dennis Johnson were Feavel's bosses at Henry Petroleum.

The Henry team analyzed the Wolfcamp and put together the completion combination that made the Spraberry-Dean-Wolfcamp (Wolfberry) play profitable. Johnson left Henry Petroleum to become president and later chairman and CEO of Summit. Concho later acquired Henry in 2008, and Jim Henry formed Henry Resources.

In a March 2012 release on mywesttexas.com, Matt Johnson, who worked with Dennis Johnson to form Summit, said the company's operations included roughly 500 undeveloped Wolfberry locations in Upton and Midland counties on 40-acre spacing and more than 1,000 additional potential locations in nonoperated Wolfberry and emerging vertical and horizontal plays.

At that time the company had a net budget of more than US \$100 million and 10,000 boe/d of gross operated production.

### Victory Energy Corp.

- *Land: 3,408 gross acres*
- *Building in the Wolfberry from a small base*

Victory Energy Corp. acquires, explores, and produces oil and gas properties through its partnership with Aurora Energy Partners with properties in Texas and New Mexico.

It has two properties that aim for production from the Wolfberry. The Lightnin' property in Glasscock County, Texas, covers 320 acres surrounded by Wolfberry production by veteran operators. The company calculates a mid-case estimated ultimate recovery of 175,000 boe with a potential to drill eight vertical wells on 40-acre spacing. The holding may support 20-acre spacing. Victory paid US \$480,000 for the stake.

Victory planned to farm out a half working interest in the prospect. That would leave Victory with a 25% working interest (18.75% net revenue interest) in the prospect. Unitex Oil and Gas LLC will operate the property.

Delivering Clean  
Water Management Solutions

**TETRA<sup>®</sup> STEEL 800**



**TETRA<sup>®</sup>**

*Celebrating 30<sup>th</sup> Year*

**EXTENSIVE WATER MANAGEMENT & FLOW BACK EXPERIENCE IN UNCONVENTIONAL SHALE GAS & SHALE OIL PLAYS:**  
BAKKEN, BARNETT, EAGLE FORD, FAYETTEVILLE, GRANITE WASH, HAYNESVILLE, MARCELLUS, NIOBRARA, PICEANCE, UTICA & WOODFORD

## WATER MANAGEMENT SOLUTIONS

- TETRA<sup>®</sup> STEEL 1200/800 Water Transfer System
- BioRid<sup>®</sup>/TETRA<sup>®</sup> Clean Treatment
- Process Water On-The-Fly Treatment & Recycle/Reuse
- TETRA<sup>®</sup> STEELWATERZ<sup>™</sup> Custom Water Containment

## PRODUCTION ENHANCEMENT SERVICES

- Well Testing
- Frac Flow Back
- Sand Management
- Early Production Facilities
- Data Acquisition Systems
- Rig Cooling Solutions

**Focused on Energy.  
Dedicated to Service & Safety.**

© 2013 TETRA<sup>®</sup> Technologies, Inc. All Rights Reserved.  
TETRA and the TETRA logo are registered trademarks of TETRA Technologies, Inc.

tetrattec.com  
pt\_sales@tetrattec.com





The companies plan to drill the first well in 1Q 2013.

Victory also has a stake in the ClearWater Project in the Wolfberry trend, a Howard County property that produced from three wells in late 2012.

The company, through Aurora Energy Partners, has a 1.5% working interest (1.125% net revenue interest) in 3,186 gross acres in the project. Development started in May 2011.

### **Whiting Petroleum Corp.**

- *Land: 91,258 net acres*
- *Working the Delaware Basin*

Whiting Petroleum Corp. targets the Bakken/Three Forks formations in North Dakota as the prime source of its income but maintains high-potential properties in the Delaware Basin segment of the Permian Basin, as well.

The company is one of the largest landholders in the Bakken play and the second largest oil producer in North Dakota. It also operates one of the largest enhanced oil recovery projects in the US at its North Ward Estes CO<sub>2</sub> project in Ward and Winkler counties in Texas.

According to a December 2012 presentation, the company also holds 121,461 gross (91,258 net) acres with vertical Wolfbone and horizontal Wolfcamp and Bone Spring potential in its Big Tex project in Pecos, Reeves, and Ward counties in the Delaware Basin. Interests vary by well but generally work out to a 76% working interest and a 57% net revenue interest.

One Wolfcamp well, the May 2501 H, came in at 323 boe/d, and the company had two more Wolfcamp horizontal wells awaiting completion in December.

The company listed proved reserves of 122.5 MMbbl and 38.1 Bcf of gas, or 128.8 MMboe, or 27% of corporate proved reserves in the Permian Basin.

Whiting set aside US \$97 million in capex for the Permian Basin in 2012, or 5% of its corporate total, to drill 19 net wells. It has 838 gross (338 net) proved, probable, and possible drilling locations on its properties — more than any other corporate area, including the Williston Basin.

### **W&T Offshore Inc.**

- *Land: 34,500 net acres*
- *Onshore prospects back offshore emphasis*

W&T Offshore Inc., as its name implies, directs much of its expertise to its Gulf of Mexico operations, but the company began assembling onshore properties during 2010 and continued into 2012.

One assembly point was the Permian Basin, where W&T put together its Yellow Rose and Terry County program, both with horizontal Wolfcamp wells.

In a December presentation the company said it held 23,400 acres at Yellow Rose, a property in Dawson, Martin, Andrews, and Gaines counties that produced approximately 3,500 boe/d from vertical wells. It drilled 59 wells on the property and completed 53 wells through October 2012. That production increased 25% in the 60 days before the presentation.

In that mix the company drilled three horizontal Wolfcamp wells, and at the time of the presentation, all three were awaiting completion or were flowing back frac fluids.

Wolfcamp horizontal wells on that property cost US \$6.5 million to drill and complete. The company planned to spud another Wolfcamp horizontal well in December 2012 and continue drilling vertical wells, including a 40-acre-spacing pilot project.

It drilled two additional horizontal Wolfcamp wells on its Terry County property. At the time of the presentation one was flowing back frac fluids, and the other had reached total depth. Wells on that 10,800-acre property cost the company \$6.3 million to drill and complete.

W&T expected to have production results from all five horizontal wells during 1Q 2013.

On its website the company said it picked up its most significant Permian Basin position, 21,500 net acres in May 2011, for \$366 million, and that property held estimated proved reserves of 30 MMboe with 91% oil and gas liquids. It held estimated probable reserves of approximately 25 MMboe.

At that time the property had approximately 75 wells producing about 2,950 boe/d and hundreds of proved and probable well locations.

W&T said it would target the Spraberry, Dean, Wolfcamp, and Strawn formations on the properties in the Wolfberry trend. ■

# What you get out of your workforce all depends on what you put in.



## The Economics of Comfort

Great food is one of the most important investments you can make in your workforce. But it's not the only one. Research has proven that in addition to nutrition, a good night's sleep and high crew morale can also have a significant impact on improving worker productivity and reducing attrition, sick days and accidents on the job. We call it the Economics of Comfort™. Your workers will call it home. To receive a case study showing how we have helped drive profits to a client's bottom line through increased worker productivity call **800-832-4242** or visit **TargetLogistics.net**.

800.832.4242 | TargetLogistics.net



**TARGET LOGISTICS**  
WHEREVER YOU GO. WHATEVER IT TAKES.



# Investigating New Tools, Technologies for the Permian Basin

While challenges have driven some companies away from West Texas, others have found success through innovation.

**By Glenn R. Meyers**  
Contributing Editor

**T**his land of few trees and little water features the country's largest basin, one that's been producing oil for approximately 90 years. Featuring what geologists call one of the world's thickest deposits of rocks from the Permian geologic period and measuring 102,000 sq miles, this hydrocarbon landmark is said to contain 29% of the estimated future oil reserve growth in the US. The Permian has 150,000 producing wells and many more are planned. According to the University of Texas of the Permian Basin, the basin yields more than 1 MMbbl/d of oil, or more than 20% of lower 48 production. As for natural gas, the basin produces 4 Bcf/d. Add to this the undiscovered resources of the Permian, which a 2010 US Geological Survey estimated to be 1,257 MMbbl of oil, 40,584 Bcf of gas, and 1,021 MMbbl of NGL.

"The Permian is an interesting beast. It doesn't want to die," said Don McClean, Packers Plus technical sales. "Not every formation in the Permian has hydrocarbons entrapped in it. It's just a function of trying to get the technology to meet up with the economic recovery of it. I think we're making some strides in that regard."

How the Permian's oil and natural gas has historically been produced using vertical technologies differs distinctly in some areas today. Vertical wells are still abundant but horizontal work is now starting to dominate the discussions of operators and service companies, especially when it comes to the

Delaware Basin's horizontal shale formations like the Wolfcamp, Bone Spring, and Cline, located below the Wolfcamp in the Midland Basin.

However, knowing the trend toward horizontal plays is only one small step in this equation. Executing successful completions in this realm involves a different set of tools and technologies, not counting dealing with the realities of limitations that exist from challenges like limited water, changing chemistry configurations, new infrastructures, and environmental regulations. Add to this the knowledge that drilling horizontally is no guarantee of success; wellbore collapses and sticking have turned more than a few away from this type of play.

A range of new or advanced products and technologies are being used today in the Permian, provided by a range of companies that includes Baker Hughes (AutoTrak Curve, H2prO, RockView, Spectralog, AziTrak, XPVision, AutographPC), Halliburton (MaxForce Perforating Charges, CleanStream, CleanWave), National Oilwell Varco (Stand Transfer Vehicle, AC Ideal Prime Rig, TDS-11SH Top Drive), Packers Plus (StackFRAC), Schlumberger (Litho Scanner, HiWAY, ThruBit), Supreme Services & Specialty Co. (Sand Dehydration Station), and Universal Pressure Pumping (PFR-21 "A").

"There have been a lot of companies showing up with new processes, new gimmicks," said Jeff Wilkinson, director of sales at Universal Pressure

Pumping. “Many of them are viable and many are not cost-effective. There are a lot of logistics in there that the operators are really learning.”

The drilling distances in the Delaware Basin are ranging from 3,500 ft to 5,000 ft for the Wolfcamp and Bone Spring. In the Midland Basin, the Wolfcamp will vary from 4,000 ft to 11,000 ft. In the Cline Formation of the Midland Basin, drilling distances are trending in the 4,000 ft to 4,500 ft range.

In the Delaware Basin, oil-based mud is used to drill the horizontal Wolfcamp and Bone Spring wells. The Cline is being drilled with a specifically designed clay-free oil-based mud, said Dean Prather, Halliburton area technology manager for the Permian Basin. The Wolfcamp is being drilled with a specifically designed brine mud that has shown higher penetration rates and the ability to push the lateral length out further. “The experience we are having is we are able to drill the laterals faster because of the properties it has,” he said. “It’s been gratifying to meet or exceed expectations.”

Many horizontal plays prove to be remarkably challenging. As David Fairhurst, Schlumberger Southwest Basin ES Wireline sales manager, said, “The Permian Basin, which is made up of three separate basins, is one of the most complex, highly laminated, especially unconventional resources in the world. It’s the proving ground for all of our formation evaluation tools – if they are going to work there, they will work anywhere, whereas in a lot of unconvensionals one will have several hundred feet with a payzone. In the Permian, one will have thousands of feet of gross thickness interspersed with various payzones. It requires the best formation evaluation available.”

### **Spectroscopy tools for horizontal work**

The Schlumberger Litho Scanner high-definition (HD) spectroscopy service provides gamma ray spectroscopy for detailed description of complex reservoirs. This tool was designed for precisely measuring key elements in a variety of rock formations like those in these Permian plays. The Litho Scanner service has been run successfully in more than 80 wells in major shale plays in North America, South America, and several conventional reservoirs, the company reports.

“We have always thought that acquiring measurements and understanding the rock is important in these unconventional plays due to heterogeneity because of the way the rock changes and varies as one moves from one drilling location to another, or as one chooses a landing location or another for a horizontal well,” Fairhurst said. “The Permian is the place where we see this requirement most dramatically.”

A pulsed neutron generator and a cerium-doped lanthanum bromide gamma ray detector enable this tool to measure spectra for an expanded set of elements in comparison to previous spectroscopy tools, according to Schlumberger. In carbonates, for instance, the magnesium measurement can be used to accurately differentiate calcite from dolomite at standard logging speeds.

Total organic carbon (TOC) and kerogen content for shale gas plays is computed by subtracting the amount of inorganic carbon associated with carbonate minerals from the total inelastic measurement of carbon, according to the company website. The stand-alone TOC output is presented as a continuous wellsite log, independent of the environment and reservoir. Also, the delay in waiting for



Litho Scanner HD spectroscopy service provides gamma ray spectroscopy to enable detailed description of complex reservoirs. *(Image courtesy of Schlumberger)*



laboratory sample analysis has been eliminated. The Litho Scanner service can be combined with most openhole services via wireline.

ThruBit, a company recently acquired by Schlumberger, specializes in logging horizontal wells with a specially designed set of slimhole logging tools, which are conveyed through drill pipe and the company's Portal bit. The technique permits data gathering in lateral wellbores at minimal risk and at low to moderate cost compared to more expensive methods. Openhole logging measurements included in the ThruBit system are resistivity, density and neutron porosities, gamma ray, caliper, and both compressional and shear wave sonic. The main benefit of having these data in the laterals is to aid in completion design and to have a better way to see variation in rock properties beyond what was previously available with a simple MWD-gamma ray curve from the directional drillers, the company said.

Since its inception ThruBit has seen a steep increase in horizontal logging activities in most of the current plays. The ThruBit system provides a way to fill these data gaps and provide the critical inputs to the Schlumberger Mangrove reservoir-centric stimulation design platform.

### Case study

In the Delaware Basin, the Wolfbone is the local name given to wells with comingled production from the Wolfcamp and the Bone Spring intervals. The wells are commonly drilled down to 9,500 ft to 12,500 ft with the targeted interval encompassing a thickness of up to 2,500 ft. Although the shallow intervals, like the Avalon and the first and second Bone Spring are viable targets, the majority of operators elect to initially complete the overpressured zones from the base of the Wolfcamp to the top of the third Bone Spring interval. Based on pressure management and economical considerations, the shallow horizons may be completed later on subsequent mobilizations.

Here the challenges include economic well development and controlling completion cost. The Wolfbone comprises multistacked conventional and unconventional packages resulting in the interval having highly heterogeneous lithologies and formation properties. An understanding of the spatial variability in the Wolfbone and applying the appropriate completion solutions are critical to the economic success of vertical Wolfbone well developments. Through detailed completion and production evaluation of the vertical well program, productive horizons within the Wolfbone can be identified and ranked for future horizontal well developments.

A balance must be struck between completion costs and optimal well performance to ensure project profitability. This also is true in Wolfbone developments where completion solutions must focus on applying the appropriate technologies that address the key technical challenges while controlling overall well cost and ensuring optimal production.

The Schlumberger Platform Express integrated wireline logging tool with spectroscopy measurements and the combinable magnetic resonance tools were run on the subject wells in order to construct oil shale montages. This provided petro-

**Well Under Control**

Keep your crews safe and your rigs operational while reducing "time to train" with the Well Control CAT™ (Competency Assurance Trainer) from Check-6.

The Well Control CAT provides interactive courseware, knowledge and skills assessment, and simulation training. It is portable, interactive, and built upon a centralized Learning Management System.

More experience in less time means:

- > Increased Proficiency
- > Improved Rig Safety
- > Greater Profitability

**CHECK 6** Accelerating Human Performance™

[www.checksix.com](http://www.checksix.com)

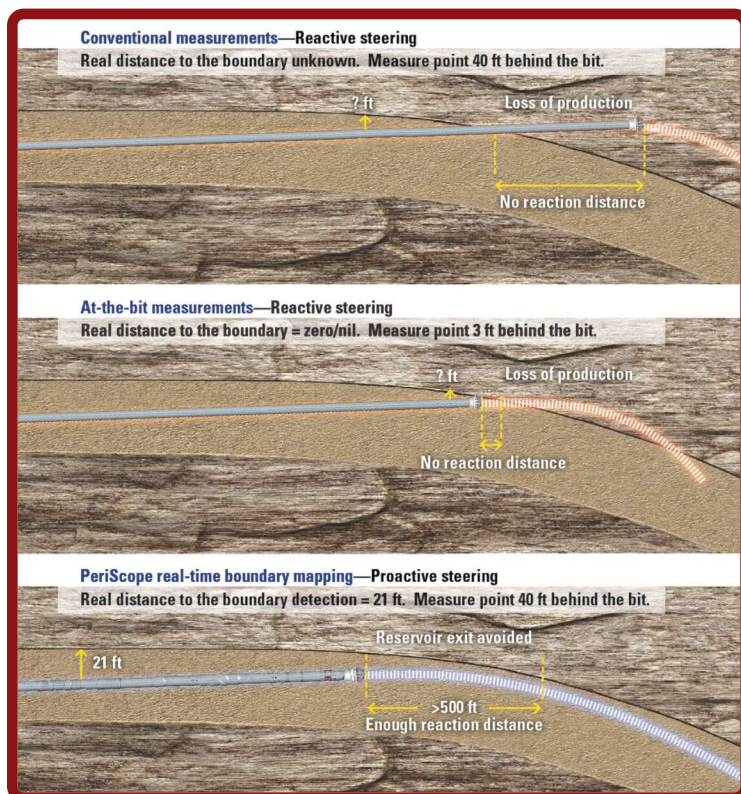
physical interpretations of the Wolfbone interval and allowed for improved identification of the pay targets, according to the company. The Sonic Scanner acoustic scanning platform also was run on the subject wells to derive anisotropic mechanical rock properties and stress models.

Using the oil shale montages and the anisotropic mechanical rock properties and stress models, Mangrove was used to determine treatment staging and perforation placement as well as perform hydraulic fracture simulations for optimized fracture treatment parameters. To address completion efficiency and fracture conductivity concerns, the HiWAY flow-channel fracturing technique was implemented on the subject wells.

The integrated completion optimization resulted in the vertical Wolfbone subject wells performing in the top 20% in initial oil production compared with offset wells, the company said. HiWAY also allowed for 6% in water and 30% proppant reduction when compared with conventional Schlumberger stimulation treatments, according to the company.

Completion and production evaluation provided critical input into the future drilling and completion program. Through critical petrophysical calibrations resulting from this analysis, cost savings of an average \$734,000 per well were identified and implemented with regard to the drilling and completions operations. This analysis also identified high potential horizontal targets within the Wolfbone that would be targeted in future horizontal developments.

With these key Wolfbone findings in mind, Schlumberger integrated solutions were also applied to an operator's initial horizontal Wolfcamp development in the Delaware Basin. Advanced reservoir characterization, well placement optimization using the PowerDrive X6 rotary steerable system (RSS), ShortPulse MWD and PeriScope bed boundary mapping services, as well as recommendations on wellbore configuration and stimulation design, all contributed to improvements in formation evaluation, drilling performance, and completions. As a result, the subject well was drilled and completed in a new and deeper target interval, with the well exhibiting a 60% increase in initial oil production compared to offset laterals landing in the shallower traditional target.



PeriScope real-time bed boundary mapping ensures precise well placement to maximize production while minimizing drilling costs. *(Image courtesy of Schlumberger)*

## Handling water logistics

Water, a critical ingredient in all fracturing work, never has been abundant in the Permian Basin. Operators who are planning E&P work in the area face numerous questions on how they will approach water management issues. Freshwater, though always preferable, may not be readily available near the site, tipping trucking transport charges into red ink domains. Storage and disposal issues also must be considered with water management planning, especially as it concerns produced or recycled waters.

Excessive water production has long been a challenge in the Permian Basin and continues to threaten the economic viability of many wells, especially in the Wolfberry play. The Wolfberry is an oil and gas producing zone characterized by low reservoir pressure. This intertwined play combines the Spraberry, Dean, and Wolfcamp formations and is composed of interbedded sandstone, shale, and dolomite. Potentially prolific oil production in the Wolfberry wells can be nullified by water influx into wells.



### Case study: water reuse

During a recent Permian Basin hydraulic fracturing job, the operator wanted to reuse produced water to offset the expense of sourcing and trucking freshwater. The hydraulic fracturing job consisted of nine stages, requiring more than 1,300 bbl per stage.

Baker Hughes recommended a water treatment solution to facilitate use of onsite-produced water in the fracturing fluids. Pretreatment water analysis determined that both the influent and effluent water samples contained high concentrations of hydrogen sulfide ( $H_2S$ ) and organics. Based on these findings, the H2prO HD was used to neutralize the  $H_2S$  and bacteria.

The system uses chlorine dioxide green chemistry to neutralize bacteria,  $H_2S$ , iron sulfide, phenols, mercaptans, and polymers. Following treatment, the water could be reused with no negative impact to the producing formation or to downhole equipment. Residual hydrocarbons could be recovered from the wastewater.

The system treated 3,400 bbl of water, which was used in the polymer-based, crosslinked hydraulic fracturing fluid. Post-job analysis confirmed the treatment used 100% of the treated water with no dilution for the job design. By eliminating freshwater and disposal costs, the operator's overall operating expenses for the project were reduced by 30%.

*(Source: Baker Hughes)*

A number of service companies have developed technologies to tackle water management questions and offer various approaches for operators to consider in their planning stages. Stephen Monroe, product line manager for surface water treatment for Baker Hughes' water management group, believes the largest issue operators face in the Permian Basin is one of logistics – beginning with sourcing and ending with disposal.

“Once you find the source water, the logistics of moving that water around or even having to store it are huge. And once you use it you've still got a problem with produced water flowing back from those formations,” Monroe said.

An integrated approach to water management is most prudent in addressing water management questions. This includes planning for water collection and distribution while designing an infrastructure with integrated treatment options for any new devel-

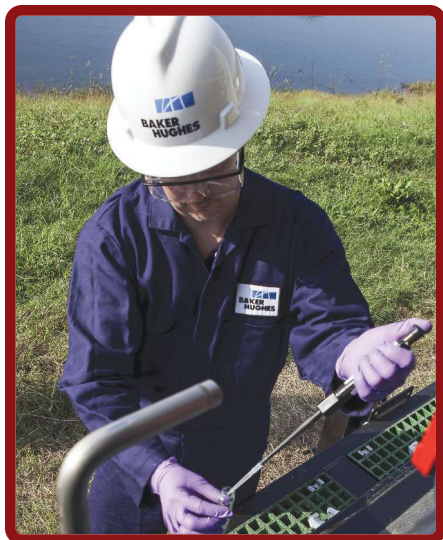
opment areas. Once the challenges of moving and storing water are resolved, treatment for recycling or reuse is a matter of applying the right technology to produce the desired water quality.

For its water management programs, Baker Hughes has identified four key technologies that it uses to offer a spectrum of treatment options: filtration units, electrocoagulation (EC), a chlorine dioxide system, and a thermal evaporation system. All systems are mobile and designed to treat water as close as possible to its point of use and can move when drilling activity shifts.

“The treatment really depends on the characteristics of the water source and what the intended use of the water is,” Monroe said. “It could be something as simple as our filtration units, which filter out suspended solids. Many times that is all that is needed if you are just doing a simple slickwater frac job.

For a crosslinked application where cleaner water is needed, Monroe suggests a tool like the company's EC system to remove heavy metals, such as iron, or chlorine dioxide for sour water or bioremediation.

When ultra-pure water is needed, Baker Hughes has a thermal evaporation system, which was released for desalinization and complete dissolved solids (TDS) removal. This system will take water at 128,000 TDS and lower it to 300 TDS with up to 70% efficiency, according to Monroe.



Using one of the company's H2prO mobile test facilities, a water management expert tests water as close as possible to its point of use. *(Image courtesy of Baker Hughes)*





Copyright Tervita Corporation 2012. EARTH MATTERS and the Tervita logo are the trademarks of Tervita Corporation. All rights reserved.

## OPERATIONAL EFFICIENCY, ENVIRONMENTAL COMPLIANCE

Now more than ever you need both. For 30 years Tervita has provided reliable and convenient environmental and energy services to help our clients minimize environmental impact and maximize returns.<sup>TM</sup>

We provide superior waste management services to our oil and gas customers at our facility in Odessa, Texas and we're continually expanding our services to meet your needs. We now offer total solids management and environmental solutions in west Texas including:

**Waste processing • Solids control • Closed loop systems • Water treatment • On-site waste management**

Whether you need drill cuttings transportation and disposal, or a custom-designed onsite waste processing solution, working with Tervita will transform your waste management from an obligation to an opportunity. We can help make your operations simpler, more efficient and more cost effective. With an unwavering commitment to safety, we ensure not just environmental compliance but operational excellence.

Visit [tervita.com](http://tervita.com) today or call 432-685-0700 to learn more about our services in the Permian.



**EARTH MATTERS**

A NORTH AMERICAN LEADER IN ENVIRONMENTAL AND ENERGY SERVICES



## Water treatment

Dale Pierce, development manager for National Oilwell Varco (NOV) Fluid Control, has overseen some water treatment pilot projects in Odessa and Andrews counties in Texas for recycling purposes, cleaning fracture flowback water for reuse as frac fluid. Such produced

water or brine happens to be very salty. “It’s very difficult to get the saltwater out of it,” he said.

Pierce said that some of the fracturing companies prefer water without a lot of calcium, magnesium, and sulfates in it due to the scaling tendencies. Keeping the fracture fluid from gelling up and cross-linking is important. “Getting it that clean is not an easy propo-

sition. It remains less expensive right now to use freshwater for fracturing purposes.

“I don’t think anybody has the solution to it yet, other than to go all the way to a distillation process which makes the water very expensive,” Pierce added.

NOV provides the AQUA-VES mobile membrane system, which removes suspended solids, oils, and greases. Depending on water quality, some chemical pretreatment also would remove the calcium, magnesium, and sulfates, according to Pierce

## Sand dehydration for flowback treatment

Supreme Service & Specialty Co.’s Sand Dehydration Station (SDS) also has been developed as part of the flowback system and is primarily used to contain sand and filter fluids. The sand and fluids flow into the station’s gas buster to ventilate volatile organic compounds. The fluids flowing through the filtration system then are transferred to the designated freshwater reservoir. The sand is contained within the system tank for the ensuing dehydration process. The sand’s profile then is tested and hauled to the disposal location.



The SDS has been developed as part of the flowback system and is primarily used to contain sand and filter fluids. *(Image courtesy of Supreme Service & Specialty Co.)*

## Case study: water treatment

Controlling bacteria growth in fracturing fluid is critical because bacteria downhole can lead to the corrosion of wellbore tubular, resulting in the production of sour (H<sub>2</sub>S) fluids. Bacteria also can destroy the fracturing fluid resulting in the failure of a fracturing treatment.

The CleanStream service uses a mobile unit capable of treating fracturing fluid at rates up to 100 bbl/min. Using the service enables operators to significantly reduce the volume of biocides used to treat for aerobic and anaerobic (sulfate reducing) bacteria, according to the company.

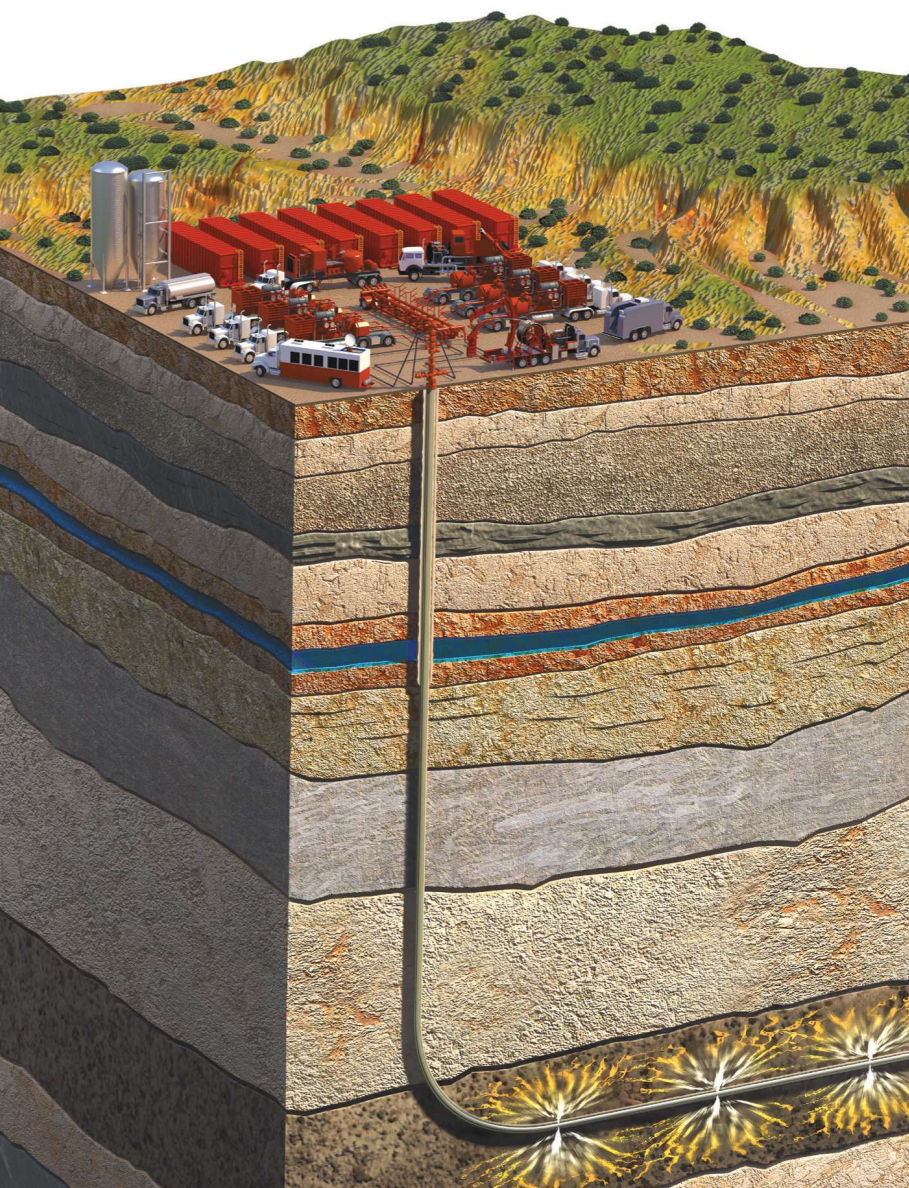
If wellsite logistics permit the use of CleanStream service on-the-fly, biocide addition can be reduced to zero. For every barrel of oil produced, approximately three barrels of water are used. Between 10% and 40% of the fluid volume used in fracturing operations flows back during the subsequent cleanup. The company’s CleanWave frac flowback and produced water treatment supports recycling of flowback and produced water at the well site. This service has a mobile electrocoagulation component that uses electricity to treat flowback and produced water at rates of up to 26,000 b/d using minimal power.

The CleanWave system destabilizes and coagulates the suspended colloidal matter in water. When contaminated water passes through the electrocoagulation cells, the anodic process releases positively charged ions which bind onto the negatively charged colloidal particles in water, resulting in coagulation. Gas bubbles, produced at the cathode, attach to the coagulated matter and cause it to float to the surface where it is removed by a surface skimmer. Heavier coagulants sink to the bottom, leaving clear water suitable for use in drilling and production operations.

*(Source: Halliburton)*



# Fracturing Fluid Additives with Elevated Environmental Standards™



TBC-Brinadd is a global provider of non-damaging drill-in, completion, workover and fracturing fluid system additives, including our patent pending aqueous-based and BTEX free synthetic fluid-based suspensions, Fracsal Ultra EM, Fracsal Waterbase EM, and Fracsal EM. Our ISO 9001:2008 certification, partnered with our R&D/Technical Services laboratory and manufacturing facility, enables us to be.....the Premier Service Company for the Service Industry.

## Aqueous-Based Suspensions

- Fracsal Ultra
- Fracsal Ultra EM
- Fracsal Waterbase
- Fracsal Waterbase EM

## Synthetic Fluid-Based Suspensions

- Fracsal III
- Fracsal IV
- Fracsal EM

## Supplemental Additives

- Polymer Breakers
- Clay Stabilizers
- Friction Reducers
- Non-Emulsifiers
- Scale Inhibitors

## TBC-BRINADD

A DIVISION OF TEXAS UNITED CHEMICAL COMPANY, LLC

4800 San Felipe  
Houston, TX 77056  
Office: 713.877.2727  
Customer Service: 281.438.2565  
[www.tbc-brinadd.com](http://www.tbc-brinadd.com)





The company has been successfully pumping its powdered friction reducer technology – PFR-21 “A” – in the Permian Basin. This dry product demonstrates the ability to decrease surface treating pressures during a fracturing treatment on a customer’s well. *(Image courtesy of Universal Pressure Pumping)*

According to Supreme Services, its SDS is economical and environmentally friendly. The system includes a 300 bbl tank, a vertical gas buster, a filtration system, and a transfer pump. Supreme Services can then transport the dehydrated sand to the disposal location.

### **Avoiding emulsions with a powdered friction reducer**

The amount of water required to fracture a horizontal well may be as much as 10 times the volume of water required to fracture a vertical well, said Dennie Martin, director of engineering and technology for Universal Pressure Pumping, which specializes in horizontal fracturing. “When you get into horizontal fracturing, issues come up logistically where the fracturing process requires so much more water than on a vertical well.”

The company has been successfully pumping its powdered friction reducer (PFR) technology – PFR-21

“A” – in the Permian Basin. This dry product demonstrates the ability to decrease surface treating pressures during a fracturing treatment, according to the company. Rapid hydrating yields friction reduction almost immediately during treatment. The product is tolerant to moderate and high brine solutions and is able to hydrate and perform in the presence of most mono and divalent ions. This hydrocarbon-free friction reducer rendering is more environmentally friendly, Martin said, adding that this product shows significant cost savings when compared to liquid emulsion-type friction reducers (FRs). The technology also helps reduce FR volume that is injected into the well.

Universal Pressure Pumping released PFR-21 “A” in August after conducting a 30-day field trial in Irion County, Texas.

“We have been using it since then with extremely positive results in produced water and flowback water,” Martin said.



I spend countless hours running to different locations to meet maintenance demands.  
If only I could monitor these wells wirelessly.

# YOU CAN DO THAT

**ROSEMOUNT®** Stop the runaround and keep production on target with Smart Wireless remote monitoring. By remotely measuring and monitoring your production and injection wells you can keep production on target and schedule maintenance before it's too late. Automate your wellheads with Smart Wireless solutions and get the information you need to get to first production faster; reduce costs for travel, maintenance and rework; and be able to keep things running with optimized production levels. Talk to Emerson so you don't have to keep going back to the well.



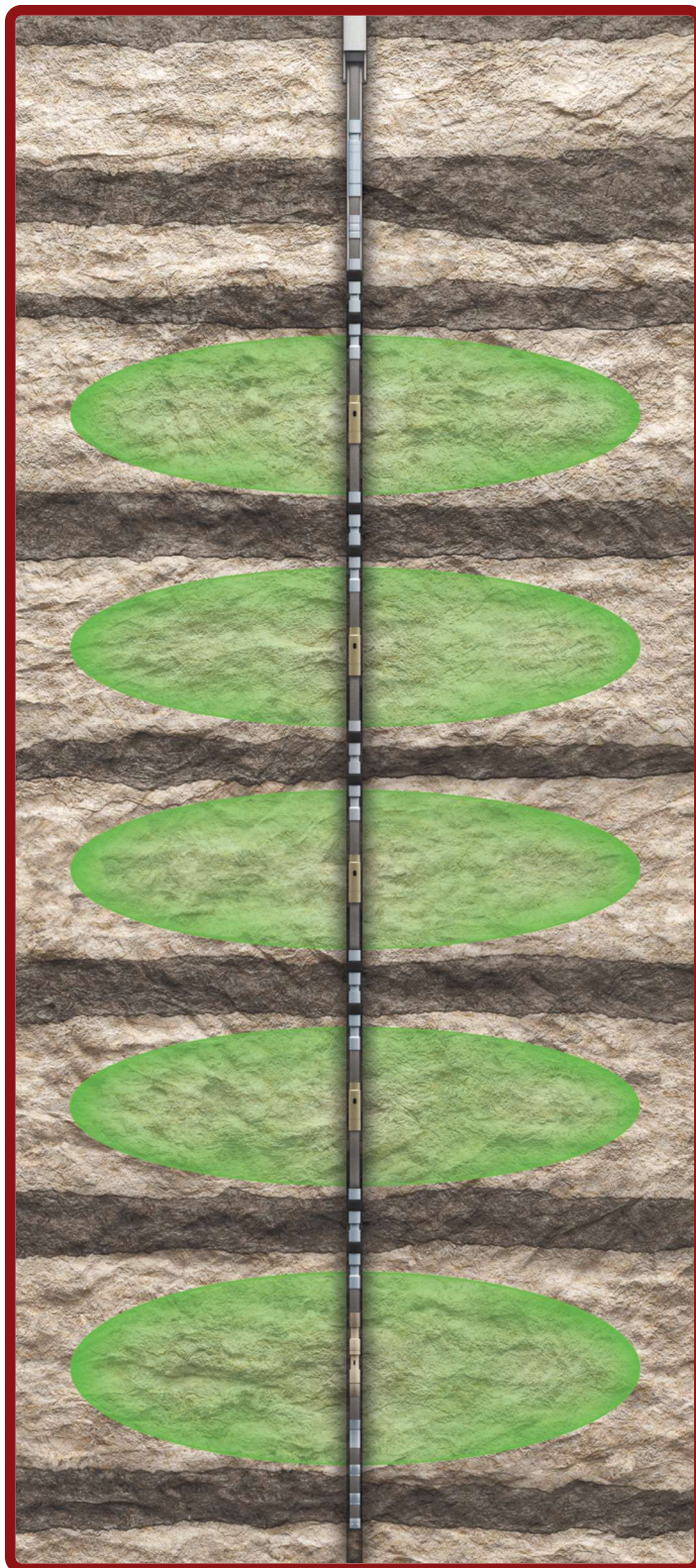
[www.EmersonProcess.com/OnshoreWellhead](http://www.EmersonProcess.com/OnshoreWellhead)

The Emerson logo is a trademark and a service mark of Emerson Electric Co. © 2013 Emerson Electric Co.



EMERSON. CONSIDER IT SOLVED.™





This image shows the vertical openhole StackFRAC multistage fracturing system completion in the Permian Basin. *(Image courtesy of Packers Plus)*

## Penetration advances for fracturing

Halliburton's 150 MaxForce FRAC is a 2¾-in., 6-shot-per-foot perforating gun system that provides positive news for the fracturing side of the drilling equation. Perforating charges traditionally have been designed for natural completions, focusing on depth of penetration but having little control concerning hole size or consistency. Oil and gas reservoirs, including unconventional in the Permian that require stimulation to be productive, can benefit from this perforating gun system, according to the company.

The charge has been designed to maximize hole size performance while providing entry hole consistency in the casing, regardless of the gun's azimuth, orientation, and standoff. Prather pointed out that when typically perforating a hole, the gun is usually laying to one side. "When you perforate, the side of the gun that's closest to the casing makes the biggest hole," he said. "And the side of the gun that's farthest away from the casing gets a very small almost impenetrable hole. What Halliburton has done is create a perforating charge, knowing we're going to be laying on the casing. The charges are built so that no matter where it goes, you are virtually the same size all the way around." These perforating charges have resulted in a lower treating pressure of 100 psi to 200 psi in fracturing treatments, according to Halliburton.

## Multistage fracing systems

In the Permian Basin Packers Plus provides a series of "stackable" openhole, high-pressure packers that run in conjunction with production casing for both vertical and horizontal wellbores. "The completion technique uses packers to replace the need to cement the casing in place



for the purposes of fracture isolation,” said Don McLean of Packers Plus. “In between those packers, we provide what is essentially considered a ball-activated sliding sleeve.”

The purpose of the ball-activated sliding sleeve is twofold: first, it provides access to the frac zone in between those packers, thus eliminating the need to perforate the casing in between the packers. Second, by eliminating that need and using a ball-drop method, this system is able to provide a continuous pumping operation for the entire wellbore using multistage fracture stimulation without having to continually shut down to set bridge plugs in between perforation stages. “We eliminate the time and cost associated with that by providing a series of ball drops,” McLean said. “We can inject the ball while we’re still pumping and shift to the next zone up the wellbore.”

The StackFRAC multistage fracturing system is predominantly used for horizontal wells in the Permian although it can be applied vertically.

### In the field

An operator working the Permian Basin was targeting the layered combination of the Wolfberry and Bone Spring formations, an unconventional trend that is a mix of fine sandstone and siltstone interbedded with various shale and carbonate layers. The shale and carbonate layers act as barriers to fracture growth, making well completions a challenge. As this is a well-established, mature field, new methods and technologies must be investigated to gain access to the remaining hydrocarbons.

The operator wanted to effectively complete these formations while keeping costs low. A horizontal technique was not viable due to the thickness of the pay zone and multiple shale and carbonate barriers. In Reeves County, Texas, the operator’s pay zone for drilling was roughly 1,000 ft to 1,500 ft thick. Standard plug and perf (PNP) stimulation methods would be costly and time-consuming, so the operator wanted alternative solutions. Focus



Portable Mixing Plants



Vacuum Trucks

## QUALITY SERVICE AND EQUIPMENT SINCE 1989

Winch-Equipped Haul Trucks  
Mixing/Transfer Pumps with  
John Deere Engines



Liquid Water-Based Mud



500 Bbl Liquid Mud-Mixing  
and Storage Tanks



**McADA**  
DRILLING FLUIDS

BAY CITY • VICTORIA • KINGSVILLE (877) MIX TANK (877) 649.8265 [www.McAdaDrillingFluids.com](http://www.McAdaDrillingFluids.com)



keyed on exploiting the higher porosity and permeability of the sandstone layers, as well as any existing natural fractures.

The operator chose to run StackFRAC in an openhole vertical well to maximize the total pay zone. The system was run on 5.5-in., 17 lb/ft casing with an average stage spacing of just over 100 ft, and a total of 11 stages. The tight spacing was required to effectively stimulate the entire pay zone and help to overcome the natural barriers of the formation. The stimulation was a combination of slickwater and crosslinked fluid with a maximum sand concentration of 4 lb/gal. A total of 1,000 tons of proppant was pumped into the well.

The vertical well completion design proved successful, the company said. The openhole completion allowed for contact with the entire length of the wellbore. As of November 2012, the operator completed seven wells, each with an 11-stage

StackFRAC system. It took, an average of 21 hours to stimulate the 11 stages in each well. Of those of 21 hours, 16 to 18 hours were spent pumping; the other hours resulted in nonproductive time (NPT) due to repairs of surface equipment. Using the PNP method would have meant a minimum of an additional 15 hours added to the stimulation time due to wireline rigup and rigdown, plus wireline trip time in and out of the hole. The system achieved time and cost savings in addition to higher production volumes compared to the standard PNP offset wells, according to the company.

### Increasing fracture conductivity

Schlumberger's HiWAY flow-channel fracturing technique has been designed to create open pathways inside a fracture, allowing hydrocarbons to flow through the stable channels rather than the proppant. This optimizes connectivity between the reservoir and the wellbore, resulting in better fracture conductivity, according to the company.

As the Schlumberger production and stimulation engineer Malcolm Yates sees it, the HiWAY service provides operators with measurable water and proppant savings in their hydraulic fracturing activities. "HiWAY ... uses proppant with specialized fibers and blending technology to engineer pillars within the fracture," he said. "Between the pillars, the hydrocarbons are free to flow through the highly conductive channels."

Yates said the company has successfully applied the technology in the Permian Basin, and had satisfactory results. "Overall in the Permian, more than 360 stages on 40 wells have been performed to date, resulting in an average 34% improvement in production versus offsets. Screenout rate has also been reduced dramatically to only 0.5% over all the stages performed. Average water savings of 6% and proppant reduction of 30% have also helped simplify logistics and reduced supply chain requirements," he said.

### Mapping and imaging while drilling

Schlumberger's MicroScope resistivity- and imaging-while-drilling service provides high-resolution electrical images and laterolog resistivity measurements in conductive mud environments for advanced formation

## Reach for the **SUMMIT** in ESP solutions



- Extreme Service
- Focused ESP Experience
- Advanced ESP Technology
- Remote Monitor & Control
- Custom Solutions





# SUMMIT

ESP

**EASTERN AREA** 918.392.7820

**SOUTHERN AREA** 432.563.7040

**WESTERN AREA** 307.764.6346

Career Opportunities @ [www.Summitesp.com](http://www.Summitesp.com)

Contact: **CHUCK OWEN**  
Plant Manager & Sales  
432.352.8852  
[www.spacoating.com](http://www.spacoating.com)

**SPAcoating LP**  
SMITH PIPE OF ABILENE

# Smith Pipe Delivers!

*We build API tanks and ASME vessels.  
We deliver in the five state region.*

**1-800-553-7473** [sales@smithpipe.net](mailto:sales@smithpipe.net)

**SPA**  
Smith Pipe  
of Abilene





The HiWAY service creates infinite fracture conductivity in vertical and horizontal wells. (Images courtesy of Schlumberger)



On a single collar, the MicroScope imaging-while-drilling service provides high-resolution laterolog resistivity and full borehole images in conductive mud environments.

evaluation in complex and challenging reservoirs. This LWD service enables drillers to stay within their zone when placing horizontal wellbores. The tool is being implemented in the Delaware and Midland basins.

Showing a 360° view around the borehole, the MicroScope service can be used to help calculate reserve estimates, optimize completion designs, and perform an invasion profile analysis, the company said. Its real-time resistivity measurements, high-resolution borehole images, and azimuthal gamma ray measurements can be interpreted to enable critical geosteering decisions in the basins' unconventional reservoirs.

Additionally, the PeriScope bed boundary mapper aids in greater precision of lateral placement in thin targets like the third Bone Spring Sands that range from 8 ft to 10 ft thick.

According to Irless Gene Brooks, Schlumberger PetroTechnical Services sales engineer, once a horizontal target is identified, it is becoming more critical to stay within that target. In the third Bone Spring sands, for example, Brooks said the company has drilled and steered more than 200 wells using the PeriScope deep-reading electromagnetic LWD service for optimal well placement. "We also have successfully deployed the PeriScope service in the Cline and Wolfcamp in the Midland Basin," he added. "Once the lateral targets are identified from our key wireline measurements in a vertical pilot hole, we then model that data to identify the best tool needed for steering within the target zone."

Schlumberger also is using MicroScope tool to identify fractures in some of the deeper Delaware Wolfcamp plays, Brooks said.

Interpretation of the technology's images for fracture identification and porosity evaluation allows for a better understanding of fracture networks, according to the company. The service's azimuthally focused laterolog resistivity measurements show little distortion from shoulder-bed and anisotropy effects, enabling accurate interpretation of vertical and horizontal resistivity used for evaluating production potential in unconventional reservoirs.

### Petrophysical evaluations

The Baker Hughes RockView service combines geochemical data from the Spectralog service and the



**TAM PosiFrac™** SYSTEMS

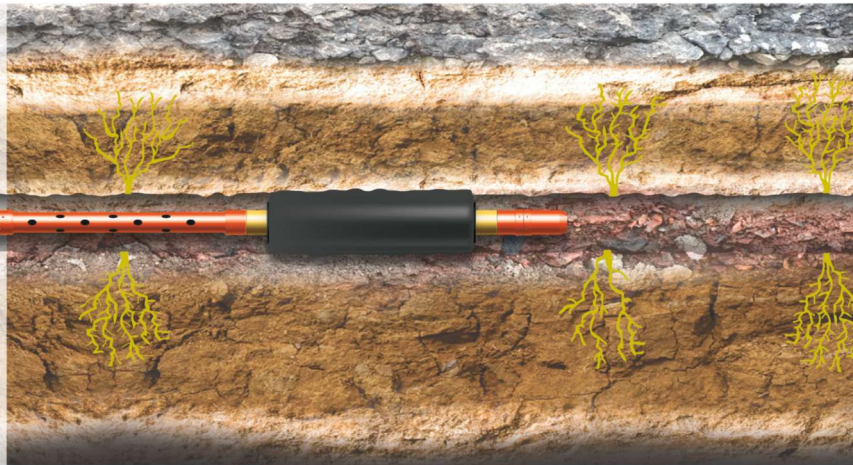
# POSITIVELY MORE FRACKING FLEXIBILITY

Open new possibilities for more production in less time. Choose from our proven PosiFrac systems for positive isolation and placement during acid stimulation or open hole multi-stage frac treatments.

## **PosiFrac Multi-Set Inflatable Straddle System**

Production has doubled, tripled, even quadrupled with our unique straddle system. Use it to selectively

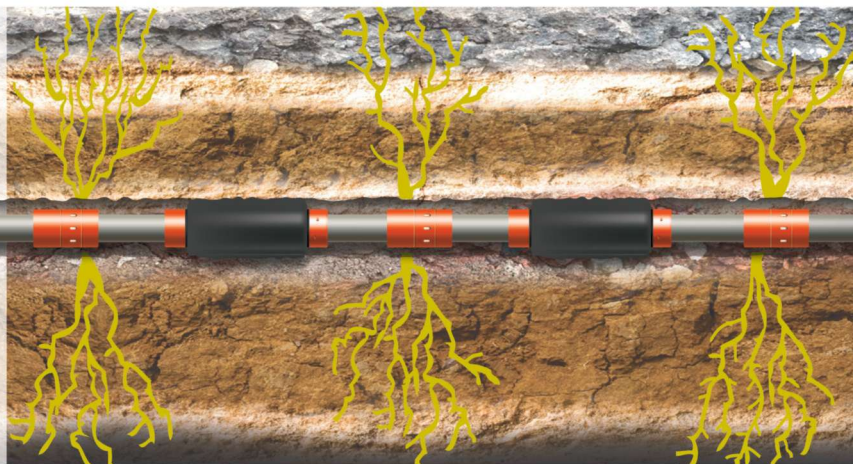
stimulate/treat in intervals from 3 feet and longer. Move the system from one zone to the next while working up the well. Modify the number of stages based on real-time reservoir feedback.



## **PosiFrac Multi-Stage Hydraulic Fracture System**

Eliminate the hazards, costs and extra time of plug-and-perf systems. Industry-leading

FREECAP® swellable packers make the PosiFrac Multi-Stage Hydraulic Fracture System ideal for fast and reliable open-hole completions.



**Think PosiFrac.** Learn more today.

[www.tamintl.com](http://www.tamintl.com)



**TAM INTERNATIONAL**  
Inflatable and Swellable Packers

PERFORMANCE MATTERS.



Formation Lithology Explore measurements. It applies the principles of gamma ray spectroscopy to provide accurate in situ mineralogical characterization of conventional and unconventional reservoirs.

The data are collected and then imported into Baker Hughes' RockView software, which is then used to compute the lithology and mineralogy of the rock. This helps to resolve the ambiguities of traditional petrophysical evaluation methods.

"Running this service in the Permian Basin is particularly useful," said Angie Guzman, Baker Hughes product line manager for mineralogy services, "because traditional logs do not paint an accurate picture. These formations typically have very high radioactive content, giving less than accurate [shale volume] values."

The Feldspar content, which creates the highly radioactive signal in the gamma ray measurement, can be determined using RockView. According to

the company, this method is more accurate than traditional shale volume computations.

### Deep azimuthal resistivity measurement

The AziTrak deep azimuthal resistivity measurement tool from Baker Hughes is being used extensively in the Permian Basin to avoid NPT by predicting the environment using an integrated MWD/LWD response package, according to the company. The tool has real-time distance-to-bed boundary and apparent-dip calculations. It is mainly being used because the intervals being targeted are very thin and the laterals can be quite long (commonly more than 4,000 ft). The intervals being targeted generally have very little resistivity contrast, making reservoir navigation difficult without the deployment of advanced MWD/LWD tools, according to the company.



The intervals in the Permian Basin generally have very little resistivity contrast, making reservoir navigation difficult without the deployment of advanced LWD tools, such as AziTrak (pictured) and azimuthal gamma imaging. *(Image courtesy of Baker Hughes)*



# When Every Run Counts

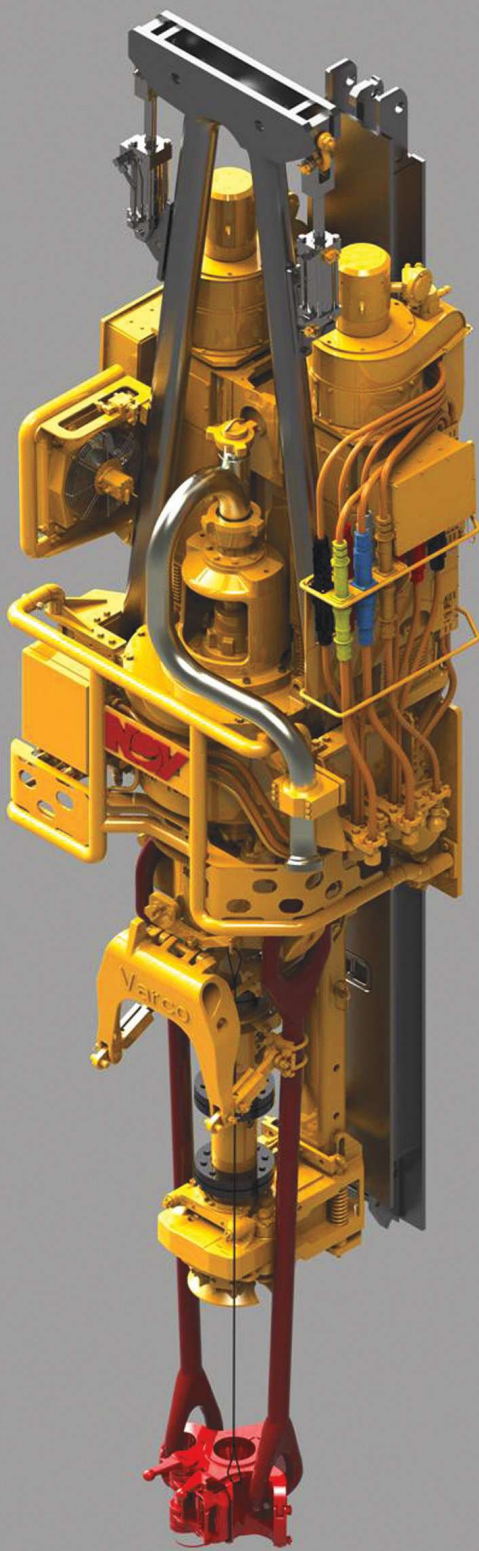
- Customer Focused
- Performance Driven
- Application Specific

When Every Run Counts, operators are calling on Ulterra to provide solutions to lower their drilling costs. Named "the fastest growing drill bit company" by a prestigious oilfield research company, Ulterra is the bit supplier of choice when drillers require a partner with unmatched credibility and a commitment to excellence.

Ulterra is unique by its flexibility to changing industry dynamics and its ability to respond to a customer's specific applications with customized solutions. Its strength resides in the experience and wisdom culled from industry veterans, designing high-quality, high-performance PDC bits for a global market.

*Contact your local representative today to find out more about the entire Ulterra line of premium drill bit technology.*





NOV improved its TDS-11SA top drive when it released the TDS-11SH AC. The top drive is built with more power density and torque. (Image courtesy of NOV)

In addition to well placement, an electrical imaging tool can be run while drilling to log the complete lateral section. The images from Baker Hughes' StarTrak high-definition LWD imaging system covers 360° of the wellbore, the company said. In shale reservoirs the resolution of these images allow the identification of natural fractures, induced fractures, and faults. This information can be used to help optimize the stimulation program, avoiding areas where fracturing will be inefficient. According to the company, the tool reduces costs by eliminating inefficient fracturing and has been shown to increase production from a well by up to 20%.

### Increasing top drive power

NOV updated its TDS-11SA top drive when it released the TDS-11SH AC. The top drive is built with more power density and torque, and as a result, the company said, deeper drilling can be achieved, both for vertical and horizontal work. Robert Goodwin, NOV's land rig solutions Top Drive product line manager, said the demand for longer drilling had much to do with the development of this top drive. "We have seen a trend over the last two years in long or horizontal drilling which has put a reliance on more horsepower, more speed, and more torque used out of our top drives."

With the operators and contractors pushing for longer wells, higher torque is an absolute. Goodwin said NOV used the TDS11SA, "And in the same package design, utilizing the majority of the components, we upgraded this top drive and updated it to be able to handle about 38 percent more torque in the same-size package." He added that the TDS11SH can rotate and hoist at 500 tons.

The NOV TDS-11SH AC is capable of 51,000 ft-lbs of continuous drilling torque at 110 rpm, with 75,000 ft-lbs of breakout torque. Powering this top drive are two 550 HP air-cooled permanent magnet AC motors.

Accuracy demands are addressed by controlling torque and speeds using a Variable Frequency Drive control system. NOV reported that a compact integral power unit also is part of the package, eliminating downtime for hydraulic service loops, according to







**Let's Go Cement!**



**Blend The Brands**



**Freemyer**   
**Industrial**  
**Pressure LP.**  
 [www.indpress.com](http://www.indpress.com)

**A GLOBAL LEADER IN FRACTURING, CEMENTING AND ALL PUMPING SERVICES**

(All pumping, blending and mixing equipment manufactured and automated by FIP)  
Our customers will back up our equipment testifying to its simplicity, accuracy and automation  
and how it has contributed to their success.

**817-548-5010**

**info@indpress.com • Fort Worth, TX**





The AutoTrak Curve BHA with a Talon PDC bit is ready for deployment. *(Image courtesy of Baker Hughes)*

the company. The unit has been designed for retrofitting with existing rigs and features a rapid-installation guide beam design. Software enhancements for SoftSpeed II, Twister, and the Monkey Board collision warning system are available.

within 22 months after the start of the field test.

AutoTrak Curve RSS is a complete BHA, which includes a drill bit, steering unit, MWD, and a power/pulser unit. The BHA is designed to improve total operational efficiency for pad drilling opera-

TDS11SH was just launched by NOV, with the first unit shipped in 4Q 2012. Before release, the product was heavily tested for its speed and torque at NOV's California facility.

### Advanced drilling systems

With the increasing demand for directional and horizontal wells in unconventional plays, Baker Hughes' drilling systems provide precise wellbore placement in one fast run, optimizing drilling costs and maximizing reservoir exposure, according to the company.

For drilling efficiency, the company's automated RSS offers precise steering control and near-bit inclination measurement. This helps operators drill a smoother wellbore and place it exactly in the sweet spot, thus reducing drilling risk, Baker Hughes reports.

The company's AutoTrak Curve RSS brings better down-hole economics in unconventional plays through precise wellbore placement, faster drilling, and the ability to drill the vertical curve and lateral section in one, according to the company. It has the ability to drill a high build-up rate curve up to 15°/100 ft.

Launched in March 2012, the new drilling system has been used in all major shale plays in the US. The AutoTrak Curve completed 3 million ft





# Reel SIMPLE

When corrosion is not an option, choose

**FIBERSPAR** 

THE LEADER IN SPOOLABLE PIPELINE SYSTEMS

Go to [fiberspar.com](http://fiberspar.com) for more information DELIVERING EXPERIENCE<sup>SM</sup>



**NOV** Fiber Glass Systems

Email: [fgspipe@nov.com](mailto:fgspipe@nov.com)



tions. Operational efficiency is achieved by reducing BHA trips and by reducing flat time because the BHA comes in one piece and does not require rig-site programming.

The RSS is controlled by the slow rotating steering sleeve, which is positioned above the bit. The steering forces can be adjusted manual or automatically by means of smart control algorithms, without interrupting the drilling process. The Baker Hughes steering principle allows for continuous steering, resulting in precise 3-D steering as well as full control while drilling a straight hole, according to the company.

The motor-powered RSS helps reduce surface torque and transfer power directly to the bit so maximum penetration rates can be achieved, minimizing harmful string dynamics and BHA or casing wear for a quality wellbore in fewer runs.

### Rotary steerable systems

The Schlumberger PowerDrive family of RSS also is enabling drillers in the Permian Basin to optimize directional drilling performance for both vertical and horizontal work. Having drilled more than 100 million ft worldwide, the technology has been deployed in unconventional formations like the third Bone Spring to help improve penetration rates and BHA performance.

In the third Bone Spring sands, Schlumberger has used the PowerDrive Archer high build-rate RSS to provide full directional control during its runs in the unconventional target. Built on PowerDrive X6 technologies, the PowerDrive Archer RSS has a unique hybrid steering unit that enables the driller to achieve maximum reservoir exposure, according to the company. The system also is fully rotational, which enables it to reduce drag and decrease the risk of sticking while drilling. Its closed-loop inclination hold mode also ensures accuracy at high drilling speeds while building high angles – from any deviation – in one run, the company said.

### Improving drilling penetration rates

In May 2012 Halliburton introduced its new fixed cutter bits titled MegaForce, setting industry-record penetration rates. These fixed cutter drill

bits have a dynamic cutting structure and matrix material with multilevel force balancing. During its press announcement, the company stated that hydraulics and shank length deliver more than a 20% improvement in drilling penetration rates for the MegaForce.

As operators drill deeper and longer wellbores in unconventional, they will be attracted to any series of bits that can drill farther and faster.

Field work in the Permian with the MegaForce bit has drillers seeing a 50% to 70% reduction in the number of bits that they need for drilling a horizontal well, said Halliburton's Dean Prather. "We think that may be something that will help reduce the cost, as well."



In May 2012 Halliburton introduced its new fixed MegaForce cutter bits titled setting industry record penetration rates. *(Image courtesy of Halliburton)*

### Case studies

Field trial data for MegaForce bits tested in Uintah County, Utah, as well as Leon, Upton, and Wheeler counties, Texas, showed penetration rate and reliability improvements over current fixed cutter bit offerings. Drilling was logged at between 18% and 31% more footage. Following each run, MegaForce bits were graded equal to or sharper than offset bits, the company said.

### Remote monitoring software

The Baker Hughes Vision well-monitoring software is a web-based service that, unlike traditional SCADA systems, provides operators with prebuilt user configurable screens that are easy to learn and navigate.



## Recycle. Reuse. Results.

Environmentally  
responsible  
water treatment  
solutions.

Over 21 million barrels treated, including  
4 million barrels of recycled fluid.

We provide onsite, offsite, and impoundment treatment with mobile units that have a small footprint. Our system employs an advanced oxidation process using ozone, hydrodynamic and acoustic cavitation, and electrochemistry to treat water.

This powerful, chemical-free combination can:

- Treat produced, flowback, and fresh water with no increased cost
- Treat at a rate of 80 barrels per minute
- Provide disinfection, scale inhibition, and organics oxidation
- Allow you to recycle/reuse more produced and flowback fluid
- Decrease your friction reducer utilization
- Improve your bottom line

**HYDROZONIX**

We make recycling easy. Contact us for more information: 214.420.7109 • [hydrozonix.com](http://hydrozonix.com)



Monitoring more than 3,000 electrical submersible pumps (ESPs) globally, with more than half of them located in the Permian Basin, Baker Hughes' Vision well monitoring software continues to be successful in this region, according to the company. The company's XPVision monitoring platform reduces an operator's monitoring and data analysis time. Baker Hughes' engineers analyze the operational data coming in from the field and then notify operators of any concerns and recommendations.

### In the field

An operator followed a chemical treatment program by restarting a Permian Basin well but inadvertently restarted the well with the tubing and casing valves closed. The well immediately began to cycle, putting the ESP at risk of failure. A Baker Hughes engineer was remotely monitoring the

ESP using XPVision monitoring software. Fewer than 16 hours after the well was restarted, exception reports generated by XPVision software identified a rise in the ESP motor temperature and a correspondingly high motor current.

The engineer analyzing the reports also noted that the pump intake pressure had a standard deviation of more than 20%. Based on this information, the engineer determined that either the well was plugged or there was a valve problem. This critical information was immediately given to the operator. A pumper sent to the field by the operator discovered the closed valves. Using the methodology and feedback of XPVision, the operator avoided an ESP failure, prevented more than eight hours of well downtime, saving significant intervention costs, according to the company.

Another customer operating a Permian Basic CO<sub>2</sub> flood partnered with Baker Hughes to evaluate the benefits of using the XPVision monitoring platform during a four-month trial.

The XPVision software delivered a complete remote monitoring and optimization service, allowing the observation of power usage, ESP parameters, well conditions, and overall production performance. Using a standardized process, ESP engineers stayed proactive and ahead of changing conditions, ensuring optimal production and efficiency. In two months, the real-time monitoring and optimization service prevented 14 immediate failures. The quick trending features allowed analysts to view multiple wells at one time. Exception reports allowed the operator and field service technicians to prioritize work. Each well had a live Auto-graphPC model operating in the background to reconcile data differences between the live data and software data predictions. This allowed for real-time diagnostics when systems began to operate in less-than-optimal conditions, saving the operator money. According to the company, the operator also added 104 bbl of oil by increasing overall production time. ■

# CRACK IT

*before you*

# FRAC IT!





Pre Frac

- Reduce tortuosity and resulting screen-outs
- Break down formation/ reduce treating pressures
- Create fractures in preferred plane



Horizontal



Close Water



Fractured



Pre Frac



Pre Acid



Injection



Open Hole

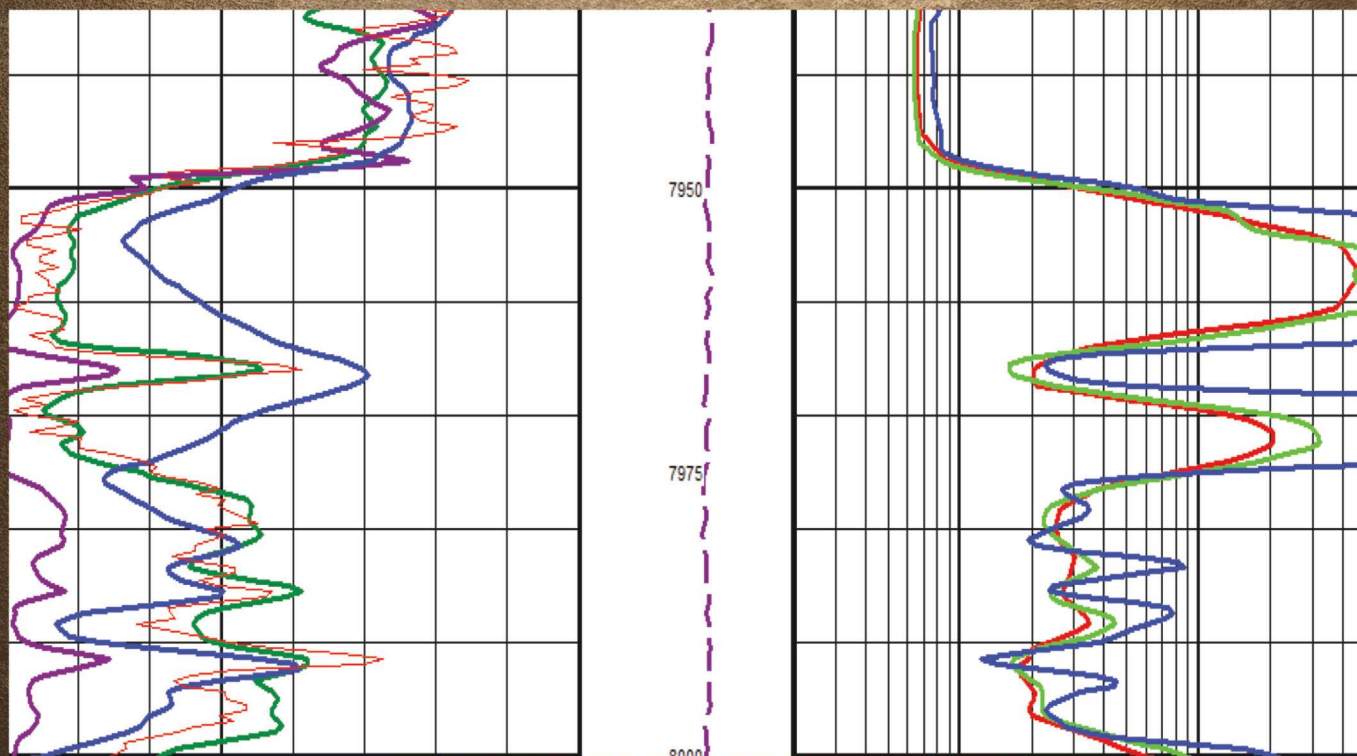


Damage

[www.TheGasGun.com](http://www.TheGasGun.com) • 877.557.1370



# TGS DELIVERS LAS PLUS



More than just your standard LAS.

LAS Plus upgrades the standard LAS to a full curve suite, including all available gamma ray, spontaneous potential, caliper, resistivity, conductivity, sonic, density, density correction, neutron, tension and rate of penetration curves. This data has been closely examined for standardization and quality assurance and is ready for cross-section, formation evaluation and petrophysical analysis.

Access LAS Plus data quickly and easily through the online well data portal, LOG-LINE Plus®!



Learn more at [WWW.TGS.COM](http://WWW.TGS.COM)



# A Phoenix **RISES** Again:

STACKED PLAYS RESPOND TO INNOVATION

**APRIL 2-4, 2013**

FORT WORTH CONVENTION CENTER

FORT WORTH, TEXAS

Register today at [dugpermian.com](http://dugpermian.com)

## CURRENT INDUSTRY TOPICS

- Opening Keynote: North America & The New Energy Economy
- Activity Overview: Rigs, Counts & Capex
- A Horizontal Wolfcamp Acceleration: Pioneer's Plans in Its Sinochem JV
- International Operator Spotlight: The World's Best Resource Plays
- Technical Roundup: The Export of North American Technology
- Spotlight: A Veteran's Guide to A New Unconventionals-Driven Approach to Petroleum Geology
- North American Midstream: The Great Reconstruction
- Panel Discussion: Resource Play Report Cards
- Emerging Resource Plays: A Global Review
- Permian Legends: The Expert Guide To The Basin That Keeps Giving

## UPSTREAM TRACK

- Operator Spotlight: Apache's New Permian
- Panel: Southern Delaware Basin Panel
- Operator Spotlight: The Midland Basin's Wolfcamp, Cline & Mississippian
- Panel: M&A Action in the Permian
- The Horizontal Wolfcamp
- Roundtable: Better, Faster & Cheaper Wells

## MIDSTREAM TRACK - **NEW FOR 2013**

- NGL Pipeline Spotlight: Sand Hills Project
- Panel: Oil Pipeline Plans in the Permian
- Operator Spotlight: Solving Processing Constraints
- Panel: New to the Neighborhood
- Spotlight: West Texas Gas
- Roundtable: Riding the Rails

## SPONSORS

### PREMIER



### GOLD



### SILVER



### BRONZE



### SPONSORS



### PRESENTED BY

**HART** ENERGY

### SUPPORTED BY



Oil and Gas  
Investor





DEVELOPING UNCONVENTIONALS



PERMIAN BASIN AND MORE

The Permian Basin has a long and storied past. Now it is in a complete reawakening. The basin's rich hydrocarbon reservoirs are being tapped with new-generation technology and its world-class source rocks offer fresh targets.

**DUG Permian Basin and More** delivers a high-level review of continental and global oil and gas dynamics, in-depth sessions on the hottest Permian unconventional plays, and special midstream tracks focused on the dramatic changes in the region's infrastructure. **DUG Permian Basin** culminates in a review of the best emerging plays around the globe.

If tight-oil, natural gas, and NGLs from shales matter to you and your business, then you cannot afford to miss the actionable intelligence available at **DUG**. Come see for yourself why **DUG™** series conferences are the largest unconventional resources events in the world.

INDUSTRY LEADING SPEAKERS



WEDNESDAY, APRIL 3, 2013 - NETWORKING LUNCHEON KEYNOTE SPEAKER

**GEN. COLIN POWELL, U.S. ARMY (RET.)**  
AND 65TH U.S. SECRETARY OF STATE

General Colin Powell's service as U.S. Secretary of State from 2001 to 2005 put him at the forefront of some of the world's most impactful events. Prior to that appointment, General Powell had a long and illustrious military career, serving as National Security Advisor, Commander of the U.S. Army Forces Command and as Chairman of the Joint Chiefs of Staff.



**Peter Tertzakian,**  
Chief Economist,  
*ARC Financial Corp.*



**John Ely,**  
President,  
*Ely & Associates Inc.*



**E. Russell (Rusty) Brazier,**  
President,  
*RBN Energy LLC*



**David J. Howard,**  
P.Eng., Director,  
*Energy Research, ITG*



**Greg Smith,**  
Senior VP,  
*DCP Midstream LLC*



**Scott Richardson,**  
Co-Founding Principal,  
*RBC Richardson Barr*



**Carl Tricoli,**  
Co-Founder, Managing  
Partner and Co-President,  
*Denham Capital Management LP*



**Randy Hoover,**  
President & COO,  
*Hoover Energy  
Partners LP*



**Bob Milam,**  
President,  
*EagleClaw Midstream*



**Robert E. Dunn,**  
President & CEO,  
*Prism Midstream LLC*



**J. Ross Craft,**  
President & CEO,  
*Approach Resources*



**John J. (Jay)  
Lendrum III,**  
President & CEO,  
*Nuevo Midstream LLC*



**Jeff Meisenholder,**  
VP, Unconventional  
Resources,  
*Unconventional  
Resources, Schlumberger*



**Dr. Carmine Difiglio,**  
Deputy Asst. Secretary,  
Policy Analysis,  
*Office of Policy and  
U.S. Dept. of Energy*



**Herve Wilczynski,**  
Partner,  
*A.T. Kearney Inc.*



**Mike Kelly,**  
VP & Senior E&P  
Analyst,  
*Global Hunter  
Securities LLC*



# Building, Rearranging, and Reconfiguring

Midstream constraints have been causing bottlenecks in the Permian Basin oil transportation system recently, but a surge of new projects promises relief in short order.

**By Hart Energy Staff**

**T**he oil production renaissance in the Permian Basin is in full bloom, and operators are drilling out their inventories of liquids-rich and oilier acres. Midstream operators are working hard to stay ahead of the surge in production. But the rapid spread of unconventional technology in this long-time producing basin makes it seem as though for every barrel that midstreamers send out from the Permian, two barrels are coming up from completed wells. Truly, the pipelines, rail cars, and trucks that currently move crude in the Permian are full to overflowing, and the difficulty in taking crude out of the basin is reflected in regional prices.

In 4Q 2012, price spreads blew out between the Permian's local crude oil pricing point in Midland, Texas, and the North American price point in Cushing, Okla. By mid-November, the spot price for Midland crude was \$20/bbl below prices for West Texas Intermediate in Cushing. That mammoth discount contrasts strikingly with the last five-year average discount of 89 cents/bbl, according to Hart Energy's analysis of Bloomberg data.

Reasons for the \$20/bbl blowout in differentials are largely credited to repair and maintenance work on refineries in Borger and Big Spring, Texas. When these outages piled on top of the burgeoning crude volumes and already tight infrastructure, the Midland-Cushing differential exploded.

Still, Permian Basin crude will continue to suffer midstream headaches during the first half of

2013. In 4Q 2012, Permian crude averaged around \$9/bbl less than Cushing crude, and expectations are that the average differential will widen to around \$12/bbl through mid-2013. At that point, additional outbound pipeline capacity will come onstream, and the differentials should lower substantially.

Certainly, the price discounts and growing liquids production are driving a new tranche of infrastructure development throughout the Permian Basin.

## **Basin takeaway**

Three major projects are adding impressive takeaway capacity, some of which is coming on quickly.

Sunoco's Permian Express is adding 90,000 b/d in 1Q 2013, and an additional 60,000 bbl is scheduled in the second half of 2013. The project comprises a reversal of an existing line between Wichita Falls and Wortham, Texas, and a new line from Wortham to the Gulf Coast. Phase 2 of this project will add another 200,000 b/d by mid-2014.

Meanwhile, Magellan Midstream Partners LP is reversing its Longhorn line, which runs from Crane, Texas, to the Gulf Coast. Initially, that will add 135,000 b/d of capacity. Phase 2 of the project will add another 90,000 b/d, bringing total capacity to 225,000 b/d. Supporting this project, Magellan will expand its delivery capability and improve refinery connectivity in the greater Houston area. Another

Crude-by-Rail Terminals				
Operator	Location		b/d	Completion
<b>EOG</b>	San Angelo, Texas	—	5,000	2012
<b>Atlas Oil</b>	Odessa, Texas	Phase 1	11,900	2011
		Phase 2	23,800	2014
<b>Cetane Energy, Murex</b>	Carlsbad, N.M.	—	77,000	2012
<b>Kinder Morgan Energy Partners LP, Martin Midstream Partners LP, Watco Co's, Inc.</b>	Pecos, Texas	Phase 1	65,000	2012
		Phase 2	145,000	2013
		Phase 3	120,000	2014
		Phase 4	90,000	2015
<b>Mercuria Energy Trading</b>	Panhandle, Texas	—	30,000	2013
<i>Source: Hart Energy</i>				

Permian Basin Crude Outbound Capacity					
Operator	Facility	Explanation	Existing Capacity (b/d)	Additional Capacity (b/d)	Start Date
<b>Kinder Morgan Inc.</b>	Line 2000 Reversal / Reconversion	During a 3rd quarter call with analysts, Kinder Morgan executives discussed reversal and reconversion of one or more segments of the El Paso natural gas line from Texas to California back into oil service.		400,000	Speculative
<b>Magellan Midstream Partners LP</b>	Longhorn Pipeline Reversal	Reversal and conversion of its refined product 24-in. pipeline to transport crude from El Paso to Houston, thereby bypassing Cushing, Okla.		135,000	Mid-2013
		Enhance the operational connectivity of the partnership's existing pipeline system.		90,000	Mid-2013
<b>Plains All American Pipeline (87%), Enterprise Products Partners (13%)</b>	Basin Crude Oil Pipeline	519-mile crude oil pipeline from Permian basin to Cushing, Okla.	400,000		Existing
	Basin Crude Oil Pipeline Expansion	Expansion of the pipeline segment from Colorado City, Texas, to Cushing, Okla.	50,000		Existing
<b>Plains All American Pipeline LP (63%), Sunoco Logistics LP (37%)</b>	Mesa Crude Oil Pipeline	The Mesa System, which originates near Midland, Texas, delivers crude oil to Alon's Big Spring, Texas, refinery and feeds both the West Texas Gulf Pipeline, which serves markets south and east of Cushing, Okla., and the Basin Pipeline system, which delivers crude oil to the Cushing hub.	320,000	100,000	Existing
<b>Plains All American Pipeline LP (40%), Sunoco Logistics Partners LP (60%)</b>	West Texas Gulf Crude Pipeline	580-mile crude oil pipeline to Mid-Valley Pipeline and Gulf Coast .	300,000		Existing
	West Texas Gulf Crude Pipeline Expansion	Crude oil pipeline expansion - Houston (40,000 b/d), Longview (30,000 b/d) and Nederland (40,000 b/d) access.		110,000	1Q 2013
<b>Occidental Petroleum Corp., Magellan Midstream Partners LP</b>	Centurion Pipeline System	2,750 miles of crude oil gathering pipeline from Midland, Texas, to Cushing, Okla., and 5.8 MMbbl storage capacity.	175,000		Existing
<b>Sunoco Logistics Partners LP</b>	Permian Express Pipeline	Phase 1 - To be completed in 2 tranches, the project involves reversing an existing pipeline to carry crude oil pipeline from West Texas at Wichita Falls to Wortham, Texas, and then on to the Gulf Coast at Nederland, Texas.		90,000	Existing
		Phase 2 - Twin a 300-mile pipeline, parallel to the existing West Texas Gulf Pipeline from Colorado City to Wortham and then connect to the West Texas Gulf Pipeline to continue to Nederland.		150,000	4Q 2013
				200,000	Second half of 2014
<i>Source: Hart Energy</i>					



New Intra-basin Crude Projects				
Operator	Facility	Explanation	Additional Capacity (b/d)	Start Date
<b>Bridger Logistics LLC</b>	Pecos River Pipeline Project	75 miles of crude oil pipeline from Delaware Basin near Pecos, Texas, to Crane, Texas.	150,000	1Q 2013
<b>Energy Transfer Partners LP, Regency Energy Partners LP</b>	Trinity Pipeline	Convert 39-mile, 8-in. CO <sub>2</sub> pipeline from Reeves County, Texas, to Lea County, New Mexico to crude oil service.	54,000	—
<b>Hoover Energy (Eagle Oil &amp; Gas)</b>	Pecos Crossing Pipeline	Phase 2 - Extend the pipeline south to Pecos County.	—	Proposal
<b>Holly Energy Partners</b>	Crude Oil Pipeline System	Phase 2 expansion - Reactivation and conversion of 70-mile, 8-in. petroleum products pipeline to crude oil service.	35,000	Early 2013
<b>Plains All American Pipeline LP</b>	Crude Oil Pipeline System	145-mile crude oil pipeline from the Bone Spring, Spraberry and Wolfberry areas in nine West Texas counties.	200,000	1Q 2013
	North Spraberry Pipeline	50-mile crude line will extend northward from Midland, Texas, to Martin County, Texas, and west to Andrews County, Texas, to transport Wolfberry and Spraberry production.	40,000	1Q 2012
	South Spraberry Pipeline	50-mile pipeline extending from Midland, Texas to north-west Reagan County and connecting to PAA's existing Spraberry Pipeline running to southeast Reagan county to serve Glasscock, Reagan, Irion and Crockett Counties.	60,000	1Q 2012
Source: Hart Energy				

New NGL Pipeline Projects				
Operator	Facility	Explanation	Additional Capacity (b/d)	Start Date
<b>Energy Transfer Partners LP, Regency Energy Partners LP</b>	West Texas Gateway NGL Pipeline System (Lone Star NGL LLC)	The project partners announced the 4Q 2012 in-service date for the new 570-mile NGL pipeline with a 209,000 b/d capacity that extends from Winkler County in West Texas to the Jackson County processing plant. The 150-mile Justice NGL Pipeline continuing on to Mount Belvieu was also said to be complete in 4Q 2012.	209,000	4Q 2012
<b>DCP Midstream LLC (66.7%), Spectra Energy Corp. (33.3%)</b>	Sand Hills Pipeline LLC and NGL Gathering Services	New 720-mile, 20-in., Y-grade NGL pipeline system from gas plants in the Permian Basin and South Texas to the various fractionator facilities along the Gulf Coast. NGL gathering services for Sand Hills new pipeline through two new interconnect points with West Texas LPG Pipeline.	350,000	Mid-2013
	NGL Pipeline	60-mile, 20-in. pipeline in Andrews and Ector counties in West Texas.	—	2Q 2013
<b>Energy Transfer Equity LP</b>	SUGS Red Bluff Project	Part of the project is a 53-km (33-mile), 10-in. pipeline to deliver NGL into Lone Star's Permian-to-Mount Belvieu pipeline expansion.	—	Mid-2013
	SUGS Mi Vida Project	Part of the project is an 7-mile, 10-in. pipeline to deliver NGL into Lone Star's Permian-to-Mount Belvieu pipeline expansion.	—	Mid-2014
Source: Hart Energy				

New Natural Gas Infrastructure				
Operator	Facility	Explanation	Capacity (MMcf/d)	Start Date
<b>Atlas Pipeline Partners LP / Pioneer Natural Resources Co.</b>	Midkiff-Benedum System (West Texas System)	Increase Midkiff plant processing capacity on the West Texas system. Phase - 2.	100	1Q 2013
		Phase - 2 expansion.	100	1Q 2015
	Sale Ranch System	Expansion of processing capacity - Initial capacity.	100	3Q 2012
		Final capacity.	100	year-round
	Driver Plant	Cryogenic processing plant.	200	2Q 2013
<b>Cimarex Energy Co.</b>	JT Facility, Culberson County	The company is ramping the startup of this new processing facility in the focus area of the Horizontal Wolfcamp to handle 50 MMcf/d of gas production. The residue gas sales go to El Paso Permian, while the NGL are trucked to various market points.	50	4Q 2012
<b>Crestwood Midstream Partners LP</b>	Bone Springs and Avalon Gas Gathering System	46 miles of dry gas gathering system to be converted to rich gas service.	50	4Q 2012
<b>Crosstex Energy LP and Apache Corp.</b>	Deadwood Gas Processing Plant	On Nov. 5, 2012, Apache announced completion of Phase - 2 expansion of processing plant in Glasscock County.	50	Q4 2012
<b>DCP Midstream LLC</b>	Rawhide Natural Gas Processing Plant	Rawhide natural gas processing plant in Glasscock County, Texas.	75	Mid 2013
	Processing Plants in Southeast New Mexico System	Artesia plant expansion.	100	2012
		Linam Ranch plant expansion.	50	2012
<b>Energy Transfer Equity LP</b>	Southern Union Gas Services Red Bluff Project	Natural gas processing plant and associated gathering, compression and treating facilities.	200	Mid 2013
	Upgrade Mi Vida Facility	Natural gas processing plant and associated gathering, compression and treating facilities.	200	Mid 2014
<b>Kinder Morgan Energy Partners LP</b>	Sasabe Lateral on the South Mainline Pipeline	60-mile, 36-in. diameter pipeline extension will carry natural gas from Kinder Morgan's El Paso pipelines to Mexican Border for export to Mazatlan, Mexico. \$60 million project.	210	Fall 2014
<b>MidAmerican Energy Holdings Co.</b>	Northern Natural Gas Company Midmar plant	Connect the new MidMar Plant (60 MMcf/d) in Andrews County, Texas, and expand the existing interconnect with West Texas Gas in Martin County, Texas.	100	4Q 2012
<b>Nuevo Midstream LLC</b>	Ramsey Gas Gathering System	Phase 2 - Extension of the system with additional large diameter, natural gas gathering lines, and an interconnect to the El Paso natural gas pipeline.	—	2012
		Phase 2 - Cryogenic processing plant and a second amine treating facility.	100	2012
<b>Regency Energy Partners/Anadarko/Chesapeake Energy</b>	Ranch JV Expansion - Cryogenic Processing Plant	Construction of a cryogenic processing plant.	100	4Q 2012
<b>Targa Resources Partners LP</b>	SAOU Gas Processing Cryogenic Expansion	In 4Q 2012, the partnership approved \$225 million capex for new cryogenic processing plant at SAOU in San Angelo, Texas.	200	Mid-2014

Source: Hart Energy



## Cushing Relief

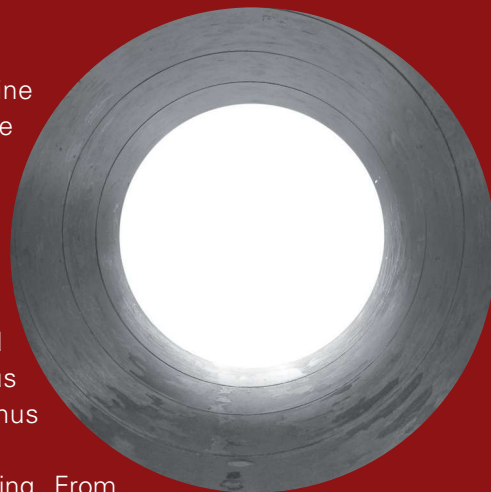
The Phase “1.5” capacity expansion of the 30-in. Seaway Pipeline to 400,000 b/d (up from Phase 1 capacity of 150,000 b/d) came online in early January 2013. The line stretches 500 miles from Cushing, Okla., to the Gulf Coast and is operated by partners Enbridge Corp. and Enterprise Products Partners.

While the Permian Basin is not directly involved in the Seaway line, the project already is impacting prices in West Texas. Seaway is actively relieving some of the bottlenecks at Cushing and is helping to ease the price differentials between the various onshore crude-producing regions. The Seaway expansion has thus added flexibility to the overall US system.

Historically, Permian producers have routed their crude to Cushing. From there the oil went to refineries in the nation’s heartland. However, the recent surge in production from the Bakken play in North Dakota and certain Midcontinent developments has overloaded Cushing. The Seaway Pipeline now is taking Cushing oil directly to the Gulf Coast, providing a much-needed outlet for producers.

In 4Q 2012 Enterprise executives also announced that first oil was flowing into the ECHO crude oil terminal. The 6-MMbbl Houston facility is designed to be interconnected with the Seaway Pipeline terminus as well as to numerous local refineries.

Phase 2 of the Seaway project, a 512-mile, 30-in. pipeline that will loop the existing Seaway Pipeline, has been upsized to provide an incremental 450,000 b/d. That is scheduled for completion in early 2014.



crude oil pipeline project is the BridgeTex Pipeline. Partners Occidental Petroleum Corp. and Magellan Midstream Partners have confirmed Federal Energy Regulatory Commission approval and shipper commitments for 400 miles of new pipeline for the venture, now upsized to 300,000 b/d. BridgeTex, scheduled for completion in mid-2014, will take Permian oil from the Colorado City, Texas, area to the Gulf Coast. This project also includes expanded delivery capability and improved refinery connectivity in the greater Houston area.

On a smaller scale, partners Plains All American Pipeline LP and Sunoco Logistics Partners LP are adding approximately 40,000 b/d of capacity to their existing West Texas Gulf crude pipeline between Colorado City and Wortham. That will raise the line’s Permian takeaway capacity to 265,000 b/d.

On the speculative side, during a 3Q 2012 conference call, Kinder Morgan Inc. executives discussed the reversal and reconversion of one or more segments of the El Paso natural gas line to

oil service. That line runs from Texas to California. The company calls the project the Freedom Pipeline and said that it would cost in the neighborhood of \$2 billion.

### Rail, truck transport

Additionally, rail transport is being used by producers to move crude out of the basin, and estimates of volumes range from 50,000 b/d to 100,000 b/d. One active shipper is Union Pacific, which has a rail line that runs from Midland through Colorado City and on to Dallas. The capacity to send crude by rail from the Permian Basin to consuming regions will likely continue to play an important role in the overall logistical portfolio, especially as offloading terminals are completed in destinations such as the West Coast that lack access via crude pipelines.

By 2015 approximately 567,000 bbl of crude-by-rail capacity will be added to send-out terminals serving Permian Basin crude, according to Hart Energy Research.

Truck transport is another option. In the Delaware Basin, Western Refining Inc. put a truck offloading and storage operation in service at year-end 2012, and in 1Q 2013 the company will start up a pipeline with capacity of 100,000 b/d.

### Intra-basin projects

Midstream projects also abound within the basin. Two recent projects of note are Plains All-American Pipeline's North Spraberry and South Spraberry pipelines. The former is a 50-mile crude line that extends northward from Midland to Martin County, Texas, and west to Andrews County, Texas. It will be used to transport Wolfberry and Spraberry production, with capacity of 40,000 b/d. The latter is a 50-mile pipeline extending from Midland to northwest Reagan County. It connects to the company's existing Spraberry Pipeline that runs to southeast Reagan County. The new line serves Glasscock, Reagan, Irion, and Crockett counties and can carry 60,000 b/d.

### NGL, natural gas infrastructure

The largest capacity venture in the NGL space is the Sand Hills Pipeline, a project owned by DCP Midstream and Spectra Energy Corp. Sand Hills is a new 720-mile NGL pipeline system that will reach from gas plants in the Permian Basin and South Texas to fractionators located along the Gulf Coast. The line, scheduled for completion in mid-2013, will be able to transport 350,000 b/d of Y-grade.


Gas processors also are building several new facilities and upgrading existing ones to handle the demands of the new production coming onstream throughout the basin.

Atlas Pipeline Partners is bringing online its new Driver cryogenic facility, with capacity of 200 MMcf/d, no later than early 2Q 2013. Based on the robust production growth that Atlas is seeing from its producer customers in the Permian Basin, the company expects to be at 60% capacity at startup. Management expects steady growth in volumes throughout the year.

Another new processing plant is the CrossTex and Apache venture in Deadwood, Texas. The cryogenic processing plant is already full at 50 MMcf/d, and further expansion is likely. It is a

50:50 joint venture between the partners, and CrossTex is the operator.

Energy Transfer Partners has two projects in progress in the Permian. The company's Southern Union Gas System (SUGS) Red Bluff project in northern Reeves County, Texas, features 200 MMcf/d of processing capacity, 33 miles of 10-in. NGL pipeline, and more than 25 miles of large-diameter gathering pipeline. The NGL pipeline will interconnect with the Lone Star NGL system. It is projected to be in service in July 2013. Farther south in central Reeves County, Energy Transfer is upgrading its existing Mi Vida plant. When it goes into service in mid-2014, Mi Vida will have 200 MMcf/d of processing capacity, 7 miles of 10-in. NGL pipelines, and 30,000 hp field compression, among other improvements. The NGL pipeline also will interconnect with Lone Star, and residue gas will connect to the Oasis system. ■





**MEDALLION**  
—MIDSTREAM—

PERFORMANCE



RELIABILITY


VALUE

**RED RIVER GATHERING SYSTEM & HARDEMAN PLANT**



-  APPROX. 100 MILES RICH GAS GATHERING
-  COMPRESSION, TREATING, DEHY, AND PROCESSING

**CHINA GROVE PROJECT MITCHELL COUNTY**

-  20 MMCFD GAS PLANT
-  50,000 ACRES OF DEDICATED LAND



AVAILABLE FOR IMMEDIATE DEPLOYMENT

-  40 MMCFD CRYO PLANT
-  90-gpm AMINE TREATER

300 E. JOHN CARPENTER FREEWAY  
IRVING, TEXAS 75062

P: 972.746.4401 F: 469.713.2819

<http://www.medallionmidstream.com>



# Oil, Oil Everywhere

The Permian Basin offers a mélange of conventional, tight oil, and shale plays, and has a cast of operators to match. Here is a look at the economic underpinnings of the resource plays most popular today.

**By Raphael Hudson**

Senior Oil and Gas Analyst

The shale gale already has transformed natural gas markets in North America. Now, with natural gas prices still in the doldrums and NGL prices also coming under pressure, operators are focusing more attention on oily plays. The Permian Basin, which covers nearly 50 counties in Texas and extends into southeastern New Mexico, offers the kind of oil-weighted resource base that operators are searching for.

The Permian is a mature oil-producing region, with majors such as Chevron and ConocoPhillips still exploiting large legacy acreage positions that have been under production for decades. Much of this acreage is in the Central Basin Platform (CBP), a regional high, and New Mexico's Northwest Shelf, areas that have enormous conventional oilfields. Many currently are being operated as secondary and enhanced oil recovery projects, notably waterfloods and CO<sub>2</sub> floods. The CBP dissects the Permian into the shallower and more heavily drilled Midland Basin to the east and the deeper and less developed Delaware Basin to the west. Large independents such as Occidental Petroleum, Apache Corp., and Devon Energy have amassed substantial positions in both of these basins, and some of the acreage is prospective for several stacked unconventional formations.

In the early 2000s, Permian operators working in the Midland Basin began to drill Spraberry wells deeper to pick up some Wolfcamp section, a carbonate and shale interval that lies below the Spraberry. These "Wolfberry" wells are a tight oil play. The very thick pay zones of carbonate debris, sands, and organic-rich shales can be tapped with

relatively inexpensive vertical wells. The "Wolffork" is a similar target consisting of the Clear Fork Formation and underlying Wolfcamp, and has been developed in similar fashion to the Wolfberry.

Besides forays into these tight oil plays, operators are seeking to develop horizontal prospects within the Permian Basin. One such target is the Cline Shale, which is identified either as a basal Permian (Wolfcamp) or Upper Pennsylvanian-era shale. Most early prospecting in the Cline is taking place along the southeastern side of the Midland Basin (in Reagan, Glasscock, Upton, and Irion counties). Early entrants into this play include Devon Energy, which planned to allocate \$350 million on a 15-well program for 2012, and Laredo Petroleum which, by year-end, had completed 33 wells targeting the Cline and had derisked 70,000 acres of its Garden City properties for Cline development.

Out west, in the Delaware Basin side, activity has been focused on the Bone Spring and Wolfcamp formations. The Bone Spring is correlative to the Spraberry in the Midland Basin. The Bone Spring is a mixture of shales, sands, and carbonates, and the main drilling targets are the shales and various sand intervals. The Bone Spring is further subdivided into the Upper and Lower Avalon (also called Leonard) shales and the first, second, and third Bone Spring sands, all of which are under development via horizontal wells in various portions of the Delaware Basin. Operators also are drilling horizontal wells that specifically target the Wolfcamp in the basin. Additionally, there is a vertical "Wolfbone" play,

primarily centered in Reeves County, Texas, in which operators target both the Bone Spring and the underlying Wolfcamp.

Occidental Petroleum, for instance, estimates that anywhere from 150,000 to 200,000 net acres of its Delaware Basin acreage is prospective for the first, second, and third Bone Spring sands, alongside 200,000 Wolfcamp and 120,000 Avalon Shale net acres. On the Midland side, Occidental estimates its net acreage position as follows: 160,000, 140,000, and 100,000 acres prospective for the Cline Shale, Wolfcamp, and Wolfberry.

### Smaller players can also find niches, but must exercise caution and discipline

Developing the Permian is not an opportunity only for large companies. A number of operators have been able to thrive by focusing on the Permian exclusively. These pure or near-pure Permian plays include Concho Resources, Energen, Laredo Petroleum, Approach Resources, and Comstock Resources.

Concho Resources, with a market cap of only one-eighth of that of ConocoPhillips, allocated nearly twice as much capital as its bigger rival in developing its 630,000 net acres in the Permian in 2012 – and is upping its Permian bet with another \$100 million in incremental capex for 2013. Likewise, Energen, Laredo Petroleum, and Approach Resources are spending almost the entirety of their

2013 development budgets (\$875 million, \$725 million, and \$260 million, respectively) in the Permian.

Pioneer Natural Resources has sought a hybrid approach, going it alone on its vertical Wolfberry acreage while seeking a joint venture partner to help finance its horizontal Wolfcamp development efforts on close to 200,000 net acres in Upton, Reagan, and Irion counties. The company believes that it holds nearly 5.6 Bboe/d in net potential resources in total, and nearly two-thirds of that is in its horizontal Wolfcamp properties. Pioneer recently signed a \$1.7 billion agreement with Petrochina in which the Chinese state-owned oil company obtains a 40% stake in Pioneer's Wolfcamp acreage in exchange for \$500 million in cash along with \$1.2 billion in drilling carry over six years.

While there has been increased interest in Permian Basin resources, recent deals make it clear that the Permian is not for everyone – over-levered operators in particular. A number of operators have sought to reduce exposure to the Permian or exit it altogether in recent months as they look to shore up their cash position and refocus on their core plays.

Chesapeake fired the first major salvo, pulling the trigger on three separate deals involving slightly more than 1 million acres, daily production of 36,000 boe/d as of 2Q 2012, and netting a total of \$3.3 billion. Chesapeake still retains 470,000 mostly undeveloped acres in the Midland Basin – an asset that the company is likely to sell, given that it has

**Figure 1: Economics of Permian Basin Shale and Tight Oil Plays**

Play	Well Type	Average 30-Day initial production (boe/d)	Average EUR (boe)	Well capex (\$ million)	Breakeven oil price (\$/bbl)
<b>Avalon</b>	Horizontal	539	455,000	\$6.4	\$53.27
<b>Bone Spring</b>	Horizontal	581	504,000	\$6.1	\$43.46
<b>Wolfcamp</b>	Horizontal	608	529,000	\$7.1	\$52.07
<b>Wolfberry/Wolfork</b>	Vertical	122	141,000	\$1.9	\$50.48

Source: North American Shale Quarterly



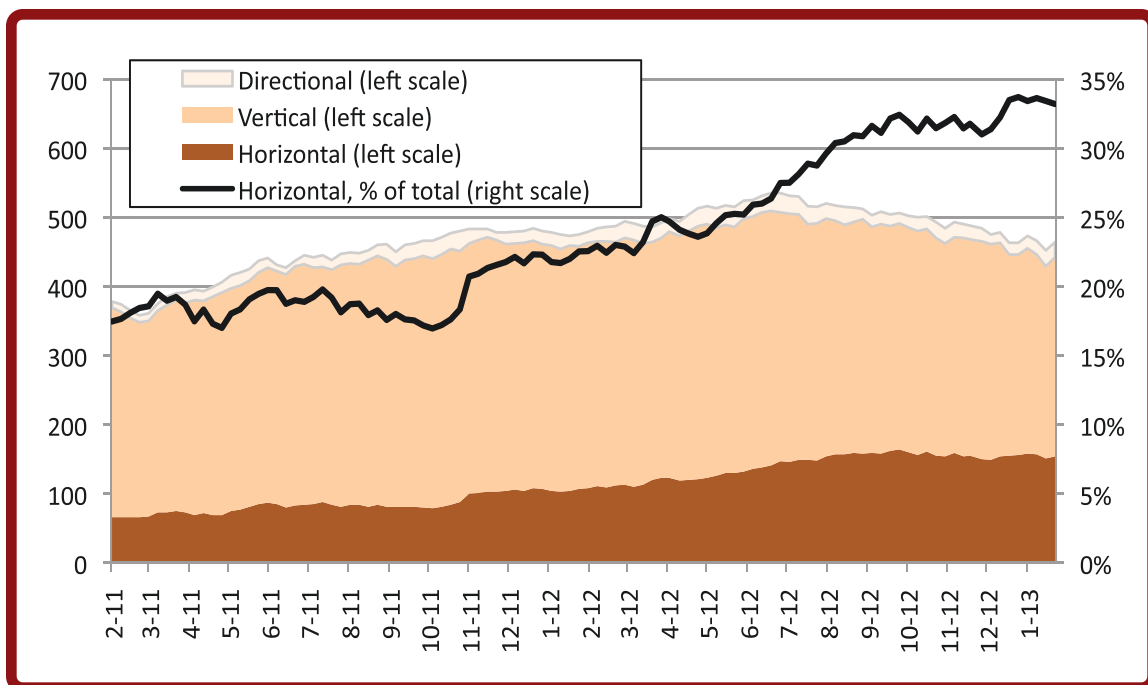


Figure 2: Permian Basin rig count by direction versus share of horizontal rigs. (Source: Hart Energy, based on Baker Hughes data)

not indicated that it considers the area a priority. SandRidge Energy has since followed suit, selling conventional Permian properties – mostly located in the CBP, and producing 24,500 boe/d as of 3Q 2012 – to Sheridan Production Partners II for \$2.6 billion. SandRidge said its rationale for the deal was similar: the need to raise cash and a desire to focus on its Mississippi Lime prospects. Last but not least, Forest Oil also has made it known that its 114,500 net acres in the Permian are on the block – here too as part of a larger divestiture campaign to shore up its balance sheet.

### With acreage derisking, horizontal drilling is gaining more traction

For those with the financial resources and the conviction to stay, continued drilling activity is providing more data points to crunch and more comparables and analogs to consider. As such, the development profile of the resource plays in the Permian Basin is tilting toward more horizontal drilling of certain target intervals, and away from Wolfberry- and Wolffork-style vertical drilling.

Hart Energy estimates the breakeven oil price applicable to Permian operators – on a net-acreage-weighted

average basis – currently is \$50.18 for vertical wells, and only slightly higher (\$50.37) for horizontal wells (this figure assumes a price deck of \$90/bbl for oil, \$42/bbl for NGL, and \$6/Mcf for gas, along with operating expenses of \$9/bbl and royalty and tax rates of 20% and 35%, respectively). The higher expected ultimate recovery (EUR) rates reported on horizontal wells offset the higher cost of these wells. Capex for horizontal wells ranges from \$5.5 million to \$8.2 million, with EURs ranging from 410,000 boe to 840,000 boe, whereas costs and EUR ranges on vertical wells tend toward \$1.2 to \$2.5 million and 120,000 boe to 270,000 boe, respectively.

With operators gaining a greater understanding of horizontal plays in the Permian they are moving more aggressively towards horizontal development. A range-bound WTI Cushing price and weakening NGL prices have blunted the urge for contracting rigs, and shorter spud-to-spud turnaround times have obviated the need for some of that hardware, too. Both have contributed to declining Permian rig counts for the past six months. Nevertheless, despite the lower aggregate numbers, the share of horizontal rigs employed in the Permian is growing (Figure 2).

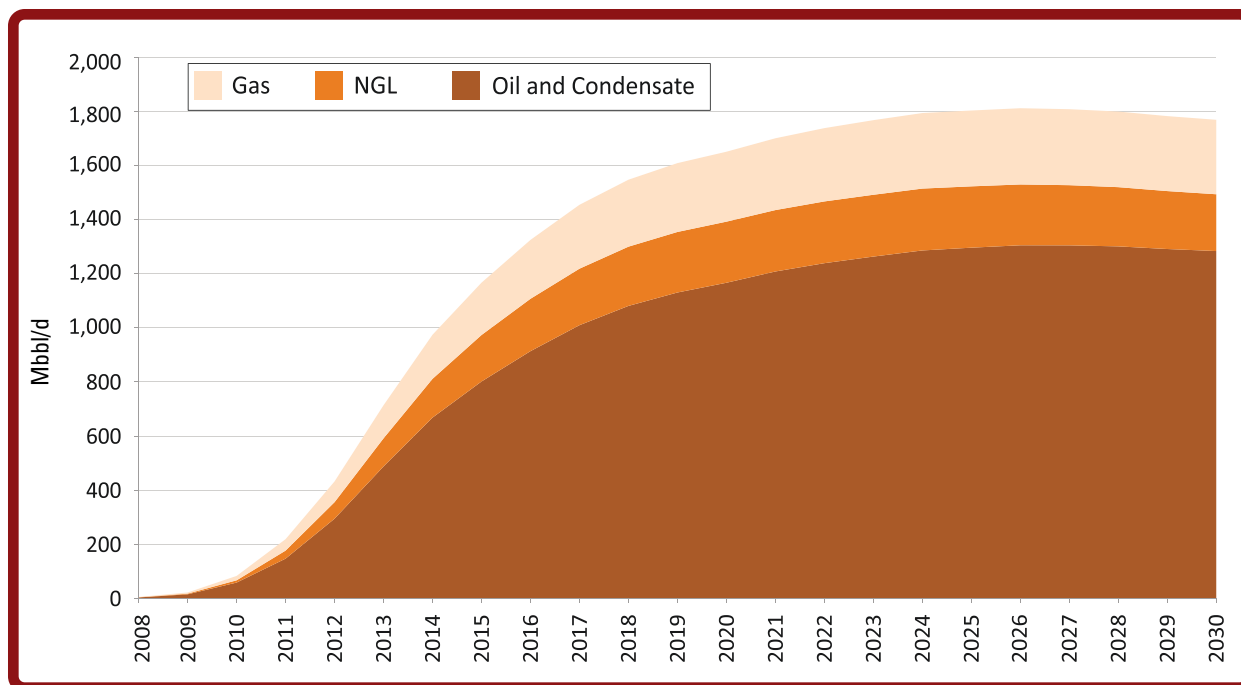


Figure 3: Permian Basin tight oil and shale oil production forecast. (Source: *North American Shale Quarterly*)

A greater level of confidence in moving ahead with horizontal drilling also is evident in some of the early guidance on 2013 capex by operators active in the Permian. For example, in early November, Concho Resources announced a substantial re-orientation of its Permian development plan, as it cut its (mostly vertical) New Mexico Shelf capex budget by nearly 40% (relative to its 2012 capex guidance) while doubling its projected spend on Delaware horizontal targets (i.e. Bone Spring, Avalon, and Wolfcamp). It also announced a deal with Legacy Reserves LP, to which it sold 120,000 net acres, mostly in the New Mexico Shelf, accounting for 5,200 boe/d of current production and 25.8 MMboe of proved reserves. Approach Resources is another example; in its 2013 capex guidance, the company cut its vertical Wolfcamp budget by nearly two-thirds, to \$26 million, while raising its Midland Wolfcamp horizontal budget by 40%, to \$229 million.

### **There is upside to Permian unconventional production, and operators are after it**

A bottom-up analysis of the trends alluded to in this article, conducted as part of Hart Energy's

North American Shale Quarterly, show greater emphasis on liquids production and the increasing pace of derisking and development of unconventional resources in the Midland and Delaware basins. This suggests that shales and tight formations will continue to add volume to Permian output as a whole. The analysis aims to isolate the development of the resource plays, and thus does not include production from conventional wells or CO<sub>2</sub> injection projects.

Development of the Permian resource plays is expected to add incremental yearly volume of roughly 200,000 boe/d between now and 2018 before the rate of growth begins to moderate. The Permian is a large piece of real estate, with an inventory of drilling locations to match – but the decline rates exhibited by shale and tight oil wells are rapid, and will gradually overcome the incremental production from a growing slate of producing wells. Nonetheless, on the aggregate, the decline from peak production in 2026 of 1.8 MMboe/day will be gradual – suggesting that the Permian Basin's unconventional revival has many years to run. ■

Source: *North American Shale Quarterly*



# SAVE *the* DATE

## APRIL 22-24, 2013

Brought to you by the  
producers of the **DUG** series

[dugmidcontinent.com](http://dugmidcontinent.com)

### NEW TARGETS FOR UNCONVENTIONAL TECHNOLOGY – MISSISSIPPI LIME *AND MORE*

The Midcontinent is alive with activity from the surging **Mississippi Lime** play to the new **South Cana** **Woodford** play to the **Marmaton** and more. This inaugural **DUG Midcontinent** conference brings attendees the latest intelligence on these fast-evolving plays. Whether you are seeking new business connections, or to learn how operators are developing their investments, **DUG Midcontinent** is *THE* conference you cannot afford to miss.

Plan to attend this year's event! For more information go to [dugmidcontinent.com](http://dugmidcontinent.com)



#### DUG Midcontinent Conference & Exhibition

Renaissance Tulsa Hotel  
& Convention Center  
Tulsa, Oklahoma

DEVELOPING UNCONVENTIONALS

**DUG**  
MIDCONTINENT

Owned by:

Presented by:

HART ENERGY

E&P

Oil and Gas  
Investor

MIDSTREAM  
Business

UG UNCONVENTIONAL  
OIL & GAS CENTER



## CURRENT INDUSTRY TOPICS

### PRELIMINARY CONFERENCE AGENDA

#### Monday, April 22, 2013

- Opening Keynote: The High-Chat Lime View from The Nemaha Ridge

#### Tuesday, April 23, 2013

- Panel: Rocks & Rigs In The Mississippi Lime
- Solving For Growth: Eagle Energy-Midstates' Mississippi Lime
- Operator Spotlight: The Scoop On The SCOOP
- Operator Spotlights: The Private Approach
- Panel: Prolific Panhandle Pays
- Midstream Spotlight: DCP's NGLs-to-Texas Plans and More Midcon Take-Away
- Midstream Panel: Legacy Infrastructure & New Projects
- Spotlight: Residents & Regulations
- Hogshooter Highlights

#### Wednesday, April 24, 2013

- Opening Keynote: Apache's Barrel-Busting Midcontinent
- Woodford Wonders
- Technical Spotlight: Seismic Strategies In Midcontinent Resource Plays
- Roundtable: Holes & Horsepower In The Heartland
- Operator Spotlights: The Two Marmatons
- Panel: Emerging Plays

*(Agenda content and timeline subject to change)*

## INDUSTRY-LEADING SPEAKERS (as of January 18)



**Ray Walker,**  
Sr. VP and COO,  
*Range Resources Corp.*



**Ralph Williams,**  
President,  
*Reservoir  
Visualization Inc. (RVI)*



**Steve Antry,**  
Chairman and CEO,  
*Eagle Energy of  
Oklahoma LLC*



**John Crum,**  
President and CEO,  
*Midstates  
Petroleum Co. Inc.*



**Hal Chappelle,**  
President and CEO,  
*Alta Mesa Holdings LP*



**Greg Smith,**  
Sr. VP,  
Permian and  
Midcontinent,  
*DCP Midstream LLC*



**Rick Wilkerson,**  
President and CEO,  
*Velocity Midstream*



**Robert Johnston,**  
Vice President,  
Central Region,  
*Apache Corp.*



**Erik Bartsch,**  
Exploration and  
Appraisal Manager,  
*Shell Oil Co.*



**Bill Ward,**  
Vice President,  
Gas Supply and  
Business Development,  
*Superior Pipeline Co*



# Additional Information on the Permian Basin

For more details on the Permian Basin, consult the selected sources below.

**By Jennifer Presley**  
Senior Editor, Production

**Ackerman, Jennifer Louise.** "Reservoir Description of the BC4 Producing Zone in the Lower Brushy Canyon Formation, Lost Tank West (Delaware) Field, Eddy County, New Mexico." MS. University of Texas of the Permian Basin, 1999. Print.

**Adams, J.E.** "Stratigraphic-Tectonic Development of the Delaware Basin." *AAPG Bulletin* 49.11 (1965): 2140-2148.

**American Association of Petroleum Geologists Southwest Section, et al.** *Transactions: Geo-2000, Into the Future: Southwest Section, AAPG, 2000 Convention. Publication.* Midland, TX: The Society, 2000. Print.

**Andreason, Mark William.** "Coastal Evaporative Environments of the Permian Yates Inner Shelf and the Effects of Penecontemporaneous Sulfate Dissolution, Central Basin Platform, Ward County, Texas." M.A. University of Texas at Austin, 1990. Print.

**Ariza, Eduardo Efen.** "High-Resolution Sequence Stratigraphy of the Leonardian Lower Clear Fork Group in the Permian Basin, West Texas." M.A. University of Texas at Austin, 1998. Print.

**Artan, Sinem.** *Aeolian Delivery of Organic Matter to a Middle Permian Deepwater Ramp.* 2012. Online.

**Atchley, S.C.** *Applied Reservoir Architecture Field School: Field Guide to Pennsylvanian and Permian Outcrops of West Texas and New Mexico.* United States: Sonat Exploration: Baylor University, Dept. of Geology, 1996. Print.

**Bae, Wisup.** "The Influence of Macropore Heterogeneity on the Petrophysical Properties of Carbonates." Ph.D. University of Texas at Austin, 1992. Print.

**Ball, Mahlon M.** "Permian Basin Province (044)." *US Geological Survey* (1995): 21.

**Blakely, R.** "Paleogeography and Geologic Evolution of North America." Northern Arizona University. Online.

**Comer, J.B.** "Stratigraphic Analysis of the Upper Devonian Woodford Formation, Permian Basin, West Texas and Southeastern New Mexico." Austin, TX: Bureau of Economic Geology, University of Texas at Austin. 1991. Print.

**DeFord, Ronald K., and University of Texas Board of Regents.** *The Permian Basin in Texas; a Definition Prepared for the Board of Regents of the University of Texas.* Austin, TX. 1969. Print.

**Dolton, G.L.** *Estimates of Undiscovered Oil and Gas, Permian Basin, West Texas and Southeast New Mexico.* Open-File Report / US Geological Survey. Denver: US Geological Survey, 1979. Print.

**Doser, D.I., M.R. Baker, and D.B. Mason.** "Seismicity in the War-Wink Gas Field, Delaware Basin, West Texas, and Its Relationship to Petroleum Production." *Bulletin of the Seismological Society of America* 81.3 (1991): 971-86. Print.

**Durham, L.** "Blended Plays: Technology Awakens Permian." *AAPG Explorer.* May 2012. Online.

**Dutton, S.P.** *Play Analysis and Digital Portfolio of Major Oil Reservoirs in the Permian Basin.* Report of Investigations. Austin, TX, and Socorro, NM: Bureau of Economic Geology, New Mexico Bureau of Geology and Mineral Resources, 2005. Print.

---. *Play Analysis and Digital Portfolio of Major Oil Reservoirs in the Permian Basin: Application and Transfer of Advanced Geological and Engineering Technologies for Incremental Production Opportunities: Final Report.* Austin, TX, and Socorro, NM: Bureau of Economic Geology, New Mexico Bureau of Geology and Mineral Resources, 2004. Print.

**Galley, J.E.** "Geologic Evolution of the Permian Basin of West Texas and New Mexico." *The Geologic Evolution of the Permian Basin: a symposium.* The University of Michigan, Society of Economic Paleontologists and Mineralogists. 1984. Print.

**Gas Research Institute, University of Texas at Austin.** Bureau of Economic Geology., and Houston Geological Society. *Integrated Strategies for Carbonate Reservoir Reserve Growth: An Example from the Ellenburger Group, Permian Basin*. Chicago, IL: Gas Research Institute, 1998. Print.

**GeoChem Laboratories.** *Regional Hydrocarbon Source Rock Evaluation Study: Twenty-Three (23) Significant Wells from the Permian Basin*. Houston: GeoChem Laboratories, Inc., 1977. Print.

**Groat, Charles G., and University of Texas at Austin.** Bureau of Economic Geology. *Mineral Resources of University Lands, Exclusive of Oil and Gas*. Austin, TX: Bureau of Economic Geology, University of Texas at Austin, 1971. Print.

**Grover, George A., Paul M. Harris, and Raymond A. Garber.** *Subsurface Geology of the Capitan Shelf Margin, Northern Delaware Basin. Slide set / Society of Economic Paleontologists and Mineralogists No. 5.* slide. Society of Economic Paleontologists and Mineralogists, Tulsa, OK, 1988.

**Haight, Jared Brandon.** *Facies, Depositional Environments, and Reservoir Properties of the Shattuck Sandstone, Mesa Queen Field, and Surrounding Areas, Southeastern New Mexico*. 2002. Web.

**Harris, Paul M., and G. Grover.** *Subsurface and Outcrop Examination of the Capitan Shelf Margin, Northern Delaware Basin*. SEPM Core Workshop. Tulsa, OK: Society of Economic Paleontologists and Mineralogists, 1989. Print.

**Hart Energy.** *Permian Basin Playbook*. Houston: Hart Energy, 2010. Print

**Hayes, P.T.** "Stratigraphy of Permian Rocks." *Geology of the Guadalupe Mountains*. US Geological Survey Professional Paper 446. 1964. Print.

**Hills, J.M.** "The Structural Evolution of the Permian Basin of West Texas and New Mexico." *The Geologic Evolution of the Permian Basin: a symposium*. The University of Michigan, Society of Economic Paleontologists and Mineralogists. 1984. Print.

**Hovorka, Susan D.** "Sedimentary Processes Controlling Halite Deposition, Permian Basin, Texas." Ph.D. University of Texas at Austin, 1990. Print.

**Hovorka, Susan D., et al.** *Salt Cavern Studies: Regional Map of Salt Thickness in the Midland Basin: Final Report*. Fossil Energy. Bartlesville, OK: Bartlesville Project Office, US Department of Energy, 1997. Print.

**Hull, Amy B.** "Kinetics of Evaporite Mineral-Brine Interactions: Mathematical Modeling and Experimental Determination of the Effect of Gamma Radiation and Threshold Crystallization Inhibition on Permian Basin Brine Composition." Ph.D. Northwestern University, 1987. Print.

**Jones, T.S., and Matchus, E.J.** "Sedimentation and Subsidence of the Permian Basin." *The Geologic Evolution of the Permian Basin: a symposium*. The University of Michigan, Society of Economic Paleontologists and Mineralogists. 1984. Print.

**Kerans, C., University of Texas at Austin.** Bureau of Economic Geology and Reservoir Characterization Research Laboratory. *Characterization of Reservoir Heterogeneity in Carbonate-Ramp Systems, San Andreas/Grayburg, Permian Basin: Final Report*. Austin, TX: Bureau of Economic Geology, University of Texas at Austin, 1991. Print.

**Kim, Eugene M., and Stephen C. Ruppel.** *Play-Based Assessment of Hydrocarbon Resources in University Lands Reservoirs, Permian Basin, West Texas*. Geological Circular. Austin, TX: Bureau of Economic Geology, University of Texas at Austin, 2003. Print.

**Laroche, T. Matthew, J. J. Viveiros, and West Texas Geological Society.** *Structure and Tectonics of the Big Bend Area and Southern Permian Basin, Texas: West Texas Geological Society 1994 Field Trip Guidebook*. Publication. Midland, TX: West Texas Geological Society, 1994. Print.

**Laumbach, J.T., and D.L. Whiteman.** "Drilling to the Wolfcamp, Strawn, and Fusselman Formations, Glasscock County, Texas: A Case History." *SPE Annual Technical Conference and Exhibition*. 1985 Copyright 1985, Society of Petroleum Engineers Inc., 1985. Print.

**Leary, David Austin.** "Diagenesis of the Permian (Guadalupian), San Andres, and Grayburg Formations, Central Basin Platform, Permian Basin, West Texas." M.A. University of Texas at Austin, 1984. Print.



**Lindsay, Robert F.** *Classic Permian Geology of West Texas and Southeastern New Mexico: 75 Years of Permian Basin Oil & Gas Exploration & Development: February 29 - March 4, 2000*. Publication / West Texas Geological Society. Midland, TX: West Texas Geological Society, 2000. Print.

**Lindsay, Robert F., Christy L. Reed, and West Texas Geological Society.** *Sequence Stratigraphy Applied to Permian Basin Reservoirs: Outcrop Analogs in the Caballo and Sacramento Mountains of New Mexico: West Texas Geological Society 1992 Field Seminar, Nov. 6-8, 1992*. Publication. Midland, TX: The Society, 1992. Print.

**Magoon, L. B., and Wallace G. Dow.** *The Petroleum System*. American Association of Petroleum Geologists, 1994. Print.

**Major, R. P., and University of Texas at Austin.** Bureau of Economic Geology. *Field Extension in a Carbonate Reservoir: An Example from the Central Basin Platform, Permian Basin, West Texas*. Geological Circular / Bureau of Economic Geology, University of Texas at Austin. Austin, TX: Bureau of Economic Geology, University of Texas at Austin, 1990. Print.

**Major, R.P., G.W. Vander Stoep, and M.H. Holtz.** *Delineation of Unrecovered Mobile Oil in a Mature Dolomite Reservoir: East Penwell San Andres Unit, University Lands, West Texas*. Report of Investigations. Austin, TX: Bureau of Economic Geology, University of Texas at Austin, 1990. Print.

**McGlasson, E.H.** "The Siluro-Devonian of West Texas and Southeast New Mexico." *Tulsa Geological Society Digest*, Vol. 35 (1967), pp. 148-164. 1967. Print.

**McGookey, Donald P.** *Geologic Wonders of West Texas*. Midland, TX: Donald P. McGookey, 2004. Print.

**McGookey, Douglas A.** "The Queen Formation of the Ozona Arch Area, Crockett County, Texas: Depositional Systems and Structure." M.A. University of Texas at Austin, 1986. Print.

**Menchaca, M.** "Midland Basin Horizontal Opportunities Go Deeper." *Drillinginfo.com*. June 20, 2012. Online.

**Miall, Andrew D.** *The Sedimentary Basins of the United States and Canada*. Sedimentary Basins of the World. 1st ed. Amsterdam; Oxford, UK; Boston, MA: Elsevier Science, 2008. Print.

**Miall, Andrew D., Noel Tyler, and Society for Sedimentary Geology.** *The Three-Dimensional Facies Architecture of Terrigenous Clastic Sediments and Its Implications for Hydrocarbon Discovery and Recovery*. Concepts in Sedimentology and Paleontology. Tulsa, OK: SEPM (Society for Sedimentary Geology), 1991. Print.

*1975 Producing Zone Map: The Permian Basin, West Texas, and Southeast New Mexico*. 1 map. Midland, TX: Midland Map Co., 1975.

*1979 Producing Zone Map: The Permian Basin, West Texas, and Southeast New Mexico*. 1 map. Midland, TX: Midland Map Co., 1979.

*1981 Producing Zone Map: The Permian Basin, West Texas, and Southeast New Mexico*. 1 map. Midland, TX: Midland Map Co., 1981.

*Permian Basin Wildcat Map, Showing Oil Fields, County Seats, and All Major Highways*. 1 map. Midland, TX: Midland Map Co., 2009.

**Olsen, D. K., et al.** *Feasibility Study of Heavy Oil Recovery in the Permian Basin (Texas and New Mexico): Topical Report*. Fossil Energy. Bartlesville, OK: Bartlesville Project Office, US Department of Energy, 1993. Print.

**Pawlewicz, M. J., et al.** *Vitrinite Reflectance Data for the Permian Basin, West Texas, and Southeast New Mexico*. 2005. Open-file report 2005-1171.

**Perot, Amy, and Steve Robichaud.** *Permian Basin Cores: A Workshop, Midland, Texas, May 22 and 23, 1985*. PBS-SEPM Core Workshop. Midland, TX: PBS-SEPM, 1985. Print.

**Rains, David B.** "Hydrocarbon Play Summary of the Central Basin Platform – Ozona Arch, and Midland Basin of the Permian Basin Region, West Texas." B.S. Baylor University, 1998. Print.

**Robinson, Keith, and Geological Survey (US).** *Petroleum Geology and Hydrocarbon Plays of the Permian Basin Petroleum Province West Texas and Southeast New Mexico*. Open-File Report. [Denver, CO]: US Geological Survey, 1991. Print.

**Ross, C.A.** "Pennsylvanian and Permian History, Southern Shelf of Permian Basin." *The Geologic Evolution of the Permian Basin: A Symposium*. The University of Michigan, Society of Economic Paleontologists and Mineralogists. 1984. Print.

**Ruppel, Stephen C., and Don G. Bebout.** *Competing Effects of Depositional Architecture and Diagenesis on Carbonate Reservoir Development: Grayburg Formation, South Cowden Field, West Texas*. Report of Investigations. Austin, TX: Bureau of Economic Geology, University of Texas at Austin, 2001. Print.

**Ruppel, Stephen C., and M.H. Holtz.** *Depositional and Diagenetic Facies Patterns and Reservoir Development in Silurian and Devonian Rocks of the Permian Basin*. Report of Investigations. Austin, TX: Bureau of Economic Geology, University of Texas at Austin, 1994. Print.

**Ruppel, Stephen C., and University of Texas.** Bureau of Economic Geology. *Controls on Reservoir Heterogeneity in Permian Shallow-Water-Platform Carbonate Reservoirs, Permian Basin: Implications for Improved Recovery*. Geological Circular. Austin, TX: Bureau of Economic Geology, University of Texas at Austin, 1995. Print.

**Said Trabelsi, Ali M.** "Sedimentology, Petrography, and Diagenesis of Selected Paleozoic Source Rocks from the Permian Basin." Ph.D. Texas Tech University, 1990. Print.

**Schaefer, K.** "The Permian Basin Oil Play: 'Unleashed.'" *Oil and Gas Investment Bulletin*. 2012. Online.

---. "My Top Junior Oil Stock in the Permian Basin 'Tight' Oil Play." *Oil and Gas Investment Bulletin*. 2012. Online.

**Scholle, Peter A.** *The Permian Reef Complex, West Texas, and New Mexico. Slide set / Society of Economic Paleontologists and Mineralogists No. 3*. Slide. Society of Economic Paleontologists and Mineralogists, Tulsa, OK, 1988.

**Sembritsky, Christopher.** "Reservoir Characterization and Optimization of Stockyard Field, Gaines County, West Texas." M.A. Baylor University, 2001. Print.

**Shaw, Ron L.** *Permian Basin Cores: A Workshop, Midland, Texas, May 17 and 18, 1983*. PBS-SEPM Core Workshop, Midland, TX: PBS-SEPM, 1983. Print.

**Smith, Gary E.** "Depositional Systems and Facies Control of Copper Mineralization: San Angelo Formation (Permian), North Texas." Thesis (M.A.). University of Texas at Austin, 1974. Print.

**Society of Economic Paleontologists and Mineralogists.** Permian Basin Section. *The Geologic Evolution of the Permian Basin: A Symposium, April 25-26, 1984, Midland, Texas: Program with Abstracts*. Tulsa, OK: Society of Economic Paleontologists and Mineralogists, 1984. Print.

**Stanley, S.M.** *Earth System History*. W.H. Freeman and Company, pp. 367-385. 2004. Print.

**Tyler, Noel, Nancy J. Banta, and University of Texas at Austin.** Bureau of Economic Geology. *Oil and Gas Resources Remaining in the Permian Basin: Targets for Additional Hydrocarbon Recovery*. Geological Circular / Bureau of Economic Geology. Austin, TX: Bureau of Economic Geology, University of Texas at Austin, 1989. Print.

**Tyler, Noel, J. C. Gholston, and Edgar H. Guevara.** *Basin Morphological Controls on Submarine-Fan Depositional Trends, Spraberry Sandstone, Permian Basin, Texas*. Geological Circular. Austin, TX: Bureau of Economic Geology, University of Texas at Austin, 1997. Print.

**Tyler, Noel, et al.** *Geological Characterization and Reserve Growth Potential of Spraberry Reservoirs in the Midland Basin, West Texas*. Austin, TX: Bureau of Economic Geology, University of Texas at Austin, 1987. Print.

**Tyler, Noel, and University of Texas at Austin.** *Integrated Characterization of Permian Basin Reservoirs, University Lands, West Texas: Targeting the Remaining Resource for Advanced Oil Recovery*. Report of Investigations. Austin, TX: Bureau of Economic Geology, University of Texas at Austin, 1991. Print.

---. *Opportunities for Additional Recovery in University Lands Reservoirs: Characterization of University Lands Reservoirs: Final Report, Prepared for the University of Texas System*. Austin, TX: Bureau of Economic Geology, University of Texas at Austin, 1990. Print.

*Regional Structural Cross Sections, Mid-Permian to Quaternary Strata, Texas Panhandle and Eastern New Mexico*. 15 maps. Austin, TX: University of Texas at Austin, Bureau of Economic Geology, 1988.



- Von Lunen, Eric.** "Observations of Acoustic Log/Petrophysical Data and Geophysical Implications for the Permian Basin." M.A. University of Texas of the Permian Basin, 1999. Print.
- Voorhies, H. Charles.** "Application of a Multicomponent Vertical Seismic Profile to Dynamic Reservoir Characterization at Vacuum Field, Lea County, New Mexico." M Sc. Colorado School of Mines, 1996. Print.
- Ward, R. F.** *Central Basin Platform and Delaware Basin Oil and Gas Fields*. S.I.: s.n. Print.
- Wayne, W.** "Depositional history of the Missourian and Virgilian succession (Upper Pennsylvanian) in the Permian Basin: The University of Texas at Austin, BEG Permian Basin Geological Synthesis Project." 2007. Unpublished manuscript.
- Weil, H.** *Permian Basin: Easy to Oversimplify, Hard to Overlook*. Howard Weil, Inc., pp. 1-26. 2012. Print.
- West Texas Geological Society, and Emily L. Stoudt.** *Precambrian-Devonian Geology of the Franklin Mountains, West Texas: Analogs for Exploration and Production of Ordovician and Silurian Karsted Reservoirs in the Permian Basin*. Publication. Midland, TX: ill. Print.
- West Texas Geological Society Fall Symposium, et al.** *The Permian Basin: Proving Ground for Tomorrow's Technologies: West Texas Geological Society: Fall Symposium, October 19-20, 2000*. Publication. Midland, TX: The Society, 2000. Print.
- West Texas Geological Society Fall Symposium, Timothy J. Hunt, and Peter Henry Lufholm.** *The Permian Basin: Back to Basics*. Publication. Midland, TX: West Texas Geological Society, 2003. Print.
- West Texas Geological Society Fall Symposium, et al.** *The Permian Basin: Providing Energy for America: West Texas Geological Society Fall Symposium, October 28-29, 1999*. Publication. Midland, TX: The Society, 1999. Print.
- West Texas Geological Society Fall Symposium, Peter Henry Lufholm, and Denise M. Cox.** *Unconventional Reservoirs Technology and Strategies: Alternative Perspectives for the Permian Basin*. Publication. Midland, TX: West Texas Geological Society, 2005. Print.
- West Texas Geological Society Fall Symposium, and Michael A. Raines.** *Resource Plays in the Permian Basin Resource to Reserves*. 2006. WTGS publication No. 06-117.
- West Texas Geological Society Fall Symposium, et al.** *Structure and Stratigraphy of the Permian Basin: Understanding the Fundamentals of Conventional and Unconventional Plays*. 2007. Publication /West Texas Geological Society No. 07-119.
- West Texas Geological Society Fall Symposium, et al.** *The Permian Basin – Geological Models to the World*. 2009. Publication /West Texas Geological Society No. 08-120.
- West Texas Geological Society Fall Symposium, and Cindy E. Bowden.** *Elusive Hydrocarbons Are Still to Be Found in the Permian Basin. Volumes 1-3*. 2010. Publication /West Texas Geological Society No. 09-122.
- West Texas Geological Society Fall Symposium, and Cindy E. Bowden.** *Hidden Treasures in Our Own Backyard. Volumes 1-2*. 2011. Publication /West Texas Geological Society No. 11-124.
- West Texas Geological Society Fall Symposium, and R. C. Trentham.** *Banking on the Permian Basin: Plays, Field Studies, and Techniques*. Publication. Midland, TX: West Texas Geological Society, 2004. Print.
- West Texas Geological Society Symposium, and W.D. DeMis.** *Permian Basin Oil and Gas Fields: Turning Ideas into Production: WTGS Fall Symposium, 1997*. Publication. Midland, TX: West Texas Geological Society, 1997. Print.
- West Texas Geological Society Symposium, Julie F. Gibbs, and West Texas Geological Society.** *Synergy Equals Energy: Teams, Tools, and Techniques: West Texas Geological Society Inc., Fall Symposium, October 31 - November 1, 1994*. Publication. Midland, TX: The Society, 1994. Print.
- West Texas Geological Society Symposium, and Robert L. Martin.** *Permian Basin Oil and Gas Fields: Keys to Success That Unlock Future Reserves*. Publication. Midland, TX: The Society, 1996. Print.
- West Texas Geological Society Symposium, Peter Henry Lufholm, and Ward Whiteman.** *Leveraging Conventional and Unconventional Play Concepts in the Permian Basin the Value of Stratigraphy and Technology*. 2010. Publication /West Texas Geological Society No. 10-123.

**Wright, W. Floyd.** *Petroleum Geology of the Permian Basin*. West Texas Geological Society, 1979. Print.

**Yang, Kenn-ming.** "Late Paleozoic Synorogenic Stratigraphy, Tectonic Evolution, and Flexural Modeling of the Permian Basin, West Texas and New Mexico." Ph.D. Texas A&M University, 1993. Print.

**Zamora, Lucas Guillermo.** "Silurian Rocks of the Permian Basin Region." M.A. University of Texas at Austin, 1968. Print.

## Bone Spring

**Adams, John Emery, et al.** "Standard Permian Section of North America." *AAPG Bulletin* 23.11 (1939): 1673-1678.

**Barker, Charles E., and Robert B. Halley.** "Fluid Inclusion, Stable Isotope, and Vitrinite Reflectance Evidence for the Thermal History of the Bone Spring Limestone, Southern Guadalupe Mountains, Texas." *Roles of organic matter in sediment diagenesis: Society of Economic Paleontologists and Mineralogists Special Publication* 38 (1986): 190-203.

**Cartwright Jr., Lon D.** "Transverse Section of Permian Basin, West Texas and Southeast New Mexico." *AAPG Bulletin* 14.8 (1930): 969-981.

**Crevello P.D., et al.** *Controls on Carbonate Platform and Basin Development*. Tulsa: SEPM Special Publication 44 (1989): 275-288.

**Hudnall, S. G.** *The Organic Content of the Bone Spring Formation as Evaluated by the Delta Log R Method of Log Analysis*. Sul Ross State University, 2011.

**Hunt, Dave, and Maurice E. Tucker.** "Stranded Parasequences and the Forced Regressive Wedge Systems Tract: Deposition During Base-level Fall." *Sedimentary Geology* 81.1 (1992): 1-9.

**Kerans, C., et al.** "A Contribution of Evolving Stratigraphic Framework of Middle Permian Strata of the Delaware Basin, Texas, and New Mexico." *New Mexico Geological Society, 44th Annual Field Conference Guidebook, Carlsbad Region, New Mexico, and West Texas*. 1993.

**Lang, Walter B.** "The Permian Formations of the Pecos Valley of New Mexico and Texas." *AAPG Bulletin* 21.7 (1937): 833-898.

**Lee, Ming-Kuo, and Daphne D. Williams.** "Paleohydrology of the Delaware Basin, Western Texas: Overpressure Development, Hydrocarbon Migration, and Ore Genesis." *AAPG Bulletin* 84.7 (2000): 961-974.

**Luo, Ming, Mark R. Baker, and David V. LeMone.** "Distribution and Generation of the Overpressure System, Eastern Delaware Basin, Western Texas and Southern New Mexico." *AAPG Bulletin* 78.9 (1994): 1386-1405.

**Martin, F. David, et al.** "Memoir 71, Chapter 7: Advanced Reservoir Characterization for Improved Oil Recovery in a New Mexico Delaware Basin Project." (1999): 93-108.

**Mazzullo, S.J.** "Mississippi Valley-Type Sulfides in Lower Permian Dolomites, Delaware Basin, Texas: Implications for Basin Evolution." *AAPG Bulletin* 70.8 (1986): 943-952.

**Mazzullo, S.J., and A.M. Reid.** "Lower Permian Platform and Basin Depositional Systems, Northern Midland Basin, Texas." (1989).

**Mazzullo, S.J., and P.M. Harris.** "An Overview of Dissolution Porosity Development in the Deep-burial Environment, With Examples From Carbonate Reservoirs in the Permian Basin." *Permian Basin plays: Tomorrow's technology today: West Texas Geological Society Publication* 91-89 (1991): 125-138.

**Montgomery, Scott L.** "Permian Bone Spring Formation: Sandstone Play in the Delaware Basin Part I-Slope." *AAPG Bulletin* 81.8 (1997): 1239-1258.

---. "Permian Bone Spring Formation: Sandstone Play in the Delaware Basin, Part II-Basin." *AAPG Bulletin* 81.9 (1997): 1423-1434.

**Montgomery, Scott L., et al.** "Warwink West Field: New Delaware Basin Bone Spring Area." *Oil and Gas Journal* 96 (1998): 61-65.



**Murchison Oil & Gas.** "Geographic Footprint: Permian Basin." *Unconventional Oil and Gas Report*. Houston: Hart Energy, 2012. Online.

**Rigby, J. Keith.** "Mass Movements in Permian Rocks of Trans-Pecos Texas." *Journal of Sedimentary Research* 28.3 (1958).

**Saller, Arthur H., Jane W. Barton, and Ricky E. Barton.** "Slope Sedimentation Associated With A Vertically Building Shelf, Bone Spring Formation, Mescalero Escarpe Field, Southeastern New Mexico." (1989).

**Silver, Burr A., and Robert G. Todd.** "Permian Cyclic Strata, Northern Midland and Delaware Basins, West Texas and Southeastern New Mexico." *AAPG Bulletin* 53.11 (1969): 2223-2251.

**Skinner, John W.** "Correlation of Permian of west Texas and southeast New Mexico." *AAPG Bulletin* 30.11 (1946): 1857-1874.

**Vertrees, C.D.** "Permian Basin." *Handbook of Texas Online*. Texas State Historical Association. Online.

**Ward, Robert F., Christopher G. St C. Kendall, and Paul M. Harris.** "Upper Permian (Guadalupian) Facies and Their Association With Hydrocarbons – Permian Basin, West Texas and New Mexico." *AAPG Bulletin* 70.3 (1986): 239-262.

**Wiggins, William D., and Paul M. Harris.** "Burial Diagenetic Sequence in Deepwater Allochthonous Dolomites, Permian Bone Spring Formation, Southeast New Mexico." *Deepwater Carbonates: Buildups, Turbidites, Debris Flows and Chalks: SEPM, Core Workshop*. No. 6. 1985.

## Cline

**Darbonne, N.** "Wolfcamp, Cline Shale, Permipenn, or Wolfcline?" Unconventional Oil and Gas Center. Houston: Hart Energy, 2012. Online.

**Menchaca, M.** "Cline Shale Holds Enormous Potential." *Drillinginfo.com*. 2012. Online.

## Wolfcamp

**Adams, John Emery, et al.** "Starved Pennsylvanian Midland Basin: Geological Notes." *AAPG Bulletin* 35.12 (1951): 2600-2607.

**Asquith, G. B.** "The Importance of Determining Pore Type from Petrophysical Logs in the Evaluation of a Permian Wolfcamp Reentry Northern Midland Basin." *The Log Analyst* 38.3, 1997. Print.

**Bebout, Don G.** Characterization of the Grayburg Reservoir, University Lands Dune Field, Crane County, Texas. Report of Investigations. Austin, TX: Bureau of Economic Geology, University of Texas at Austin, 1987. Print.

**Bebout, Don G, et al.** Geologic and Engineering Approaches in Evaluation of San Andres/Grayburg Hydrocarbon Reservoirs – Permian Basin. Austin, TX: Bureau of Economic Geology, University of Texas at Austin, 1990. Print.

**Bebout, Don G, et al.** Hydrocarbon Reservoir Studies, San Andres/Grayburg Formations, Permian Basin: Proceedings, Research Conference, October 7-9. PBS-SEPM Publication. Midland, TX: The Section, 1986. Print.

**Benzing, W.M, P.E. Byerly, and J.R. Hopkins.** Shear and Compressional Wave Data Interpretation-Midland Basin, Texas. 1983. Print.

**Campbell, S.M, Jr., N.R. Fairchild, and D.L. Arnold.** "Liquid CO<sub>2</sub> and Sand Stimulation in the Lewis Shale, San Juan Basin, New Mexico: A Case Study." SPE Rocky Mountain Regional/Low-Permeability Reservoirs Symposium and Exhibition. Society of Petroleum Engineers Inc., 2000. Print.

**Candelaria, Magell P, J.F. Sarg, and G.L. Wilde.** "Wolfcampian Sequence Stratigraphy of the Eastern Central Basin Platform." Permian Basin Exploration and Production Strategies: Applications of Sequence-stratigraphic and Reservoir Characterization Concepts: West Texas Geological Society Publication (1992): 92-91.

**Castagna, John P, Michael L. Batzle, and Raymond L. Eastwood.** Relationship Between Compressional and Shear-wave Velocities in Classic Silicate Rocks. 1984. Print.

- Cone, Clifford.** Case History of the University Block 9 (Wolfcamp) Field Gas-Water Injection Secondary Recovery Project. 1970. Print.
- Cook, V.O.** Regional Geology of the Delaware Basin. 1966. Print.
- Cowan, P.E., and P.M. Harris.** "Porosity distribution in San Andres Formation (Permian), Cochran and Hockley counties, Texas." *AAPG Bulletin* 70.7 (1986): 888-897.
- Doser, D.I., et al.** "The Not So Simple Relationship Between Seismicity and Oil Production in the Permian Basin, West Texas." *Pure and Applied Geophysics* 139.3 (1992): 481-506.
- Dutton, Shirley P, et al.** "Play Analysis and Leading-edge Oil-reservoir Development Methods in the Permian Basin: Increased Recovery Through Advanced Technologies." *AAPG bulletin* 89.5 (2005): 553-576.
- Ejofodomi, Efejera Akpodiate, et al.** "Improving Well Completion Via Real-time Microseismic Monitoring: A West Texas Case Study." Tight Gas Completions Conference. Society of Petroleum Engineers, 2010. Print.
- Fairhurst, B. and M.L. Hanson.** "Evolution and Development of the Wolfbone Play, Southern Delaware Basin, West Texas: An Emerging Frontier, An Oil-Rich Unconventional Resource." Search and Discovery Article #10412. 2012. Online.
- Fairhurst, B.** "Wolfbone Exploration to Field Development in an Oil-rich Unconventional Resource: Not Getting Stuck in a Conventional World." Houston: SIPES meeting. 2012. Presentation.
- Hamlin, H. Scott.** "Ozona Sandstone, Val Verde Basin, Texas: Synorogenic Stratigraphy and Depositional History in a Permian Foredeep Basin." *AAPG bulletin* 93.5 (2009): 573-594. Print.
- Harris, P.M., and S.D. Walker.** "McElroy Field: Development Geology of a Dolostone Reservoir, Permian Basin, West Texas." *Geologic and Engineering Approaches in Evaluation of San Andres/Grayburg Reservoirs: Permian Basin: Austin, Texas, University of Texas at Austin Bureau of Economic Geology* (1990): 275-296.
- Hills, John M.** "Rhythm of Permian Seas – A Paleogeographic Study." *AAPG Bulletin* 26.2 (1942): 217-255. Print.
- . "Late Paleozoic Sedimentation in West Texas Permian Basin." *AAPG Bulletin* 56.12 (1972): 2303-2322. Print.
- Hoak, T., K. Sundberg, and P. Ortoleva.** *Overview of the Structural Geology and Tectonics of the Central Basin Platform, Delaware Basin, and Midland Basin, West Texas, and New Mexico*. No. DOE/PC/91008-23-Pt. 8. Science Applications International Corp., Germantown, MD (US), 1998.
- Holmquest, Harold J.** "Deep Pays in Delaware and Val Verde Basins." *Fluids in Subsurface Environments: AAPG Mem* 4 (1965): 257-279. Print.
- Jones, Theodore S., and Harold M. Smith.** "Relationships of Oil Composition and Stratigraphy in the Permian Basin of West Texas and New Mexico." *Fluids in Subsurface Environments: AAPG Mem* 4 (1965): 101-224.
- Johnson, Raymond L., et al.** "CO<sub>2</sub> Energized and Remedial 100% CO<sub>2</sub> Treatments Improve Productivity in Wolfcamp Intervals, Val Verde Basin, West Texas." SPE Permian Basin Oil and Gas Recovery Conference. Society of Petroleum Engineers, 1998. Print.
- Khan, Azad, et al.** *A Look Into the Val Verde Basin, Texas*. 2001. Print.
- Kim, J.S.** "Compositional Simulation of the Cayanosa Wolfcamp Field Gas Cycling Operation." Permian Basin Oil and Gas Recovery Conference. Society of Petroleum Engineers Inc., 1990. Print.
- King, Philip B.** "Permian of West Texas and Southeastern New Mexico: PART 1." *AAPG Bulletin* 26.4 (1942): 535-763b.
- Kvenvolden, Keith A., and Rodney M. Squires.** "Carbon Isotopic Composition of Crude Oils from Ellenburger Group (Lower Ordovician), Permian Basin, West Texas and Eastern New Mexico." *AAPG Bulletin* 51.7 (1967): 1293-1303.
- Langan, Robert T, et al.** *Crosswell Seismic Imaging in the Permian Basin, West Texas, USA*. 1995. Print.
- Laumbach, J.T, and D.L. Whiteman.** "Drilling to the Wolfcamp, Strawn, and Fusselman Formations, Glasscock County, Texas: A Case History." SPE Annual Technical Conference and Exhibition. Society of Petroleum Engineers Inc., 1985. Print.



**Major, R.P.** Field Extension in a Carbonate Reservoir: An Example from the Central Basin Platform, Permian Basin, West Texas. Geological Circular. Austin, TX: Bureau of Economic Geology, University of Texas at Austin, 1990. Print.

**Manrique, Eduardo J., Viviana E. Muci, and Mariano E. Gurfinkel.** "EOR Field Experiences in Carbonate Reservoirs in the United States." SPE Reservoir Evaluation & Engineering 10.6 (2007): 667-86. Print.

**Metcalf, Arthur, and Juan Coronado.** "Permian Basin Wolfberry: Stimulation Evolution and Economic Optimization." *SPE Production and Operations Symposium*. 2011.

**Metcalf, Arthur Steven, et al.** "A Case Study of Hydraulically Fractured Eddy County, New Mexico, Horizontal Wolfcamp Producers." SPE Annual Technical Conference and Exhibition. Society of Petroleum Engineers, 2008. Print.

**Metcalf, Arthur Steven, and Juan Antonio Coronado.** "Permian Basin Wolfberry: Stimulation Evolution and Economic Optimization." SPE Production and Operations Symposium. Society of Petroleum Engineers, 2011. Print.

*Midland Basin Wolfcamp Study*. NuTech Energy Alliance. 2012.

**Montgomery, Scott L.** "Permian." *AAPG bulletin* 80.9 (1996): 1349-1365. Print.

**Nelson, Scott Lathrop, Jeffery Wayne Hudson, and Andrew Hooker.** "Leveraging Stochastic Analysis to Optimize Pioneer Natural Resources' Spraberry Trend Portfolio." SPE Hydrocarbon Economics and Evaluation Symposium. Society of Petroleum Engineers, 2012. Print.

**Playton, T., and Kerans, C.** *Early Leonardian to Late Wolfcampian, Deep-water Carbonate System in the Permian Basin: Evidence From West Texas Outcrops*. Austin: Bureau of Economic Geology, University of Texas at Austin, 2008. Print.

**Pugh Jr, T.D, B.W. McDaniel, and R.L. Seglem.** "A New Fracturing Technique for Dean Sand." *Journal of Petroleum Technology* 30.2 (1978): 167-72. Print.

**Ross, Charles A.** "Paleozoic Evolution of Southern Margin of Permian Basin." *Geological Society of America Bulletin* 97.5 (1986): 536-554.

**Russell, Boyd, and Randy Freeborn.** "A Practical Guide to Unconventional Petroleum Evaluation." SPE Asia Pacific Oil and Gas Conference and Exhibition. Society of Petroleum Engineers, 2012. Print.

**Vincent, Mike C.** "Optimizing Transverse Fractures in Liquid-Rich Formations." SPE Annual Technical Conference and Exhibition. Society of Petroleum Engineers, 2011. Print.

**Wright, C.A, et al.** "Fracture Treatment Design and Evaluation in the Pakenham Field: A Real-data Approach." SPE Annual Technical Conference and Exhibition. Society of Petroleum Engineers Inc., 1996. Print.

**Yang, Kenn-Ming, and Stephen L. Dorobek.** "The Permian Basin of West Texas and New Mexico: Tectonic History of a 'Composite' Foreland Basin and Its Effects on Stratigraphic Development." *Stratigraphic Evolution of Foreland Basins: SEPM Special Publication* 52 (1995): 149-174.

**Zhou, Dengen, Meisong Yan, and William Marc Calvin.** "Optimization of a Mature CO<sub>2</sub> Flood – From Continuous Injection to WAG." SPE Improved Oil Recovery Symposium. Society of Petroleum Engineers, 2012. Print.



Upstream



Midstream



Downstream

EDGE™

You have a challenge.  
We solve it.

Forum Production Equipment takes your operation as seriously as you do. Count on us for smart, custom-engineered solutions and a complete range of powerful products to help you streamline field construction and production: from tanks and separators to electrostatic crude desalters and electrostatic dehydrators, from process design for gas conditioning to pipeline equipment. For ultimate efficiency, performance and safety almost anywhere along the line, Forum is the name to remember.

Smart Solutions. Powerful Products.

**FORUM**  
ENERGY TECHNOLOGIES

To find the products to meet your challenges, visit [f-e-t.com](http://f-e-t.com)



Just how consistent can we expect production to be across these shale wells?



## Heterogeneous rock will never give homogeneous results.

In shale, production logs indicate that up to 40% of perforation clusters do not contribute to production. Experience in more than 20,000 wells in every active shale play worldwide has taught us that identifying and stimulating the right zones requires accurate measurements, a collaborative, analytical software environment, and innovative stimulation technologies.

Turn greater understanding into better production.  
[slb.com/shale](http://slb.com/shale)

**Schlumberger**