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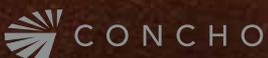
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ANNIVERSARY

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100th ANNIVERSARY

THE PERMIAN BASIN 1920 - 2020

Welcome to a celebration of the Permian Basin. A region like no other, it has played a major role in domestic oil production for 100 years, and even more so now, it is still going strong. The EIA reported that U.S. exports of crude and petroleum products exceeded imports in September 2019, making the country a net petroleum exporter for the first time since 1949. Permian producers made that happen.

The Permian promises to sustain big production for many years to come. Experts have forecast its crude output could grow another 50% to 100% by 2025. Whether this is achieved by a fast pace or a measured one, the potential is without question.

Hart Energy is proud to be commemorating the 100th anniversary of this great region, to honor its proud past, examine its enviable present, and illuminate its promising future, as its significance on the world energy scene increases.

So many remarkable men and women have contributed to the basin's progress over the years. We can't possibly cite them all, but we do

commend all of them for their wildcatting spirit, their steadfast commitment to their employees and communities, and their extraordinary technical innovation. Small partnerships, independents of every size, even the majors, are making it the place to be.

We'd like to thank the many people and organizations that have helped us gather material for this special edition. In particular, we would like to thank the staff of the Petroleum Museum in Midland for their generous help by providing archival photos and access to many important histories that recount the basin's past. Further, we'd like to thank the American Oil & Gas Historical Society, The Handbook of Texas Online and the Texas State Historical Association.

Several books were of enormous help, such as "Black Gold: The Story of Texas Oil and Gas" by Roger Olien and "Permian: A Continuing Saga" by Elmer Kelton.

The sun shines brightly over the Permian Basin as it enters its next phase of sustained production.

—The editors



HARTENERGY



Concho has been proud to call the Permian Basin home for more than a decade and we believe our success is the net result of our team and assets working together to execute our strategy. We are working today to deliver a better tomorrow for our shareholders, people and communities.

Better begins here.





PROUD PAST; EXCITING FUTURE



Leslie Haines
Editor-At-Large
Hart Energy

Stretching across West Texas and southeast New Mexico, the Permian Basin is now the largest oil-producing field in the world, with daily production of more than 4.3 million barrels of oil and 14 billion cubic feet of natural gas. Half of all drilling rigs working in the U.S. are here.

It's indisputably great rock. Some experts foresee output rising to peak at 5.5 million barrels a day (MMbbl/d) by 2023, and up to 6.8 MMbbl/d by 2029. "This basin will lead all other U.S. areas in production growth in the short, mid- and long term," said Enverus.

Drilling began in 1920 with the W.H. Abrams No. 1 in Mitchell County, a small well whose significance at the time could not have been understood. The well flowed only 20 bbl/d. But wildcatters soon realized there was more to the Texas oil story than the giant East Texas Field, and so, they moved west to drill from Midland to New Mexico.

Today companies are pouring enormous amounts of capital into the vast basin. Since 2015, some \$98 billion of mergers and acquisitions have occurred here, not counting Occidental Petroleum Corp.'s buy of Anadarko Petroleum Corp. in 2019. ExxonMobil Corp. and Chevron Corp. are racing to become the first major company to reach 1 MMbbl/d of Permian production.

This writer moved to Midland in 1975 during that era's boom only to be told there was no house to buy and no apartment to rent. Four decades later, newcomers to Midland and Odessa, and Carlsbad and Hobbs, are hearing the same thing.

In between, citizens in the cities and towns dotting the region have seen it all, from exciting and frantic boom times to discouraging, frightening busts. But the Permian always comes back. This time its resilience and future will be fueled not only by oil prices, but by the technical revolution in recovering the oil and gas.

From Wall Street conference rooms to London think tanks to the halls of OPEC headquarters, not to mention in the offices of Asian oil importers, the Permian Basin is on everyone's mind. Who's in; who's out? What's next?

This special publication celebrates the rich history of 100 years in the Permian, from famous wildcatters to historic wells—gushers and failures alike. It looks at the technologies that made a difference. We don't send nitroglycerin bombs downhole anymore; we do rely on artificial intelligence, remote control centers and recycled water. We transport crude oil from the Permian to the Gulf Coast and export it to many countries.

The world has changed dramatically in the past 100 years and so has the Permian's role within it. It will do so again. But the entrepreneurial spirit, innovation, persistence and daring of the Permian players will continue on.

We would like to thank the IPAA and TIPRO for their support of this project. It is through their efforts that we are able to distribute this book to the Texas, New Mexico and U.S. legislatures, whose members should know how the Permian Basin is changing everything.

Leslie Haines

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THE
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The Play That's Changing Everything

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All photos on this page courtesy of Shutterstock.

About the cover: Unit Drilling Rig 408 drills in Andrews County, Texas. Photo by Tom Fox

CELEBRATING OVER
25
YEARS

Kayne Anderson

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GOVERNOR GREG ABBOTT

Greetings:

As Governor of Texas, it is my pleasure to join you all in celebrating the 100th anniversary of the first Permian Basin oil well.

When we look at the rich history of the Lone Star State, the influence of the oil and gas industry upon our prosperity and growth is undeniable. Presently, Texas is the number one state in oil and gas production, and this incredible legacy would not be possible without the contributions of oil production in West Texas counties known as the Permian Basin.

Since oil was discovered in Mitchell County 100 years ago, oil production in the Permian Basin has shaped the economy of our state and nation and helped to provide valuable jobs and services to Texans. I commend the men and women of the Texas oil and gas industry, including the invaluable Permian Basin.

As you celebrate your accomplishments and prepare for the challenges to come, know that your dedication will help build a better future for the Lone Star State.

First Lady Cecilia Abbott joins me in saluting the hard working Texans of the Permian Basin upon this historic milestone. We look forward to many more years of safe and efficient production, as Texas continues to be a global leader in energy.

Sincerely,

A handwritten signature in black ink that reads "Greg Abbott".

Greg Abbott
Governor



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Fellow New Mexicans and Members of the Energy Industry,

The discovery of oil and natural gas in the Permian Basin 100 years ago was a momentous event for the United States and altered the course of New Mexico's history.

After the Westbrook Field was found in Mitchell County, Texas, in 1920, major companies and small independents began to flock to other counties in West Texas and further west into Lea and Eddy counties, New Mexico, to drill for oil.

Legendary wildcatter Martin Yates, Jr. of Artesia was one of them. His Illinois No. 3 well, the most successful of Yates' three wells drilled at that time, started the Artesia Field in 1924. By 1925, it produced more than 700,000 barrels. In 1927, exploration began in nearby Lea County near Hobbs, and southeast New Mexico was off and running as one of the most prolific producing areas in the world.

New Mexico's energy story has a proud heritage that stands on the shoulders of greatness. Trailblazers like the Yates, Besses, Armstrongs, Grays, Nichols, and Chases; Mewbourne, Leach, Read and many, many others built an energy industry in New Mexico that today stands as a global leader.

The long and storied history of oil and gas in New Mexico, which started a century ago, is making noise today in America and around the world. Thanks to new technologies, the rapid growth of oil and gas production in New Mexico currently stands at record levels. The oil and gas industry in New Mexico is the largest employer in the state. Jobs and production translate into income, taxes, and ancillary jobs, giving the industry a total economic impact of more than \$12.8 billion. And last year, the oil and gas industry provided over one-third of the revenue for the state's budget, nearly \$2 billion. That revenue is used to fund schools, roads, police officers, and health care.

Thanks to New Mexico's energy industry, we can make critical investments in our future that will help New Mexico today and for years to come. Ultimately, our industry's legacy is defined by the opportunities we have provided and will continue to provide, ensuring the future is bright for all New Mexicans.

Sincerely yours,

A handwritten signature in black ink, appearing to read "Ryan Flynn", is written over a light blue horizontal line.

Ryan Flynn

Executive Director



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Permian Power At A Glance

Estimated Reserves

Undiscovered, technically recoverable Wolfcamp resources: 46.3 billion barrels of oil, 281 Tcf of natural gas and 19.9 billion barrels of NGLs.



Longest Lateral

Longest Lateral in Permian: 17,935 feet or 3.4 miles (drilled by Moss Creek Resources Holdings Inc., a subsidiary of Surge Energy)



Estimated Investment

Capex for Permian E&Ps up to \$40 billion by 2021.



Employment Numbers

Permian oil and gas industry to support 93,201 jobs in 2020 (a 15,000+ increase since 2018).



Production

Permian crude oil production to exceed 5 million barrels per day in 2020.



Rig Count

The Permian accounts for over 50% of all active rigs in U.S.



Drilled Wells

An average of 5,316 wells drilled per year in the Permian over the past five years.



Sand Usage

Average Permian horizontal well sand consumption: 2,250 pounds per lateral foot.



DUCS

4,039 drilled but uncompleted wells in Permian by the end of 2018 (only 639 in 2013).



Water Usage

Average Permian frack job's water consumption: 13 million gallons (49 million liters).



Takeaway Capacity

Estimated Permian takeaway capacity: 3.6 million barrels per day (pre-recent additions).



New Well Production

Typical 2019 horizontal Permian well production: 830 barrels per day.





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- RP 96, Deepwater Well Design and Construction
- RP 100-1, Hydraulic Fracturing – Well Integrity and Fracture Containment

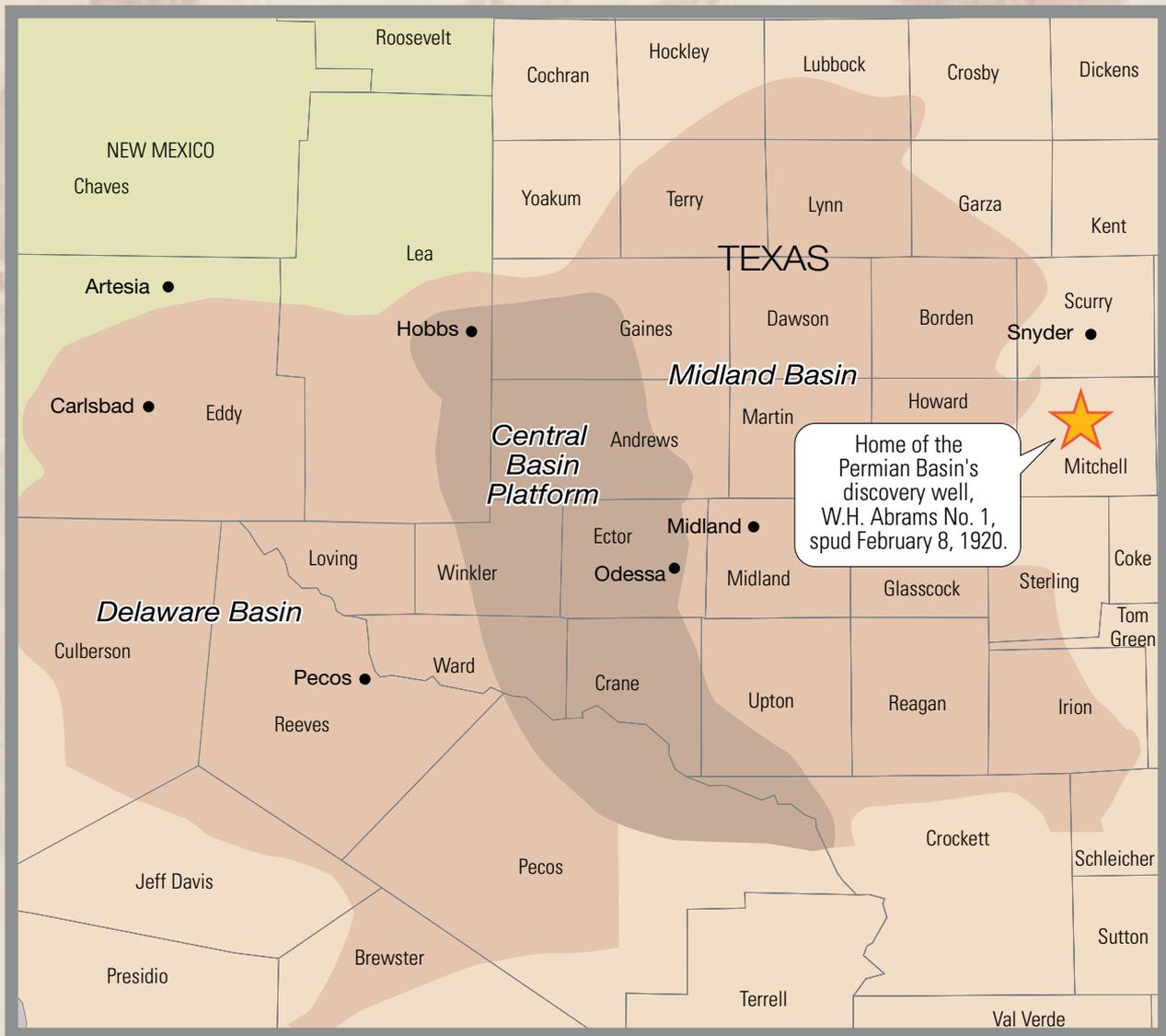


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THE PERMIAN BASIN



From a fairly inauspicious beginning with one small well in Mitchell County in 1920, the W.H. Abrams No. 1, drilling activity has expanded throughout the Permian Basin for 100 years, culminating in its prominence today, as the basin supplies the bulk of the growth in U.S. crude oil production.

Along the way, wells in Texas and New Mexico have made and destroyed fortunes, only to remake them once again. E&P, midstream and service companies have emerged as one-man shops, grown and divided, merged and acquired, and become ever bigger and stronger.

More important, well results in the Permian have often shattered preconceived notions about what the experts thought was technically possible, and where oil and gas could be found and produced economically. Hydraulic fracturing in longer and longer horizontal wells revolutionized every corner of the basin. Further technical advances we can only dream of will no doubt change conventional thinking again in the future.

Throughout the 1920s and ensuing decades, several huge fields were discovered to kick off the most productive century: Big Lake, Yates, Slaughter-Levelland, Wasson, Cowden, Goldsmith, Howard-Glasscock, SACROC, Maljamar, Hobbs and Vacuum.

Today, the Spraberry and Wolfcamp, Bone Spring, Avalon and Yeso provide unmatched potential for continued development throughout the basin.

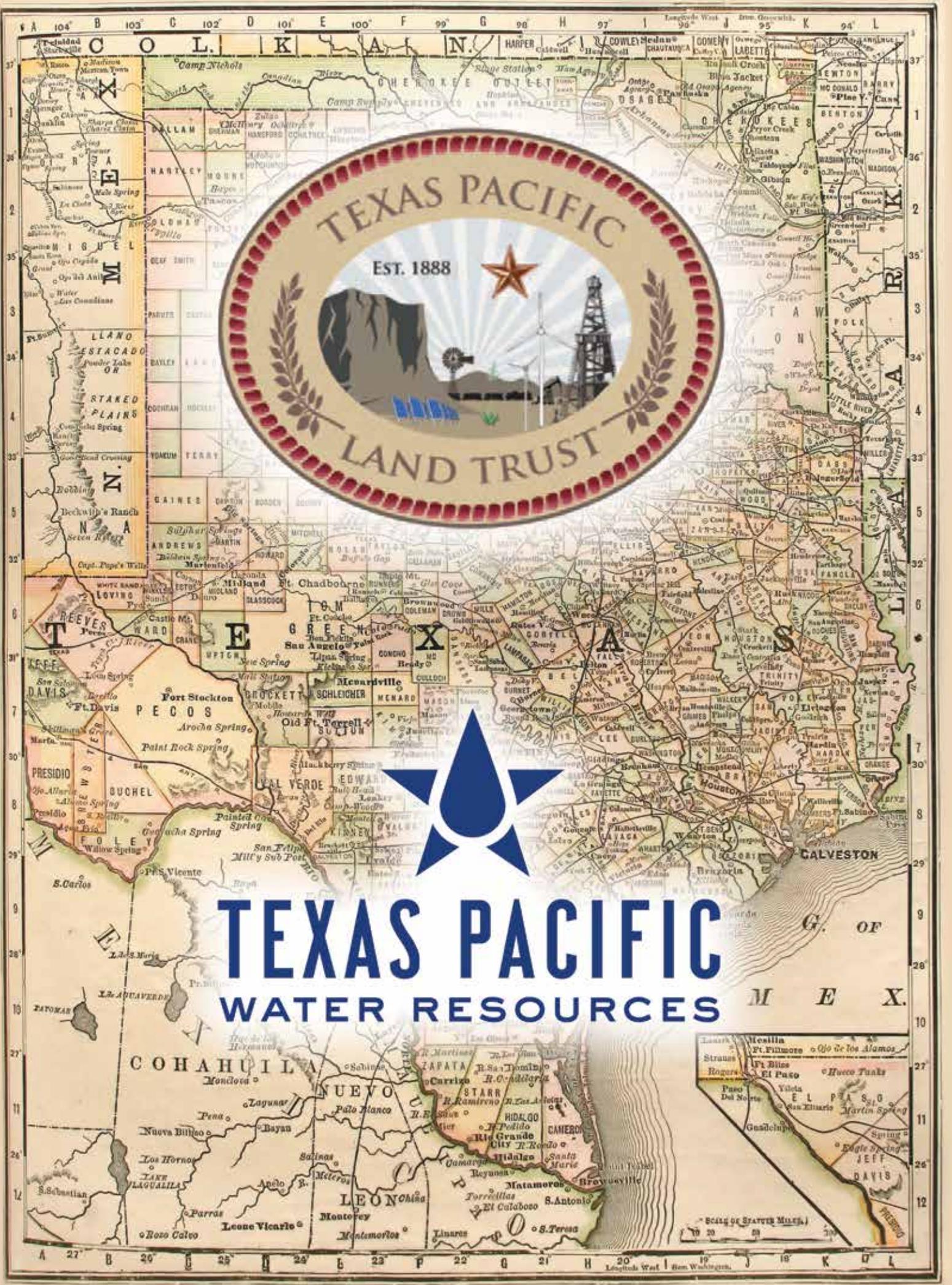
Production results have always exceeded expectations, so there's no way to predict what the future brings, if new water floods, refracked wells and enhanced oil recovery methods bring more oil to the surface.

The next frontier is already opening up: Operators are using artificial intelligence and data analytics. On the horizon? New technologies yet to leave the lab. Companies are already moving to increase ultimate recovery of oil and gas and do so in a more prudent way, by reducing their carbon footprint and capturing emissions, making wind and solar power work for them.



TEXAS PACIFIC

WATER RESOURCES



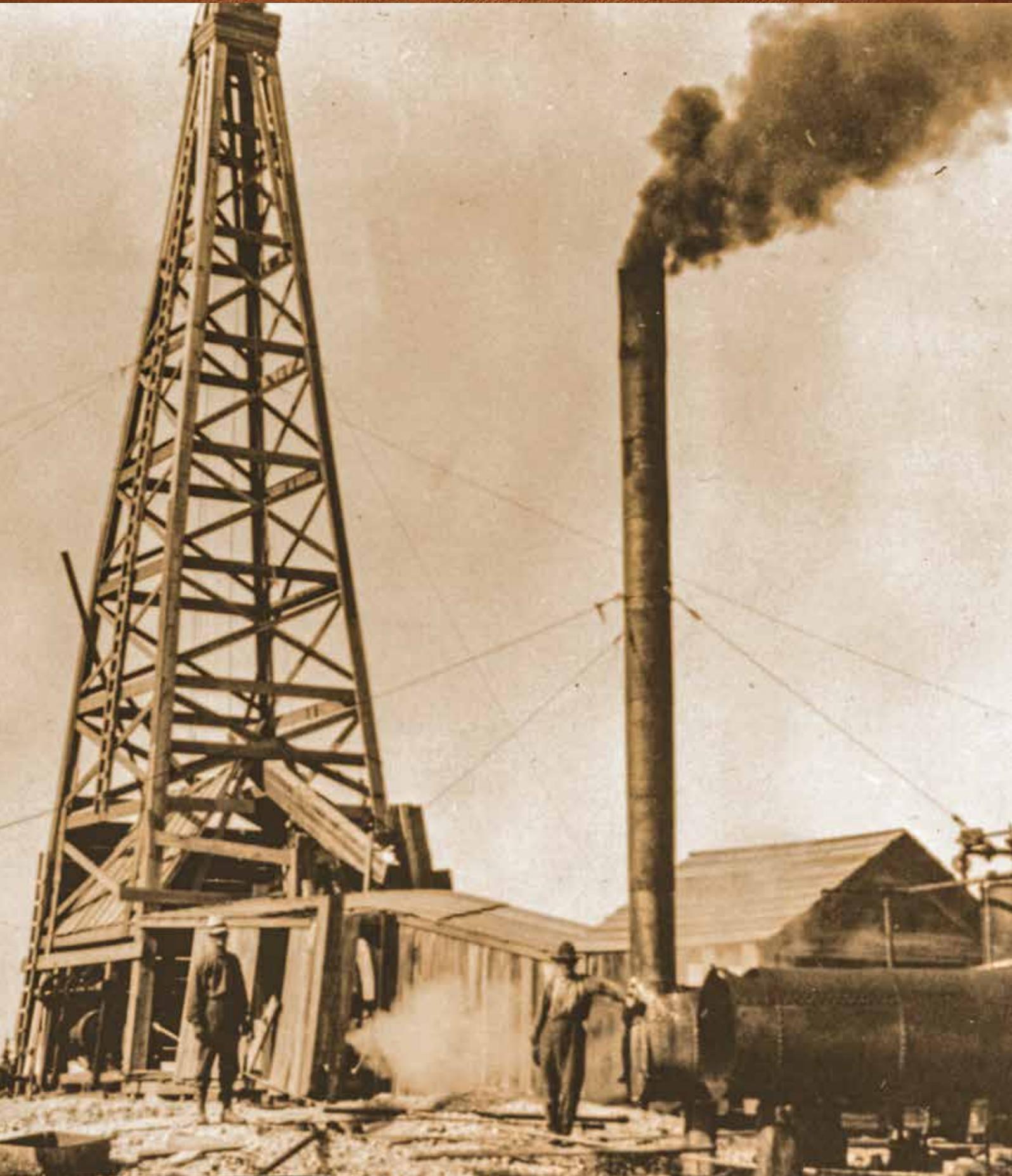
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CHAPTER 1 | HISTORY: 1920-1960

ONE

Photo by Tom Fox



THE LEGACY OF THE PERMIAN BASIN BEGINS

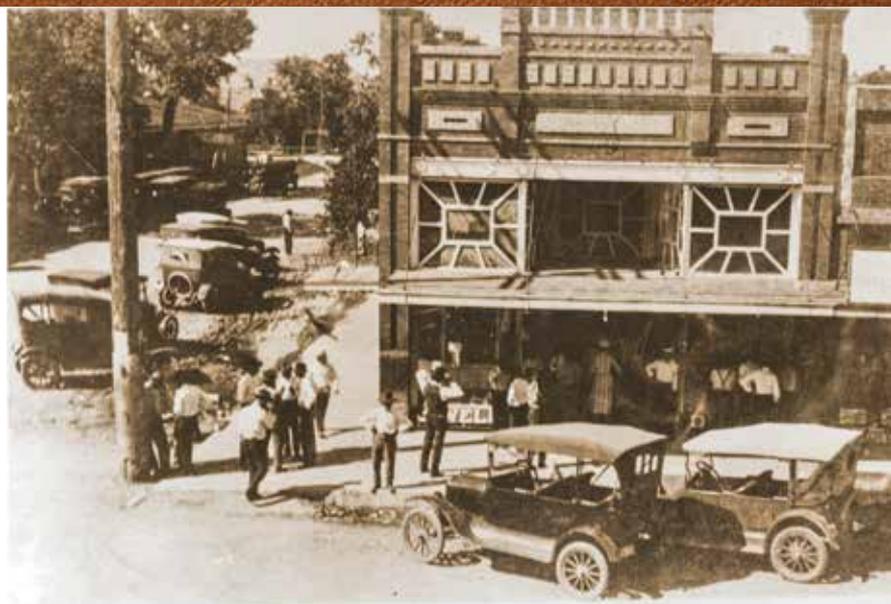
BY TRAVIS E. POLING,
CONTRIBUTING EDITOR

*Wildcatters in the Permian Basin
from 1920 to 1960 proved up a
tremendous resource.*

More than a dozen teams of horses stood at the ready to haul wagonloads of lumber from the Texas & Pacific railroad depot at Colorado City, Texas. The workers posed for a photo while standing atop the loads destined for a Mitchell County lease on railroad land. At the end of the 17-mile journey the lumber became a drilling derrick, and in June 1920, the site became the first commercial discovery well in the Permian Basin.

After putting nitroglycerine torpedoes down the hole, the well eventually came in flowing 129 barrels

Pictured left: Oilfield workers, such as these men at the Illinois No. 3 site, worked tirelessly to develop newly discovered resources in the Permian's early years. *Photo courtesy Permian Basin Petroleum Museum, Abell-Hanger Collection*



a day before tapering off to 20 a day. It was enough, though, to drill a second well on the next closest lease.

It was an inauspicious start to development of what became the largest oil-producing basin in the United States, topping 33 billion barrels of production between 1920 and 2018. There are now 7,000 fields spread across 86,000 square miles, covering more than 60 Texas counties and two in southeastern New Mexico.

The beginnings of the Westbrook Field (see sidebar) in 1920 and 1921 didn't set off an immediate rush to lease land in the vast and shifting sands of the Permian Basin. There wasn't much to recommend it using the geologic knowledge of the time. Other than decades of poking holes in the ground for water to try to make ranching and farming successful, there was little data for major oil companies to bet on.

Most of Texas, or at least those places with promising surface structures, had been explored. There had been some success in Ranger, west of Fort Worth in Eastland County, and with the Toyah-Bell No. 2 in Reeves County, but those were in counties on the edge of what was determined as the Permian Basin.

Speculation, however, was in full force in the 1920s before the nation's financial markets and economy collapsed in 1929. That fervor led entrepreneurial West Texans to buy up leases—on the cheap—from the State of Texas, railroads, farmers and ranchers, and to sell them off in blocks at a profit. Money and leases would change hands several times over, but eventually someone was going to have to drill.

Today, we know many of the largest oil fields ever found in the Lower 48 were discovered in the Permian Basin between 1920 and the 1950s. Several have produced more than 1 billion barrels of oil. Many of these legendary fields are being revived today with advanced horizontal drilling techniques to produce more oil.

Colorado City, Texas, saw a great deal of oil and gas activity, and here it is shown bustling at midday. *Photo courtesy Permian Basin Petroleum Museum, Abell-Hanger Collection*

A survey party sent out by Gulf Oil in 1923, the same year that the Santa Rita No. 1 came in at what became known as Big Lake Field. Photo courtesy Permian Basin Petroleum Museum, Abell-Hanger Collection



Santa Rita and Big Lake

Rupert Ricker, a young lawyer in Big Lake, Texas, came to believe that oil existed in Reagan County, despite the lack of any hard evidence. He arranged to lease 431,000 acres at 10 cents an acre on University of Texas lands. When he went to Fort Worth to find somebody with the money to back his play, he found little interest—that is, until he ran into Frank Pickrell, a friend from his Army days. Pickrell and Haymon Krupp, an El Paso merchant, were trying to break into the promotions game in Fort Worth and didn't have expertise to know that most geologists didn't think much of the Permian's oil prospects.

The lease was secured, but the promoters had no luck selling interest in the lease to make a profit. They had to become wildcatters. Emboldened by the still-distant finds in Mitchell County in 1920 and 1921, they set out to drill, first forming the Texon Oil and Land Co. They picked up some small investments here and there, including some from a community of Catholic women in New York City.

On May 28, 1923, the Santa Rita No. 1, the first well on University Lands in the Permian, provided a surprise gusher that eventually made about 100 barrels of oil a day. Even though it was close to the railroad, the transportation of the oil to market was too costly to provide the money now needed to develop the field. The University of Texas received a royalty check for \$516.53 three months after the discovery.

Even a producing well wasn't enough to convince large oil companies or well-financed independents to take a risk, so the task was left once again to novice oilmen to prove the viability of the lease.

Successful Pittsburgh wildcatter Michael Benedum, however, had gone several years without a major find after his role in the highly successful Ranger-Desdemona Field. He decided to gamble on Big Lake and formed Big Lake Oil Co. to throw in with Texon, after directors of his own company, Transcontinental Oil Co., weren't willing to take the risk.

Additional wells didn't perform well, but just as the credit had nearly dried up to carry on drilling, several very successful wells brought the field's production up to several thousand barrels a day, providing funds for continued development.

Big companies such as Humble Oil (a forerunner of what became Exxon) took note of the fresh supply of high-quality crude just as their own steady supply from Mexia-Corsicana, south of Dallas, took a downturn, creating a need for new sources to meet contracts with refineries. A large independent from Oklahoma called Marland Oil Co. (a forerunner of Conoco) beat them to a deal and made a contract to purchase significant amounts of oil from Texon and Big Lake each year. Through a subsidiary, Marland then sold the oil to Humble at its cost plus a gathering fee. That sparked construction of the first major Permian pipeline to the Gulf Coast.

Majors and wildcatters alike began to flock to the Permian Basin, along with geologists and other scientists, to reevaluate what lay beneath the sands.

New Mexico and the western edge

Oil production along the western edge of the Permian Basin was extended when Illinois Producers Co. principals Van Welch and Tom Flynn, and Artesia,

New Mexico, wildcatter Martin Yates Jr., teamed up for the first commercial well in the Artesia Field. Illinois Producers No. 3 on state land in the Pecos Valley brought hope to the oil seekers in Eddy County.

Martin Yates (no relation to the Texas rancher whose name was later given to the Yates Field near Iraan, Texas) had drilled at least a dozen wells before the Illinois discovery well spudded in late 1923. His dry holes were known around Artesia as “Martin’s Annual Boom,” his grandson, Peyton Yates, told Hart Energy. “He was a dreamer. There had been shows of oil contaminating water wells and that triggered his dreams.” When Illinois Producers No. 1 (sometimes

referred to as Flynn-Welch-Yates No. 1) showed only a little oil, and the second well produced only gas, the group put all its hope in the last well.

According to Yates family legend, after the second well didn’t show well, Martin’s wife, Mary, was asked to supplement the would-be oilman’s “cornfield geology” and use her intuition to pick the site for the third well. When it came in with production of 250 barrels of oil per day, all eyes turned to New Mexico and, in 1925, Artesia Field produced more than 700,000 barrels of oil.

In those days, oil companies often set up man-camps for their workers, and some of these grew to be small towns, usually with their own softball

The Permian Discovery Well Still Flows After 100 Years

Nothing unusual draws the eye to a pump jack surrounded by scrub brush in Mitchell County, Texas. An understated sign identifies it as the WSEU #701 well. But underneath is the brief history lesson: “Formerly W.H. Abrams #1. Spud date February 8, 1920. Discovery well of the Permian Basin.”

This is the first well of the Westbrook Field, the one that proved there was oil in a place with none of the traditional geological signs of wealth below. Miles from any town, the site hasn’t been enshrined. The counter balance still spins and horse head nods because it is living history and proof of the enormous staying power of the Permian Basin.

A hundred years after it was drilled, the well still produces about a barrel of oil a day for Sabinal Energy, a private company that bought the discovery well and other Westbrook assets from Energen in July 2019. Fina (later a part of Chevron) held these assets for decades and injected water in the well and others in the field to re-pressurize in the late 1960s.

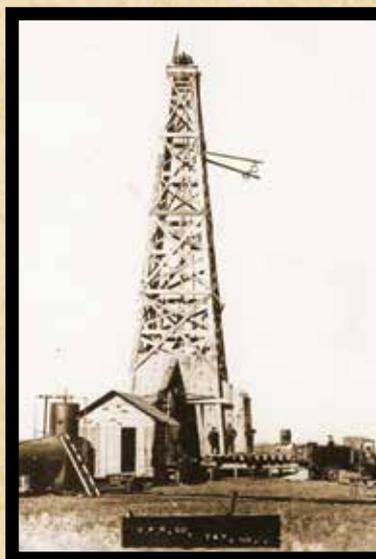
“It’s amazing that you’ve got a well still producing after 100 years,” said Bret Jameson, president and CEO of Sabinal, a company heavily invested in long-producing fields in West Texas and New Mexico.

The more famous Santa Rita No. 1, the first discovery well on University of Texas land in 1923, was plugged in 1990.

The Westbrook discovery well was never a big producer, with about 100 barrels a day at its peak. The field itself is still a steady producer, thanks to water flooding and other stimulation techniques. Westbrook has given up 120 million

barrels of oil in the last century and is now producing about 4,000 barrels a day, Jameson said.

In 1920, the discovery well underwent a stimulation of the old-fashioned kind. It didn’t take long after oil started to show, and drilling continued to 2,807 feet, though rumors of 1,000 barrels a day production flowed faster than the oil itself. After shooting the well with torpedoes of nitroglycerin on two occasions, the well promised a potential of 129 barrels a day, but it settled down to about 20 a day. The excitement died down just as quickly, and it was several years before Permian Basin oil fever came to the region. ■



The Permian endures. Left, the W.H. Abrams No. 1, discovery well for the Westbrook Field, still produces 100 years later, and is owned by Sabinal Energy, right. Photo courtesy Permian Basin Petroleum Museum, Abell-Hanger Collection

teams. Illinois Camp, boasting a schoolhouse/church and worker housing, soon became southeastern New Mexico's "epicenter of the region's oil dreams, the place where the myth of the 'petroleum graveyard' east of the Pecos River was finally vanquished," writes Tiffany Owens in the newspaper *Carlsbad Argus Current*. The population of Artesia doubled to 2,800 from 1924 to 1926.

It wasn't long before exploration began in neighboring Lea County. In 1927, Midwest Refining Co. started drilling near the town of Hobbs. Exhaust from the engine of the cable-tool drilling rig caught fire as the well approached 1,500 feet and turned the wooden derrick to char, according to the American Oil & Gas Historical Society. Undaunted, a steel derrick was brought in from Amarillo, Texas, as the engine was cleaned and rebuilt.



The Illinois No. 3 Well, the most successful of the three discoveries financed by Martin Yates Jr., came in to start Artesia Field in 1924. *Photo courtesy Hanson Yates*

At 4,330 feet in November 1928, the Midwest State No. 1 was producing at 700 barrels a day.

That drew the attention of the big oil companies, and in 1930, Humble Oil Co. drilled three miles northwest of Hobbs to bring in a well producing 9,500 barrels a day. Using the newly developed rotary rig made it possible to drill faster and deeper through the stacked formations of the Permian Basin.

Hendrick and Yates

Other early notable Texas fields started producing in 1925, including Pecos Valley Petroleum Co.'s completion in the Wheat oil field in Loving County, the Powell field in Crockett County and the discovery of the McCamey oil field in Upton County.

Another 1925 find came as part of a gimmick by Fort Worth printer Chester Bunker. A new subscription to his "Texas Oil World" tipsheet for promoters came with an interest in a lease he acquired on the Lewis Powell Ranch 20 miles from the Big Lake discovery. This got subscribers in the door, but Bunker was soon forced to drill a random well on the lease to keep U.S. postal inspectors from coming after him for not living up to promises, according to Roger Olien, the author of "Black Gold: The Story of Texas Oil and Gas" and numerous other books on the subject.

Bunker started drilling in 1923 about 20 miles from the Big Lake discovery and, after two years, had a surprise find with a well producing 25 barrels of oil a day. Everything was sold for \$1.4 million to Humble Oil. Bunker recapitalized a new company called World Oil to keep looking for oil in the Permian Basin, but the company ultimately failed for lack of another find of significance—and Bunker's mismanagement, according to the American Oil & Gas Historical Society.

By 1926, Permian Basin production was 14 million barrels, and it topped 50 million barrels in 1927.

This incredible leap in production came from aggressive drilling across the basin. It was poised for even greater things when oil was found in the Hendrick Field, and in what later became the mighty Yates Field, one of the largest ever found in the Lower 48.

Westbrook Oil Co. bought the lease on T.G. Hendrick's Winkler County ranch for 35 cents an acre. In February 1927, Eastland Oil Co. began drilling the first well. At 3,006 feet, the well flowed 120 barrels a day. Soon after, Southern Crude Oil Purchasing Co.

1920

The first commercial discovery of oil in the Permian Basin was named for W.H. Abrams, leasing agent for the Texas and Pacific Land Trust. The well, in Mitchell County, first produced oil in February 1920 from a depth of 450 ft; but in June 1920, a better showing of oil was found at 2,345-2,410 ft. This encouraged explorers to move west into the rest of the Permian Basin.

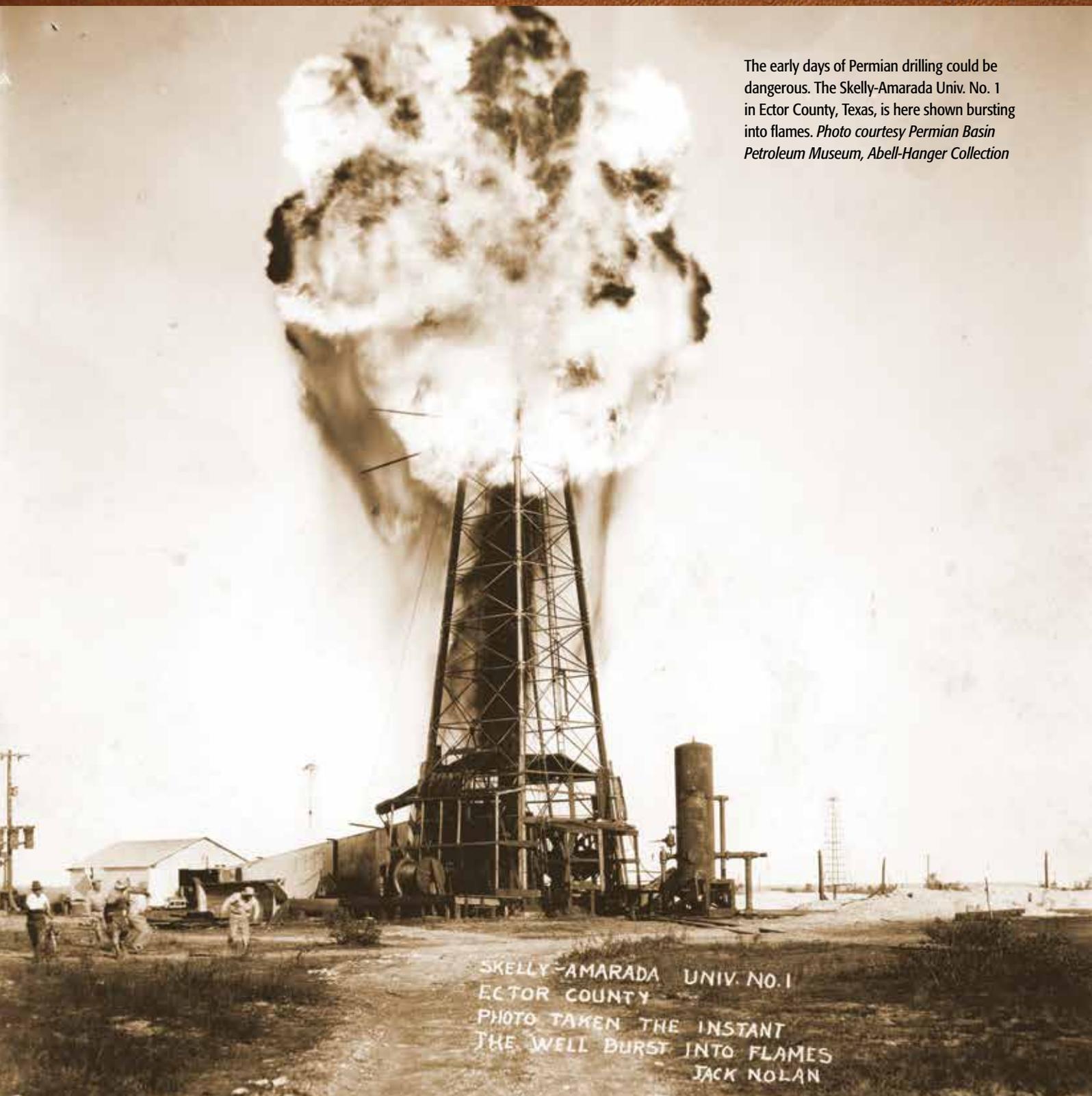
1921

Clarence Karcher conducted the first successful experiment to use seismic waves to image the subsurface in Oklahoma, setting the stage for a revolution in oil and gas exploration.

1922

Midwest Refining Company completed New Mexico's first commercial oil well, the Hogback No. 1, on the Navajo Indian Reservation. The company completed 11 more wells to establish the Hogback Field.

The early days of Permian drilling could be dangerous. The Skelly-Amarada Univ. No. 1 in Ector County, Texas, is here shown bursting into flames. *Photo courtesy Permian Basin Petroleum Museum, Abell-Hanger Collection*



SKELLY-AMARADA UNIV. NO. 1
ECTOR COUNTY
PHOTO TAKEN THE INSTANT
THE WELL BURST INTO FLAMES
JACK NOLAN

1923

The Santa Rita No. 1 discovery well began production, prompting development of Big Lake Field, the Permian's first major commercial oil field. In May, the well's first royalty payment (\$516.53) was made to the University of Texas.

1925

Howard County opened oil production, after the discovery of the Howard-Glasscock Field. The following year, the Otis Chalk No. 1 well came in, and a boom began.

1925

McCamey Field was discovered in Upton County.

1926

The Yates Field was discovered at the Ira G. Yates 1-A well in Pecos County, TX. Pundits had always flatly declared there was no oil west of the Pecos River.



Spud 1-2-35

BONER B-2

Comp 3-30-35

With discoveries such as Slaughter Field, the Texas Panhandle became an active drilling area. The Boner B-2 well shown here was spud in Andrews County, in the far southwest of the Panhandle. *Photo courtesy Permian Basin Petroleum Museum, Abell-Hanger Collection*

picked up a controlling interest in the discovery well and 1,440 acres of checkerboard leases, according to “The Handbook of Texas Online.” Southern Crude took the well down another 42 feet, and production more than tripled to 390 barrels a day.

Other leases around the first well were snatched up quickly by more than a dozen major oil companies including Humble Oil, Marland Oil and Gulf. Gulf’s first well in the Hendrick produced nearly 400 barrels a day at 2,836 feet, but drilling just six feet more shot production up to 2,000 barrels a day.

At its peak in March 1929, the Hendrick Field had 577 wells producing 5.3 million barrels of oil in that month. It went into decline, though (in part because every barrel of oil came with 26 barrels of water) from 26 million barrels of oil in 1930 to just 1.5 million in 1945. It produces to this day and is considered one of the biggest producing fields in West Texas over the last 100 years.

Just three months after the Hendrick discovery, Transcontinental Oil Co. found oil on its 8,000 acres, in southeastern Pecos County—about half of the Pecos River Ranch—leased from Ira G. Yates in 1923. The Yates 1-A well was spudded Oct. 5, 1926

and drilled to 992 feet in a joint operation with Mid-Kansas Oil and Gas Co. for \$15,000.

On Oct. 25, production came in at 450 barrels of oil per day. Like the Illinois Field in New Mexico, accessibility was an issue. However, as construction started on a 55,000-barrel storage tank that would allow the Humble Pipeline Co. to take Yates oil to its main line in nearby Upton County, drilling operations commenced. By spring 1927, the first well and four even better-performing wells brought Yates production to nearly 9,100 barrels a day.

Drilling three years later just a few hundred yards from the discovery well, the Yates 30-A set a world record when it flowed at 8,528 barrels an hour, nearly equal to a full day’s production on most other Yates producing wells. The Yates Field has since produced more than 1 billion barrels of oil.

Transcontinental and Mid-Kansas continued drilling and then expanded and opened the Yates Field to other operators, but production soon outpaced storage and pipeline capacity. That led to the Texas Railroad Commission, for the first time, stepping in to prorate the production for each well based on pipeline capacity and potential production. That kept one operator from getting a disproportionate share of its oil to market over another. What’s more, the field-wide proration rules kept all operators at a depth of no more than 225 feet into the formation, to balance the playing field. Proration also was applied to the Hendrick Field around the same time.

The early years were not without mishaps and grief. The Magnolia Tank Farm had a massive fire on Aug. 17, 1928. A month later, five new tanks were under construction there, but in 1929, a boiler explosion killed and injured several workers, bringing the dangers of the oil enterprise into stark contrast with the fortunes it was creating. Likewise, makeshift refineries were popping up in the region. These jobs were considered dangerous, but these companies found no shortage of workers from among the struggling farms and ranches because of the good pay.

Going deeper in Wasson and Slaughter fields

The deepest well in the first decade of Permian exploration came in 1928 when Carl G. Cromwell, who oversaw drilling of the Santa Rita No. 1 years earlier, decided to push past the standard 3,000 feet. Texon engineer Clayton Williams Sr. located a site in 1926 in Reagan County, and more than a year of expensive and troubled drilling began. Although ordered to close up shop on the prospect in late November, Cromwell was defiant. On Dec. 4, 1928, that stubbornness paid off when the University 1-B, in Reagan County, came in at 8,525 feet. It was the deepest in the world at the time, and it encouraged others to go deeper in the next decade.

The 1930s weren't an ideal time for any industry and money was tight all around with the onset of The Great Depression in the fall of 1929. The oil and the will of wildcatters was there—but not the money. Leases on the western edge of the Texas Panhandle went largely unexplored until the mid-1930s.

By the time Honolulu Oil Corp. and Davidson Drilling Co. spudded the L.P. Bennett No. 1 in 1935 in Yoakum County, wildcatters were finding the resources to come back into the field. The Bennett came in as a steady producer in April 1936. It was considered a discovery well, as were several other widely spaced wells drilled by other companies over the next two years, all at a depth at almost 5,000 feet to more than 5,300 using rotary drilling methods. They all were later deemed to be part of the same structure, and the Texas Railroad Commission lumped all the sectors of the widespread acreage into the Wasson Field.

Once a pipeline was installed to take oil to a terminal in Hobbs, N.M., the Wasson Field was a good bet for rapid development and provided an economic model that allowed drilling to go even deeper. By the early 1940s, with pay levels as deep as 7,200 feet, potential production in the Wasson Field was estimated at 1.2 million barrels a day, but the Texas Railroad Commission allowed only 57,280 barrels a day. Demand for fuel and other refined products created by World War II saw the annual production leap from 12.4 million barrels in 1943 to 23.7 million barrels from 1,509 wells in 1944, according to Julia Cauble Smith, writing for the Texas State Historical Association.

Also in 1936, exploration fired up again in the Texas Panhandle area in Hockley, Cochran and Terry counties. The Duggan and Slaughter fields to the west and east of the Hockley-Cochran county line respectively were developed separately in the latter half of the 1930s but were combined as the Slaughter Field in 1940. The combined field produced 1.16 million barrels of oil from 199 wells in 1940.

Sid Richardson, who was a major player in the Slaughter Field, in 1941 augmented three existing pipelines serving Slaughter with a line that moved oil to connections in the Wasson Field allowing production to increase. The Texas Railroad Commission allowed more drilling on each lease as the war continued and in 1945, the last year of World War II, Slaughter wells produced 71.1 million barrels of oil. That figure doubled to close out the decade in 1949. Recovery projects beginning in the late 1950s kept the field a powerful producer for decades and lifetime production topped 1 billion barrels of oil in 1993.

Spraberry-Dean reveals secrets

The 1940s brought more exploration and some major new finds, even though much of the labor

How Midland Became The Permian Basin's Capital

Midland was one of many small towns that dotted the West Texas landscape every 20 miles along the railroad, thanks to the worker camps that popped up during track construction. They became mostly ranching and farm towns until oil made some of them so much more.

Midland had seen plenty of drilling, but it was looking for water for crops, livestock and people. Enough windmills dotted the town lots and farmsteads that Midland soon earned the nickname Windmill City.

In the first years of the boom in the 1920s after the Santa Rita find and others in nearby counties, drilling in Midland County came up short. But forward-thinking businessmen provided amenities that surrounding boomtowns didn't have, establishing the city as the center of the Permian Basin oil enterprise for generations.

Clarence Scharbauer, who managed and then inherited his uncle John's ranches in five Texas counties and one in New Mexico, didn't see direct oil money until a strike on one of the family ranches in 1935. The family founded First National Bank of Midland, which served as a vital financial institution throughout the early years of oil growth in the basin. A personal loan taken out by the Scharbauer family from a Fort Worth bank in 1929 kept First National afloat at the beginning of the Great Depression.

In 1928, Scharbauer established the 250-room hotel bearing his name and later added 100 rooms. It is still the site of one of the city's preeminent hotels, now a Doubletree by Hilton.

T.S. Hogan, a lawyer and rancher from Montana, set up shop in Midland in 1925 to pursue the oil business, deciding that Midland was the center of the Permian. Construction of Hogan's Petroleum Building began in 1927 and was dedicated July 4, 1929. The 12-story structure at 214 W. Texas Avenue served as offices for homegrown companies and divisions of large, out-of-town firms. With the onset of the Great Depression less than four months after the building opened, and oil prices dropping to 15 cents a barrel after significant East Texas finds, many oil firms shuttered their Midland offices.

By 1935, the majors and independents resumed their drilling activity and filled the Petroleum Building again, cementing Midland's role as the business capital of the Permian for generations. ■



Thanks to booms and despite busts, Midland, Texas, seen here in 1952, continued to grow as oil and gas entrepreneurs flocked to the Permian. *Photo courtesy Permian Basin Petroleum Museum, Abell-Hanger Collection*



1926

Three other major oil discoveries occurred in the Permian: Hendrick Field was discovered in Winkler County; Iatan East Field, in Howard County; and McElroy Field, in Crane County.

1926

The first buildings of Iraan, Texas, were built, sparking the growth of the oil boom town that followed the discovery of Yates Field.

1927

Permian Basin production leapt to 50 million bbls from a substantially lower 14 million bbls in the previous year, thanks to aggressive drilling and new discoveries.

1928

Hobbs Field was discovered in New Mexico with the successful completion of Midwest Refining Co's State No. 1 well.

force had gone off to fight in Europe and the Pacific theaters in the first half of the decade. In 1940, attention turned back to the eastern edge of the Permian on Continental Oil (formerly Marland) leases on the Todd Ranch, about 30 miles south of Big Lake oil field in Reagan County.

The Stanolind Todd No. 1 test well was drilled in 1932 at 8,041 feet but did not produce commercially. The 1937 Superior Oil Co. test well on the neighboring Massie Ranch brought sulphur water with it, and the company walked away from it at 7,948 feet.

Continental-Stanolind's Todd Unit No. 2 proved a different story, and in April 1940, initial production came in at 850 barrels in the first 12.5 hours, according to the June 1940 issue of the Bulletin of the American Association of Petroleum Geologists.

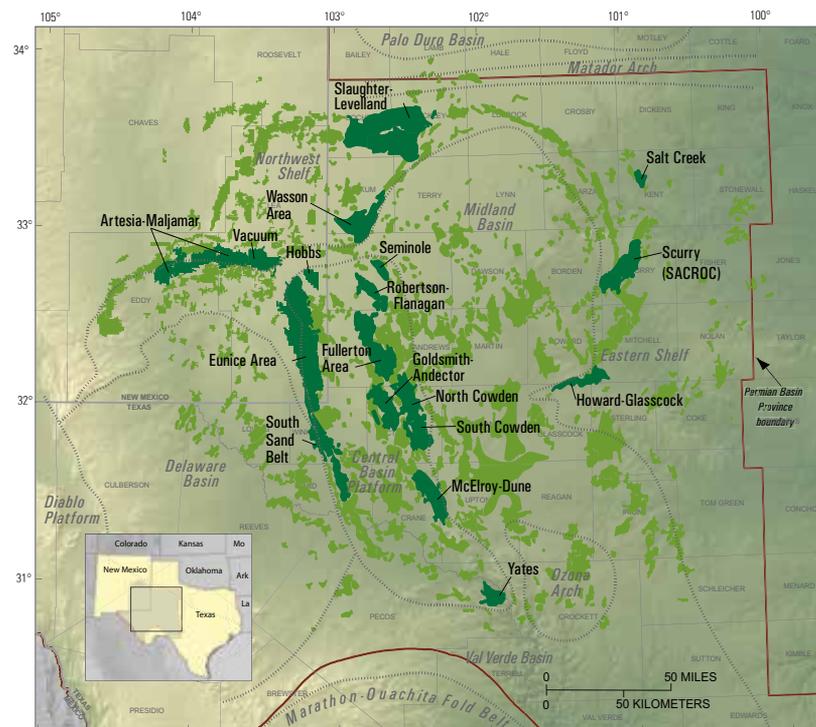
Perhaps one of the most significant finds, especially related to technology-driven development half a century in the future, was the late 1940s and early 1950s discovery and exploration of the Spraberry and Dean Sandstone formation under the nine counties that make up the Midland Basin.

Wells in this tight sandstone weren't big producers, so the formation was considered uneconomic. In fact, the first Spraberry showing was in 1944 when the Seaboard Oil Co.'s No. 1 turned up dry on Abner Spraberry's farm in Dawson County. Sandstone samples from the well showed oil but didn't entice completion of the well. Seaboard No. 2 in 1949, however, made 319 barrels of oil a day below 6,420 feet. Tex-Harvey Oil Co. had a similar find more than 1,400 feet deeper in Midland County.

More wells showed geologists that fingers of oil splayed throughout the Midland Basin, and those who drilled there soon found they were almost guaranteed to have a producing well, albeit one that might give only 30 or 40 barrels a day. In 1953, the Texas Railroad Commission merged numerous smaller fields into one designation dubbed the Spraberry Trend, to this day one of the largest oil trends in the world.

Midland oilman Bill Bynum recalls his father, Rufe S. Bynum Jr., a longtime executive of Core

THE PERMIAN BASIN'S MAJOR OIL FIELDS



Lab's Mid-Century Division, who revolutionized the way core sample data was analyzed, disparaging the sandstone. The elder Bynum had core samples scattered across a table at the house and Bill as a child was impressed with the core that was still leaking oil long after it had been removed from the hole. His father explained the bleeding core wasn't the best thing. "It was seeping out onto the table, and he said, "That crappy Spraberry."

Bynum said leaseholders kept the wells going to provide some small royalties and keep the lease claims current and now the "crappy" Spraberry is providing major dividends to the original royalty owners who are their descendants, thanks to the advent of modern fracturing techniques that take advantage of the once-difficult tight formation that challenged E&P companies throughout the 1950s, '60s and '70s. Estimated reserves of the entire Spraberry Trend exceed 10 billion barrels.

The post-war can-do boom

By the late 1940s and early 1950s, a new crop of oil seekers entered the picture. They flocked to the

The largest oil fields in the Lower 48 were found in the Permian Basin from the 1920s to the 1950s. Source: USGS

Pictured left: Seen here in 1965, the famous Petroleum Building in Midland, Texas, built in 1928 and originally named the Hogan Building after the eponymous oilfield entrepreneur. Photo courtesy Permian Basin Petroleum Museum, Abell-Hanger Collection

1928

In Texas, Waddell (Crane County) and Kermit (Winkler County) fields were discovered.

1928

The Permian's deepest well, as of the first decade, came in at 8,525 ft. In fact, the University 1-B was the deepest well in the world at the time.

1929

The Yates 30-A well flowed 204,672 bbl/d or 8,528 bbl/hour from a depth of 1,070 ft. It was the largest flowing well in the world at the time.

1929

The New Mexico Oil and Gas Association (NMOGA) was organized to represent oil and gas interests when working with state and federal regulatory agencies.

'Million Barrel' Reservoir: Leaky Lake Of Oil Now A Tourist Treasure

The town of Monahans in Ward County was a hub for West Texas ranching, but it became the site of an oddity of the Permian Basin oil boom: The Million Barrel Reservoir.

The four-acre, elliptical concrete reservoir was actually designed to hold up to 5 million barrels of oil from nearby wells that were producing mighty amounts of oil but weren't yet supported with pipelines to get the crude to market.

Most tank farms at the time held about 55,000 barrels, but wells in the Hendrick Field in Winkler County and others in Ward County were producing at too high a rate for a standard tank farm to make much difference. As a stop-gap solution, Roxana Petroleum, which later was subsumed by Shell Oil, excavated the massive hole using mule teams. Working around the clock, the concrete floor and walls, redwood timber supports and beams and a tar paper cover, took just three months to finish and began receiving oil in the spring of 1928.

It held a million barrels of oil just once.

The relentless West Texas sun, despite the covering, managed to evaporate some of the oil, and the massive pressure on the segmented concrete lining pushed oil through the seams and into the sandy earth below, according to an article from the American Oil & Gas Historical Society.

Shell pumped the oil out in 1930 and dismantled the roof and other wood-
en structures, leaving behind an oil-stained empty hole in the ground.

In the 1940s and much of the 1950s, Monahans used the huge stretch of pavement for community events from parades to square dancing. Wayne and Amalie Long, both residents of Monahans, bought the abandoned reservoir in 1954, and in 1958 they pumped in water from surrounding wells to turn it into a water recreation area. Melody Lake opened with professional water skiers brought in from Austin for the Oct. 5 celebration.

The following day, it closed, as the water leaked its way through the same seams as the oil had three decades earlier.

Amalie Long donated the 14.5-acre tract that included the graffiti-marked reservoir to the Ward County Historical Society in 1986. In 1987, it became the focal point of the Million Barrel Museum and holds a 400-seat covered amphitheater. ■



Built to outsize all other oil tank farms, the gigantic oil tank in Monahans, Texas, held a million barrels of oil—but only once.

*Photo courtesy
Library of Congress*

Permian because all the major Texas discoveries from the end of the war until 1960 were happening there.

An article in Life Magazine brought further attention to Midland, and locals in the Permian Basin dubbed the new arrivals the "Ivy Leaguers," no matter what their pedigree. The major oil companies were actively working their leases, many of them snatched up in the down times, but seasoned and new independents also could find opportunities. Roger Olien writes that the Ivy Leaguers and experienced independents "had in common the 'can-do' attitude of veterans and the optimism of wildcatters."

Among those were men such as John and Hugh Liedtke and George H.W. Bush, later the 41st President of the United States. Bush and the Liedtkes teamed up to form Zapata Petroleum Co. in 1953. Bush later spun off the offshore side of the business while the Liedtke brothers continued to grow through exploration and acquisition in the Permian Basin.

The discovery of natural gas fields in New Mexico's Pecos Slope in 1951, the Puckett Field find of 1952 and 1955's South Sand Belt added another dimension to the gifts from the Permian, although these gas-rich fields didn't become major targets for production until the early 1980s when prices were favorable.

1953 brought the discovery of the Wolfcamp oil field, now a massively important formation that was discovered to hold far more oil than once thought. A recent study from the U.S. Geological Survey believes there could be 46 billion barrels of oil to tap and 20 billion barrels of natural gas equivalents.

One of the last significant finds of the 1950s was the Ford-Geraldine Field in the Delaware Basin in Reeves and Culberson counties.

Albert William (Bill) Rutter, at 93, still works oil deals from his Midland office. He saw all the ebbs and flows of the Permian Basin fortunes from a childhood spent with a father who started putting money into wildcat exploration beginning in the late 1920s. Bill Rutter continued the tradition when he returned to the oil patch from U.S. Navy service in 1948.

Rutter said he carefully watched as noted driller Tex Harvey found the first oil in Midland County, and later did his first well about 11 miles away. Even though the Spraberry Trend was largely uneconomical then, money was still coming in to drill thanks to the tax breaks oil exploration provided at the time.

People in the top tax brackets such as hotelier Conrad Hilton and entertainers Bing Crosby and Bob Hope had invested in the Permian because they could keep 40% of the income from oil, but only 13% of the money that they made from movies or other types of deals. "That's what made the boom in the '50s," Rutter said. "Nobody ever thought the oil was going to last this long." 100



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Photo by Tom Fox



CHAPTER 2 | HISTORY: 1960-2000

TRAVEL



Photo by Tom Fox

THE BASIN ENDURES

BY GREGORY DL MORRIS,
CONTRIBUTING EDITOR

The second half of the 20th Century saw the billionth barrel from Yates Field, OPEC's birth, low oil prices, huge mergers and the Spraberry surge.



The 1940s and 1950s were the golden age of the Permian Basin, marked by many of its biggest, most legendary field discoveries. In 1950, more than 215 oil companies had offices in Midland and the population increased to almost 22,000, according to the Texas State Historical Association.

By 1960, the population was close to three times that. Midland residents also began to enjoy a new two-story library and museum constructed by the county. However, volatility remained the force that underpinned the fate of cities and companies throughout the basin. The local economy slumped between 1960 and 1970 as the domestic oil industry was overwhelmed by oil imports, primarily from the OPEC cartel. Oil traded as low as \$3 per barrel.

Some 5,200 wells were drilled in West Texas and Southeast New Mexico in 1960, with development drilling concentrated on the Central Basin Platform. A couple of big, exciting discoveries were brought in that year. Two Pecos County wildcats gave the industry glimpses of the immense potential of the deep Delaware Basin, finding gas in Pennsylvanian, Devonian, Silurian and Ordovician pays at depths down to 16,680 feet, a Texas record.

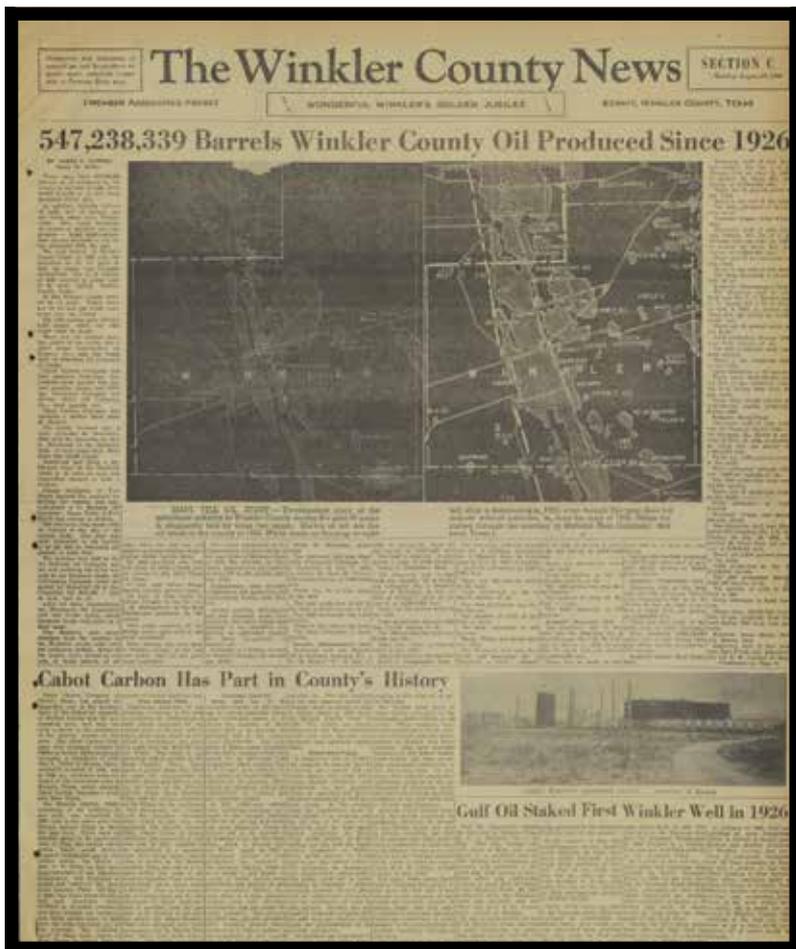
But at the decade's end in 1969, the number of wells completed annually had slumped to just above 3,000, although deep exploration for gas had proved quite successful throughout the 1960s, with numerous wells being successfully drilled to depths below 20,000 ft. and production established below 22,000 ft. This was not routine, by any means, but the industry had found huge, highly prolific gas fields such as Gomez and Wink at depths that were unreachable in past decades.

Midland's population had again slipped below 60,000 by 1970—but then it grew again when a new boom unfolded. In 1971, the federal government under Richard Nixon instituted a set of complex federal oil price controls. U.S. oil production peaked that year, even though operators in the Permian continued drilling more wells through the decade.

But big changes were afoot. In October 1973, the Organization of Arab Petroleum Exporting Countries (OAPEC), a subset of OPEC, instituted an oil embargo against the U.S. in retaliation for President Nixon's request for Congress to send \$2.2 billion in emergency aid to Israel for the Yom Kippur War.

And when the same flood of imported oil that swamped the 1960s was suddenly withdrawn in the notorious OPEC embargoes, oil prices skyrocketed,

On his first day in office, President Ronald Reagan deregulated oil and natural gas prices, a decision which has had lasting consequences. *Photo courtesy Executive Office of the President of the United States*



The period beginning with 1960 saw increased oil production in the Permian Basin, evidenced here in Winkler County's newspaper. Photo courtesy Winkler County News

and the effects were experienced nationwide. Families around the country that had abandoned cities and public transportation for the lure of the suburbs and cars, questioned their decision, as they faced long lines and high gasoline prices.

"The embargo began a series of production cuts that altered the world price of oil," according to an analysis by Michael Corbett of the Federal Reserve Bank of Boston.

"Those cuts nearly quadrupled the price of oil from \$2.90 a barrel before the embargo to \$11.65 a barrel in January 1974," he wrote. "In March 1974, amid disagreements within OAPEC on how long to continue the punishment, the embargo was officially lifted. The higher oil prices, on the other hand, remained."

As would be expected, these prices brought renewed investment to the industry, particularly to the Permian Basin. Drilling and production

boomed, lubricated by relatively relaxed regulation of both finance and environmental protection. (The Environmental Protection Agency had only just been created in 1970.)

This led to a boom similar to what is happening today. New office buildings rose in downtown Midland, rigs were built, new companies were formed, and housing was tight.

During the first years of the 1970s, activity continued much as before. Drilling for deep gas reservoirs in the Devonian, Silurian and Ordovician continued to dominate activity in the Delaware Basin, and the Morrow gas play in southeastern New Mexico was also an important focus. Drilling continued a generally upward trajectory throughout the decade, and by 1979 some 5,200 wells were completed in the basin. The industry had shifted focus from deep, structural gas plays in the Delaware and Val Verde basins to shallower oil plays, particularly in the Midland Basin. The potential of overthrust plays was exciting, and the Ouachita thrust belt in Terrell County, Texas, was of high interest.

A second oil shock occurred in 1979 when Iranian output was curtailed by the Iranian Revolution. The supply crisis widened during the initial phases of the Iran-Iraq war in 1980. The rig count rose basin-wide.

Also in 1979, President Carter began to phase out the federal price controls, and the price of oil peaked in 1980 at more than \$35 per barrel (equivalent to about \$100 today). On his first day in office in 1981, President Reagan killed off all remaining controls. At the same time, he changed some investment and tax regulations, which upended the popularity of wealthy people buying oil investments as a tax shelter. Just as this outside money dried up, once again, Middle East wars and geopolitics caused oil to plunge back down to \$10 when demand fell and OPEC opened its taps.

The biggest blow of all

From a high-water mark of nearly 8,500 wells completed in the Permian Basin in 1982, drilling activity crashed to a low of below 2,500 wells in 1989. The activity downturn lingered throughout the 1980s.

Oil prices fell by more than half, causing rig counts to plummet—some equipment sold at auction for pennies on the dollar. Several small community banks in Midland and Odessa failed. Plans for more skyscrapers in Midland were shelved.

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NATURAL RESOURCES

1929
Penwell Field was discovered in Ector County.

1930
Columbus (Dad) Joiner brought in the Daisy Bradford No. 3 to open the East Texas Field, the largest oil field in the world at the time.

1930
Humble Oil Co. drilled a well 3 miles from Hobbs Field that flowed at 9,500 bbl/d.

This was a stark contrast to the preceding years, when the population had boomed along with production. Midland had passed 70,000 by 1980 and roared to an estimated 92,000 by 1983. In a familiar cycle, “thousands of new apartments and houses were built in the city during the boom, [but] contractors could not keep pace with demand. By 1981, when the price of oil rose to \$40 per barrel, newcomers to the city were living in tents, cars and trailers,” according to the TSHA.

(In 1982, Forbes counted several Midlanders on its list of the 400 richest Americans—an extraordinary thing for a small city.)

The biggest blow of all came on October 14, 1983, when the First National Bank of Midland failed. Ironically, the bank was undone by bad energy loans.

From its inception in 1890, First National had been the financial and social heart of the region, a generous donor to local charities, becoming one of the largest banks in Texas by deposits. Its collapse had repercussions throughout the Permian Basin for years. As the New York Times reported, “Never in American history had such a large bank failed in such a small city; indeed, it was the second-largest commercial bank failure in American history, after the Franklin National Bank of New York.”

First National was woven into the fabric of the Permian in a way that is difficult to imagine now. When the Federal Deposit Insurance Corp. took over to protect depositors, it became the reluctant owner of 67 oil wells, two Rolls-Royces, rights to books and movies,

numerous office buildings and condominiums, and a huge chunk of real estate in Midland, the Times said.

“Agency officials say that if they wanted to play strictly by the rules, they could foreclose immediately on 365 homes, 12 commercial buildings, a million acres of land and 139 drilling rigs, shutting 451 businesses and putting 6,500 people out of work in Midland and nearby Odessa,” the Times reported.

It was complicated

Thomas R. Procopio, a veteran of dealing with big bank failures, was named liquidator-in-charge. He had already handled the failures of Franklin National in 1974 and the Penn Square Bank of Oklahoma City in 1982. The size of his staff in Midland, more than 300 people, gave an indication of the size of the task.

Many local and regional businesses were merged; others had to be closed outright, including the local Rolls-Royce dealership between Midland and Odessa.

First National had been “horrendously” sloppy in record keeping, Procopio told the Times. “Everything was done on a handshake. It was like a \$50-million good-old-boy bank.”

Some local leaders concurred. “It was unbelievable the way they were dishing out money,” the Times quoted William M. Kerr, a leading Midland lawyer who represented many debtors. “You could borrow money without collateral for deals that had no chance of paying back.”

For the most part, local leaders said, the agency has been patient and cooperative. “I’ve been pleas-



Decades later, the discovery well that started it all, the Abrams No. 1, continued to produce, shown here in 1969. Photo courtesy Permian Basin Petroleum Museum, Abell-Hanger Collection

1931

East Texas Field was under martial law after the Texas Railroad Commission had been enjoined from enforcing production restrictions. Afterward, the Texas Legislature enacted legal proration, the current system of production regulation.

1932

Lane-Wells Co. performed first successful bullet perforations.

1933

Hughes Tool Co. was granted patent rights for the tricone bit, which was invented by two engineers a year before. The tricone would go on to become the bit for nearly all major oil discoveries of the time.

1934

The First National Bank of Midland was insured.

antly surprised,” said Ike Lovelady, a leading wildcatter. “The FDIC has been cooperating with us in getting back on our feet.”

The First National Bank of Midland had been a \$1.4-billion institution, the largest independent bank in the state. It grew because management decided in early 1980 to move aggressively into energy lending. To be sure, every bank in the region lent to energy merely by opening its doors. At that time, the Permian Basin accounted for about a fifth of all oil and gas production in the country.

Thinking bigger may have been First National’s undoing. To run with the big dogs, it solicited large deposits from Wall Street investors; by the end of 1981, the bank had doubled its assets. “Euphoric about the energy boom, the bank departed from prudent banking practices in evaluating loans,” the FDIC recounted.

But by 1983 the bank’s non-paying loans reached 25% of assets, the highest percentage of any large

bank in the U.S. at the time, and it reported three quarters of losses. Widespread publicity about the situation eroded public confidence and led to a run on deposits, which triggered FDIC intervention in October 1983.

The beat went on. From 1987 through 1989, 71% of the banks that failed in the United States were in the Southwest. The sorry roundup included significant failures, such as First City Bancorporation and First Republic Bank Corp. in Dallas. In the end, nine of the 10 largest bank holding companies in Texas failed, according to an official FDIC history.

A changing landscape

Banks weren’t the only entities to disappear or change shape. The ’80s was a decade of major industry consolidation: In 1981 alone, DuPont acquired Conoco and Mobil launched a hostile bid for Marathon Oil Co. (See Yates Field EOR.) The

Yates Field EOR

From the many rounds of mergers and acquisitions through the 1980s, the bitter legal battle between Texaco and Pennzoil over Getty Oil Co. is most often remembered, but there was no bigger prize than Marathon Oil Co., which led to a jousting match between Mobil Corp. and U.S. Steel. U.S. Steel won. And one of the biggest prizes it got was the Yates Field in the heart of the Permian Basin.

“There is really no Marathon Oil without Yates,” said John Martin, oil analyst for the Provident Bank, speaking to the *New York Times* in November 1981.

“It is a uniquely secure and reliable source of domestic crude oil, which is by far Marathon’s single largest producing field and the one with the longest potential life.”

The *Times* also quoted Archie Farr, manager of the Midland office of the Texas Railroad Commission. “There has never been a field discovered anywhere in the United States with comparable producing capacity. Taking oil out of there is like sticking a straw in a barrel. Marathon has oil wells all over the world, but probably nothing compared to Yates,” he said.

The analogy of sticking a straw in a barrel is almost literally true. The highly permeable, high-porosity limestone lies at a mere 1,200 and 1,500 feet. For a petroleum engineer, that is effectively gift-wrapped.

At the time the 26,000-acre Yates Field was considered the largest oil reserve in the United States besides Prudhoe Bay, which had been discovered in 1968. And while the chilly and distant Prudhoe was bigger, Yates was more accessible. The field had been producing since 1926; at the time of the bidding war over Marathon, it had already produced 800 million barrels. Experts contended at the time that Yates’ production to date was still less than half the recoverable reserves.

BY RICHARD MASON, HART ENERGY

This was when unconventional development through horizontal fracking was only a glimmer in George Mitchell’s eye.

Yates had been discovered in October 1926 by Transcontinental Oil Co. and Mid-Kansas Oil and Gas Co., a subsidiary of the Ohio Oil Co. (later known as Marathon).

By the middle of the 1960s, the time had come for enhanced oil recovery (EOR). Marathon began water flooding it in 1968 and continued through 1972. At that point the company added carbon dioxide injection. Marathon continued with several flooding campaigns which eventually included polymer stimulation.

Meanwhile, the company reported the billionth barrel was produced on January 11, 1985. There were still more than a thousand producing wells in the Yates Field into the early 1990s. Marathon was spun back out of U.S. Steel in 2002, and in turn spun out the midstream, refining and marketing business as Marathon Petroleum in 2011 to become a pure-play E&P firm.

In the 1980s the field represented about half of Marathon’s global reserves and about a third of its domestic production.

Throughout its history the field has been remarkable. In public disclosures, Marathon reported that on average the company’s wells were commercially productive for less than 10 years—but in contrast it expected to maintain Yates production at then-current levels for almost three times longer.

By the end of the millennium, the Yates Field had produced an amazing 1.34 billion barrels. In 2003 Marathon sold its operations there to Kinder Morgan Energy Partners, the upstream subsidiary of the midstream major, for \$225 million. This included a 42.45% interest in the Yates Field unit as well as all of the associated 90-mile gathering system. Kinder Morgan bought a minority interest in other nearby fields, as well as a carbon-dioxide pipeline. ■

PIONEER IS COMMITTED TO THE PERMIAN

We come from humble roots. Founded on honesty, steadiness and sweat equity – that’s our story, and that’s something we’re awfully proud of.

In 1962, two West Texas oilmen with a dream, a beat-up car and plenty of guts set out to form a company that would set itself apart from the scores of wildcatters who were looking to swoop in on the latest fly-by-night play.

Howard Parker and Joe Parsley shook hands and flipped a coin to determine whose name would come first in the fledgling company’s moniker. Parker won the toss, and Parker & Parsley was born.

The company became known for making smart decisions, conservative hedges and shrewd deals as it assembled acreage and drilling plays. While competitors sunk millions and billions into global operations, Parker & Parsley never abandoned its legacy wells in the Permian—a loyalty that continues today.

In 1997, Parker & Parsley merged with MESA Inc. to form Pioneer. At the time, MESA boasted heavy natural gas holdings, offshore drilling expertise and an attractive internal culture that paid specific attention to its employees. Those things helped sell Parker & Parsley executives on the merger.

“We continue to operate in the Permian Basin, and we remain steadfast in this belief: We are in a people business first, oil business second.”

The name changed to Pioneer Natural Resources Co., but components of the two founding companies endure. We continue to operate in the Permian Basin, and we remain steadfast in this belief: We are in a people business first, oil business second.

Our lineage is tied to the Permian Basin

This vast patch of rugged terrain in West Texas is home to the world’s second-largest oil field. Decades



ago, Pioneer first staked its claim to those legacy wells that hiccupped just 10 or 12 barrels of oil a day. We stayed, and now that commitment is paying off.

Today, some estimates hold that the untapped resources spindled deep below the Permian Basin’s surface could rival the supply of what’s now considered the world’s largest oil field in Saudi Arabia.

Achieving such a milestone is a prize greater than financial wealth; it’s a geopolitical game-changer.

We’ve long known the Permian’s enormous potential, and we made a recent decision to become a Permian pure-play company.

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The work we do in the Permian Basin is changing the world. ■

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for **THREE GENERATIONS**,
we are proud to salute it's
100th year of perseverance
and prosperity!*

M O N T E G O



M I N E R A L S

degree of consolidation was strong. In 1979, investment banker Petrie Parkman & Co. had counted 62 public E&P companies (several based in the Permian), but only 19 were left by 1987.

In 1983, Nymex had launched crude oil futures trading, allowing companies and traders to mitigate at least some of these oil price risks. Yet that did not insulate anyone when in 1986, oil prices collapsed again, as OPEC (created back in 1960) tried to manage its market share by flooding the market.

Oil prices fell steadily to bottom in 1986 at around \$10 per barrel, equivalent to \$21 in current dollars. It was a notable foreshadowing of the collapse of oil prices in 2014-15.

Industry leaders noted at the time that the surplus was temporary, but high prices and supply shortages through the '70s had a lasting effect on demand, which fell by more than 10% in North America, Europe and Japan from 1979 to 1981. The impact on the Permian Basin was hard and fast, notably on banks with overextended or unsound industry lending.

In short, the 1980s were difficult, and public sentiment reflected this. Bumper stickers ruefully said, "Stay alive till '85 or Chapter 11 in '87." A roadside sign pleaded, "Lord, send us another boom and we promise not to mess it up."

By the end of the decade, drilling had contracted to mature areas with good oil productivity and reserves. Remote and ultradeep wildcats were a thing of the past.

Toil and trouble

The 1990s started out bleakly for the U.S. industry as a whole, and things were no better in the Permian Basin. Companies had to retrench and rethink their business models.

Still, scrappy individuals continued to look for oil and gas. For some, there was no other way of life or no other options than to keep doing what they knew how to do. One of the truths of the Permian Basin is that it has gone through multiple business cycles, and the 1990s were a time of rolled up sleeves, hard work and new looks at what was already a mature basin.

During the drilling boom in the late 1970s and early 1980s, hundreds of wells were drilled across the Permian to deep targets in the Pennsylvanian, Mississippian, Devonian, Silurian and Ordovician. These deep wells (below 15,000 feet) discovered prodigious fields in such reservoirs as the Fusselman and Ellenburger.

After the price crash, however, companies reined in their ambitions. The many deep tests provided large and fruitful new datasets, and quite a few explorationists set about looking for shallow, cost-effective prospects.



Curtis Mewbourne
Founder
Mewbourne Oil Co.

"I started the company in 1965 in a one-room rental office; I was 29 years old. Our only assets were an old desk and two old chairs that were a gift from my former employer. I chose the Permian Basin because it was perfect for a small independent trying to get started: It had multiple pay zones, many of them shallow or medium depth, many extension opportunities, and farmouts available from the majors. I found the Glasscock West Garden

City Field in 1966, and I've still got those leases today. Now we are drilling 2-mile-lateral wells.

"We learn something from every well we drill: where to put the laterals, what is the proper spacing between wells, how to recycle produced water, how to improve fracturing fluid.

"The Permian is the greatest place in the world to do business. The long-term, continued technology advancements will bring opportunity for young people beyond their wildest imagination."

The reexamination of the Permian section kicked off a brisk play in the Delaware Mountain Group, for example. While these siltstones and sandstones had long been known to be productive in the Bell Canyon and Cherry Canyon intervals, the 1990s saw a revival of interest in the lowest portion, the Brushy Canyon. This reservoir had been overlooked in prior years due to less-than-enticing logs and tests, but some newly developed completion strategies unlocked fresh reserves.

Other reservoirs that were revisited with renewed success in the 1990s included the Bone Spring sandstones, San Andres and Greyburg carbonates and the Canyon sandstones.

One of the bright spots of the 1990s was the success of 3-D seismic. The use of this technology exploded in the Permian Basin as it proved able to uncover pinnacle reefs in the Horseshoe Atoll area and carbonate detrital reservoirs in the Wolfcamp. By the end of the decade, most active areas in the basin had been shot with 3-D.

Another area of interest during these slower times was fractured plays. Beginning back in 1965, hundreds of small independents made their living drilling vertical Spraberry wells, when the first well was deepened because all the oil was being drained via natural fractures and the wells got overly gassy. Operators started to deepen the wells to access more oil.

Though oil shocks caused slumps in Permian drilling activity, by the turn of the 21st century the region's rig count was steadily rising. *Photo by Tom Fox*



Then after the crash in oil prices and drilling activity, in 1986, Midland independent Parker & Parsley Petroleum Co. began assembling drilling units that ran the vertical wells with multistage hydraulic fracturing, creating enough free cash flow to drill extra wells. This was the beginnings of the big hydraulic fracturing play. By 2003, that evolved into the Wolfberry, which led to the Spraberry and Wolfcamp revival we see today.

The cyclical nature of the Permian can be illustrated by the ups and downs endured by a prominent local wildcatter, Clayton Williams Jr., who rose to fame and fortune by building Clajon Gas, a pipeline company, as well as having strong oil and gas production. On New Year's Day 1975, his huge new well called Gataga No. 2 in remote Loving County had come in. It flowed 30 million cubic feet a day once it was finally brought under control, after erupting with much more gas than that and being out of control for several days.

During the period 1972 to 1982 while oil prices were soaring, natural gas prices also rose, from 50 cents to \$6 and \$8 per thousand cubic feet (Mcf).

At one time Williams was on his way to becoming "the first Aggie billionaire," as the Texas media pointed out. But by 1991, he came close to filing for bankruptcy protection. He prevailed however, eventually paying back all his creditors without taking that dreaded step. He fought his way back, and in 1994, took Clayton Williams Energy Inc. public. Many other independents were not so lucky.

Turn of the century

As the 20th century ended, Permian Basin producers

held steady, after a decade of severe ups and downs, and a gas supply glut, called the bubble, which had persisted for most of the 1980s. They were still drilling mostly vertical wells, although experts were projecting that horizontal drilling could work in the Ellenberger formations. These experts cautioned that drilling horizontal wells in shales was not a good idea. Operators were drilling old vertical standbys like the Fusselman and Strawn formations in Texas and the Bone Spring in New Mexico.

But geopolitics intervened once more. In August 1990, Iraq invaded Kuwait, prompting President George H.W. Bush, a former Midland oilman, to answer with a broad coalition to drive the Iraqi army out. Oil briefly spiked from \$17/bbl to \$36.

Later, the Asian financial collapse of 1997 spread a deep recession around the world. At the same time, OPEC raised production just as world oil demand was slackening, which meant another round of troubles for the Permian Basin and industry consolidation. Changes occurred in Midland as the biggest players with local activity merged. In August 1998, BP acquired Amoco, which had acquired Arco. Exxon merged with Mobil Oil to form the world's largest oil company.

By the time 2000 ushered in a new decade, leasing was picking up in Ward and Pecos counties for deeper Devonian and Montoya gas targets. And the U.S. rig count, which dropped to 480 in 1999, would rise, reaching above 1,200 by the summer of 2001. **100**

Peggy Williams, Vice President, Content, also contributed to this chapter.

1934

Means Field was discovered in Andrews County.

1935

Goldsmith (Ector County) and Keystone (Winkler County) fields were discovered. In the same year, the first rotary drilling rig arrived in the Permian, replacing cable tool rigs.

1936

Duggan Field was discovered in Cochran County. Later, in 1940 the Railroad Commission ruled that Duggan and the adjacent Slaughter Field produced from one reservoir and called both areas Slaughter.

1937

Near the East Texas Field, the New London School Explosion occurred. To this day, it is the deadliest school disaster in the U.S., having claimed the lives of 294 people.

Recollections: Tim Dunn

Timothy M. Dunn, co-founder and CEO of CrownQuest Operating LLC, grew up in Big Spring, Texas. His co-founder and now president of CrownQuest, Robert (Bobby) W. Floyd, grew up in Midland.

"My dad was a farmer turned insurance salesman," said Dunn. "Bobby is a fourth generation oil man—he has a relative that died in the Alamo. So Bobby has the full-scale Texas oilman pedigree, and I am the small-town boy who has experienced the American dream beyond his wildest imagination through this wonderful thing we call the oil business."

After earning his chemical engineering degree and having a brief stint with Exxon, Dunn went into banking—but his family moved to Midland the very month First National Bank of Midland folded, October 1983. "I expected to grow Midland National Bank, First National's primary competitor. Instead I started my new position as head of the energy department by leading it through a comprehensive bank examination," Dunn recalled.

"I got to live through the boom and bust of the '80s by doing a lot of financial forensics on many shipwrecks. I sat across from individuals who were losing most of what they had worked to own."

Many of the businesses had common problems such as too much debt. Dunn said he got a Ph.D. in risk management that was invaluable. "I learned some important lessons; the most important thing was 'How to stay listed in the phone book.'"

Dunn remembers asking one of his mentors at Exxon who had 30 years of experience how oil prices were determined. "After listening to his answer, I determined that no one really knew," Dunn said.

"In the mid-'80s a revolution began with the addition of oil as a traded commodity. The posted price was stable; the traded Nymex price was not. The Saudis converted from balancing the market, to defending market share. In the process, oil dropped from the mid \$20s to below \$10 a barrel. I remember wondering if there was even going to be an oil industry."

Later Dunn joined Parker & Parsley Petroleum Co. to start an acquisition department. He remembers talking to a European investor about what is now known as the acquire-and-exploit strategy. "He asked me, 'Where are the properties going to come from?' Conventional wisdom at that time was that the majors owned most everything and that they never sold, so the idea that they would sell us assets was unusual."

Nevertheless, Parker & Parsley did consolidate a lot of drilling and income funds that had failed. Those partnerships had raised money from doctors and lawyers based on rising oil prices, so when prices crashed, the investments soured. "When I left in 1995, we had become a public company with a billion dollars of assets. It was quite a ride. And, along the way, some of our most important asset

purchases were from majors, most particularly in the Spraberry Trend, which was Parker & Parsley's bread and butter."

The size and scope of some fields in the Permian, even pre-shale, tend to overshadow fields that otherwise would stand out in another play. When Dunn came into the business the blueblood fields were Yates and Sacroc, and the big San Andres waterfloods such as Slaughter, Denver City and Wasson fields.

"One of the truly great things about Midland is its openness to newcomers. No one cares where you came from, or what you already have. They are willing to give you a chance to show what you can be."

In the early days of CrownQuest, the last half of the '90s, companies were leaving the Permian. Conventional wisdom was that oil was bad and gas was good. There was particular disdain for water floods. "The margins were too low," Dunn explained. "So that is what we bought, and we did very well. This was a big part of the first decade of CrownQuest. But now it is all horizontal drilling all the time. I won't be surprised to see the same cycle repeat, and many of these horizontal wells end up in EOR projects of some kind."

Living through the downturns was extremely challenging, Dunn admitted. "Bobby remembers looking at a check from a New Mexico lease and the price was less than \$9 a barrel. He remembers wondering if there would be any way to survive.

"When we started CrownQuest, Bobby flipped a lease and made \$16,000, which we used to pay the legal bill to form an entity. One of the truly great things about the oil business is that if you have just a little capital, in our case enough to buy groceries, and some ideas, you can find backing."

CrownQuest has found several good financial partners along the way, beginning with friends and family. Permian legend Joe Parsley was one of the original investors, as were some other industry players. "We did a number of deals with GE Capital, while they were still financing the oil business, and we have now participated in five different investments with Lime Rock Partners. The Crown-Rock partnership we have with them is now 12 years old. In August, CrownQuest's publicly reported, operated oil production was over 60,000 bbl/day. Being aligned with good partners has been a huge benefit for us." ■



Timothy M. Dunn
Co-founder and CEO
CrownQuest Operating LLC

1937

Jordan Field was discovered in Crane and Ector counties.

1938

Dune Field was discovered in Crane County.

1939

Alexandre Hogue completed his mural "Oil Fields Of Graham," a historic work of art depicting oil field life at the time.

1939

A device for perforating casing is invented by Ira J. McCullough of Los Angeles.



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CHAPTER 3

CHAPTER 3 | HISTORY: 2000-2019



Photo by Ricardo Merendoni



Photo courtesy Amerienergy II LLC

REACHING NEW HEIGHTS

BY REED OLMSTEAD
IHS MARKIT

In the last decade, the Permian has resurged like a phoenix, shattering expectations for a basin once thought barren.

The Permian Basin was thought by many to be in its twilight years—a basin dominated by enhanced recovery, small independents and stripper wells. Permian production by all accounts was heading towards zero, after peaking in the early 1970s. (See Figure 1, blue line.)

However, conventional specialists such as Occidental Petroleum Corp., Apache Corp., Pioneer Natural Resources Co., and Yates Petroleum Corp. were all committed to sustaining conventional activity in the basin through the early 2000s, though to varying degrees. Conventional volumes fell below 1 million barrels per day (MMbbl/d) in 2009, but the high oil prices of 2010 through 2013 helped conventional volumes surpass 1 MMbbl/d again in early 2014. Nonetheless, the tides of activity were changing, as unconvensionals began to take the industry by storm.

The story of Henry Petroleum LP's activity offers a snapshot of this changing tide. Henry was a key operator to rejuvenate the basin through conventional development on multiple horizons of the basin. The company drilled over 800 wells by 2009, which proved enough acreage and potential to eventually woo Concho Resources Inc. to acquire the entire company. This early risk by Concho was not the first by the company, and the operator quickly began unconventional development, helping spur the initial interest in the basin's resurrection.

In 2010, a new source of supply gradually began to emerge—dominated by horizontal wells. (See Figure 2.) But still many viewed the Permian apprehensively; operators were more focused on generating oil volumes from other “hot” shale plays, such as North Dakota's Bakken Formation.

The Permian's unconventional activity began in earnest in 2012, as operators who had found

Figure 1: Permian Production

Source: IHS Markit

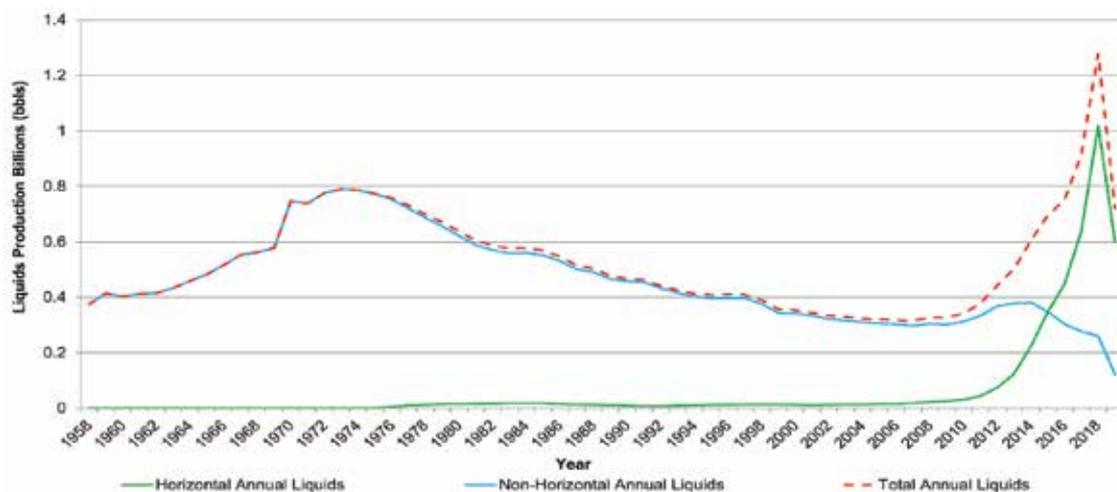
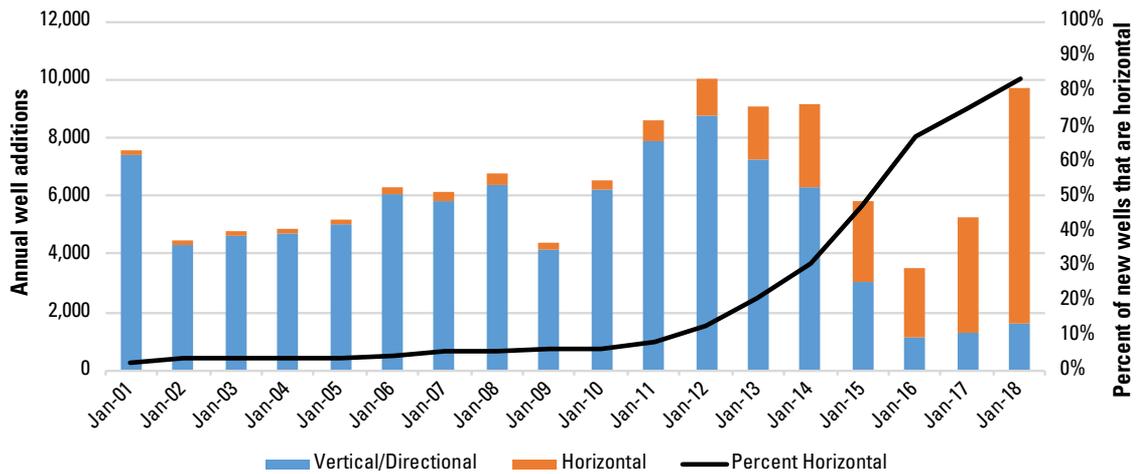


Figure 2: Permian Well Counts by Type; Percentage Unconventional

Source: IHS Markit



The northern Delaware Basin sees constant activity, represented here by Ameredev II LLC's Firethorn 133H drilling rig and tank battery. *Photo courtesy Ameredev II LLC*

success in other unconventional plays looked to apply new techniques to their legacy acreage. Companies including EOG Resources Inc., Devon Energy Production Co., Pioneer, and Concho all tested the basin in search of generating new volumes and accelerating production growth. This enthusiasm was felt throughout the industry, as over 100 operators tested the basin's potential for unconventional production during 2012. (For reference, over 600 operators were active in conventional activity that same year.) And while unconventional drilling comprised only 13%

of all activity in the basin that year, it supported two-thirds of the basin's growth in oil output.

The great land rush began, and in 2013 and 2014, operators rushed to get a piece of the Permian action, buying into acreage, testing new horizons on legacy acreage and doing whatever they could to prove up this potential "new" unconventional resource base.

Acreage costs rose to over \$30,000/ acre. In 2014, nearly one-third of activity was horizontal wells, sending the basin's oil production up an astonishing 300,000 bbl/d from 1.5 MMbbl/d to over 1.8 MMbbl/d.



TRACKER CONTINUES TO PERFECT ITS RESOURCE RECOVERY

After successful operations and an exit in the Bakken, the team at Tracker Resource Development III LLC has returned to the Permian and is optimizing its Midland Basin position.

Q. How did Tracker get started?

A. Tracker Resource Development (Tracker) was formed in 2004 by Jeff Vaughan, CEO, and Shawn McCarter, COO, in Denver, Colorado. Our strategy was to apply modern technical expertise to generate profitable and repeatable resource projects from previously uneconomic plays. In short, our mission is “Tracking down value in unconventional resources”—hence the company name.

Q. What is your experience in the Permian Basin?

A. The principals of Tracker initially served as executive officers of several companies controlled by Sandefer Capital Partners (SCP) of Austin, Texas. One of these was Entre’ Energy Partners, which had a majority working interest in the original Wolfberry play (Sweetie Peck Field) conceived and operated by Henry Petroleum. Tracker developed the strategy of drilling 64 wells across 13,000 acres to prove the resource potential. To mitigate the risk, Tracker and SCP structured a “virtual” production payment by hedging oil and gas, locking in rig contracts and prepaying for equipment. The Henry team executed well and improved the completions with each phase of drilling, ultimately proving up 261 additional locations and 54 million barrels of recoverable reserves. This property was sold to St. Mary Land and Exploration (SM Energy) in December 2006.

Q. What did you do next?

A. After winding down Tracker I, Tracker II was funded by EnCap Investments to pursue similar resource plays. Jim Wason, VP Land, and F.X. O’Keefe, VP Geology, joined the team, and we got in early on the Bakken play in North Dakota. With additional funding from ZIP Ventures, Tracker built a 176,000-acre position, drilled 53 horizontal wells and proved up 440 MMBO recoverable reserves.

Q. What drew you back to the Permian?

A. After selling the Bakken project to Hess in 2010, we formed Tracker III. We saw an opportunity to apply the horizontal drilling and completion technology that we employed in the Bakken to the emerging Wolfcamp play in the Permian. After extensive geotechnical anal-



ysis, Tracker III assembled a 26,000-acre position in a unique part of Irion County where a 1,200-foot thick Wolfcamp section contains more than 200 MMBO per 1,280 acres. To date, Tracker has drilled 28 horizontal wells with laterals ranging from 10,000 to 12,000 feet. Results of each round of drilling improved as Tracker was able to dial in the optimum landing zones and completion formula. With an average 180-day cumulative production of 140 MMBO (85% liquids), these are some of the best wells in this part of the Midland Basin.

From left to right, Jeff Vaughan, F.X. O’Keefe, Shawn McCarter and Jim Wason.

Q. Those are impressive results—what was your key to success?

A. Tracker attributes this success to having the right team, being in the right area, controlling the lateral placement, optimizing the completions and being willing to learn from others. Tracker is honored to be a part of the history of the Permian Basin. It provides us the opportunity to work with some of the finest and most talented people in the industry in a world-class play. ■



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Conventional volumes also surprised the industry; they held flat, largely due to operators drilling conventional wells only to test and delineate unconventional possibilities.

The future was clear: The Permian Basin would soon become a behemoth of supply that would have historic impacts on global markets.

Surviving the downturn

In late November 2014, OPEC representatives met in Vienna to discuss the rise of U.S. production, consider the cartel's production targets, and decide how to manage their supply (and price) in light of U.S. shale. Looking at projections, fiscal budgets, and the financial strength of the U.S. supply system, OPEC members chose not to reduce their quotas but rather to let the markets self-regulate to determine the intrinsic value of a barrel of oil. In fact, this was the first time since OPEC's creation that it would not seek to actively balance the markets. The following two years saw oil prices fall below \$30/bbl, resulting in several hundred bankruptcies of U.S. operators and a 1.2 MMbbl/d decline in U.S. oil production.

However, through these challenging times, the Permian Basin cemented its place in U.S. and global supply, as volumes continued to increase, nearly without a misstep. The rest of U.S. supply was in a near free-fall, but the Permian showed resilience and growth during the most challenging period of U.S. supply and low prices in decades. (See Figure 3.)

So how was the Permian Basin, the "new kid on the unconventional block," able to survive better than any other U.S. play during the initial years of the price downturn? What was so special about this resource base?

Part of the reason is timing—it was the last to the shale party—part is the quality of rock in the basin. The Permian Basin, with its 34-plus individual reservoirs, is one of the richest basins per square mile in the world. It's a rare member of the top tier of super basins. While geologists had always known about the stacked pays, the execution of horizontal production from stacked zones from one pad was new to the industry. This drove down production costs by extending drilling inventories without having to lease additional acreage.

The Permian is No. 1

Being one of the late comers to the unconventional game allowed Permian operators to fast-track their learning from other plays and accelerate the technological advancements in the Permian. Lateral lengths and proppant intensities rose faster in the Permian than in other unconventional plays. Operators didn't wait to drill 8,000 lateral length wells before experimenting with new engineering and completion con-



Rick Muncrief
Chairman & CEO
WPX Energy

“Tuesday, July 14, 2015, was an exciting day for WPX, forever changing the face of the company. It's the day we announced our agreement to purchase RKI Exploration & Production, entering the Delaware Basin.

“Our technical staff analyzed basins all over the country as we pursued a multi-year strategy to enhance our returns by getting oilier. We weren't looking for just any opportunity. We were looking for a perfect fit.

“The Permian's stacked pay reservoirs were a unique opportunity to high-grade our portfolio and bolster our inventory in a big way. This wasn't just a bet on oil. It was a bet on ourselves, our organization and a vision to compete against the industry's best companies.

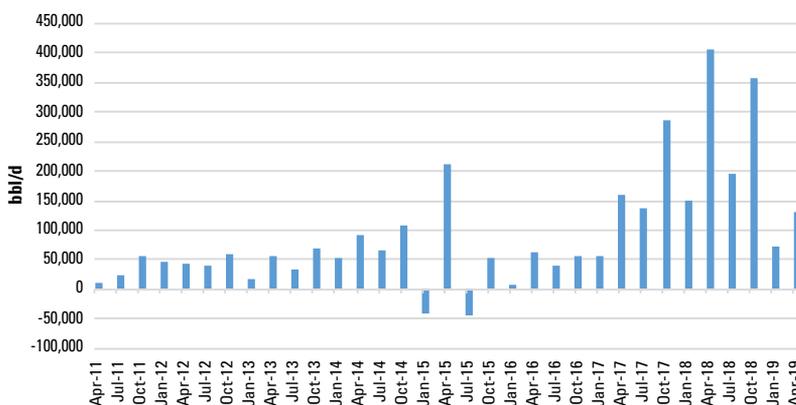
“Since then, we've tripled how much oil WPX produces and embarked on science work in the basin that is drastically reducing our development costs and changing how we complete wells across the company in both of our operating areas.

“The Permian is an unmatched marvel that will be touched by generations to come. As someone who spent most of my formative years in the Permian, I can personally attest to how its legacy is going to keep on living for a very long time.”

figurations; in the Permian, once an area was proven productive, optimization began immediately. This led to rapid rises in per-lateral-foot productivity improvements not seen in other plays. (See Figure 4.) Operators wasted no time finding the most capital-efficient means of producing on their acreage.

Figure 3: Quarterly Change in Permian Oil Production

Source: IHS Markit





100 / 50

**From one old-timer to another.
Congratulations, Permian.**

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IHS Markit data shows that the basic productivity of the Permian is better than most other plays in the U.S. Considering peak-month production (boe 6-1) per 1,000 lateral feet of well bore, the Delaware Basin clearly outperforms other unconventional plays, and the Midland Basin is a strong competitor. (See Figure 5.) The Delaware is over 175, and the Midland is 90, though variances will arise depending on the target formation. This is considerably more than the Eagle Ford, where productivity per 1,000 lateral feet is around 115, and the Bakken, which is closer to 90.

Unconventional production first materialized in the Midland Basin. By early 2015, the basin was already producing over 300,000 bbl/d from unconventional wells, while the Wolfcamp Delaware supported an additional 200,000 bbl/d. Pioneer has been and still is the dominant Midland producer, generating over 250,000 bbl/d of operated production through the drillbit, while other material producers including Diamondback Energy and Concho have leveraged the M&A markets to complement their own operations.

And though the Wolfcamp Delaware did not see unconventional volumes develop as quickly as the Wolfcamp Midland, the basin has certainly proven its ability to generate significant volumes at attractive break-even prices. The operator landscape is much more diverse, with material volumes generated by Occidental, EOG, Cimarex Energy Co., and Concho.



Ben Shepperd
President, Permian Basin
Petroleum Association

“Since 2010, oil production in the Permian region has increased from less than 1 million barrels per day to nearly 5 million bbl/d in 2019, and it is anticipated to increase to as much as 8 million bbl/d by 2023.

“Over the same period, the United States surpassed Russia as the leading producer of natural gas in 2011, and in 2018, it surpassed Saudi Arabia as the largest producer of petroleum.

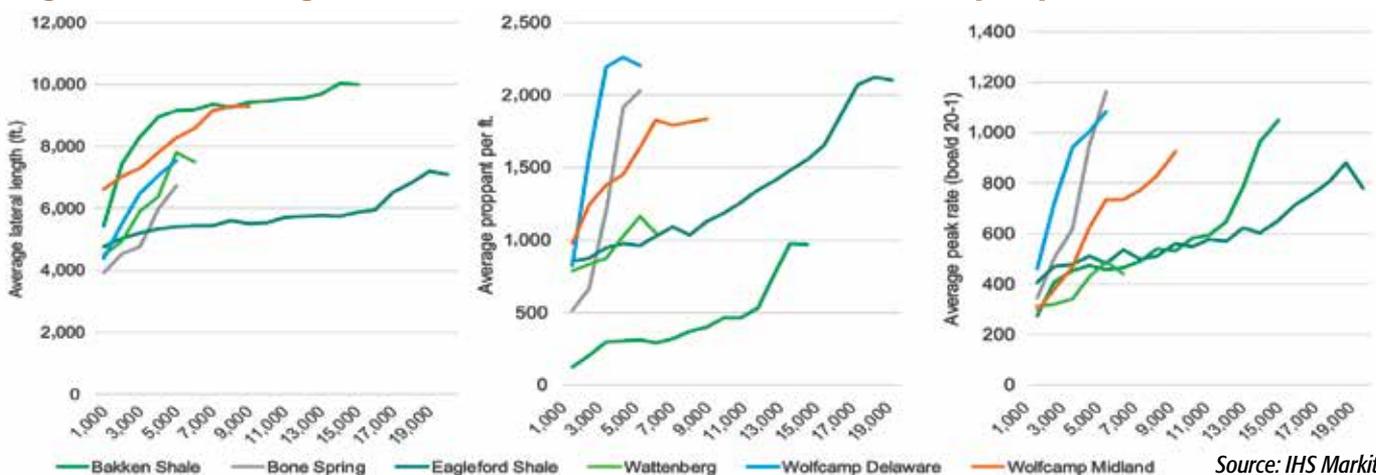
“In short, hundreds of miles away from the largest metropolitan areas in Texas and New Mexico, and 8,000 miles from the [September 2019 drone] attacks in Saudi Arabia, the Permian Basin is buoying the world’s energy supply and ensuring peace, when at any other time, chaos could have ensued.

“Today, because of the Permian Basin, the United States is a safer place.”

What is the future for the basin?

As both the basin and the U.S. mature, a new set of challenges has arisen—volatile prices, takeaway

Figure 4: Technological Advancements in Unconventional Plays by Well Count



Underwritten by
Stephens Inc.

1940
The Todd Unit No. 2 well, owned by Continental-Stanolind, came in at 850 bbls in the first 12.5 hours in Reagan County.

1940
Odessa hosted the “Little International Oil Show” with 35 exhibits. Hosted every two years, it is now known as the Permian Basin International Oil Show and drew over 700 exhibitors in 2018.

1940
By combining two publications, Henderson Shuffler formed the Odessa American, an Odessa-based newspaper that has published over a million words about local events and the Permian Basin.

Figure 5: Permian Unconventional Productivity by Play

Source: IHS Markit

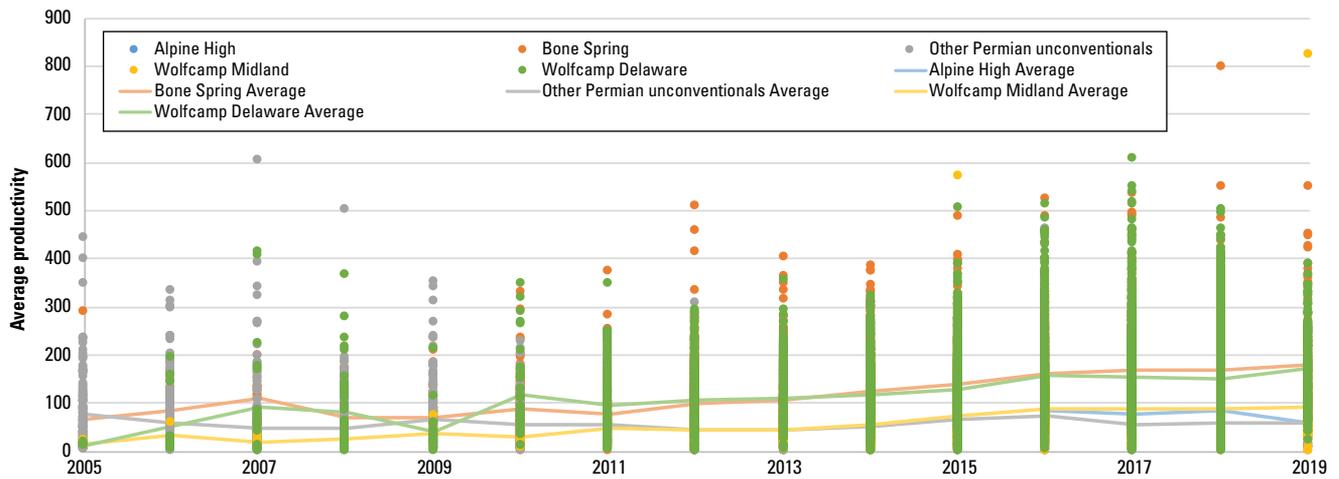


Figure 6: Permian Forecast for Majors

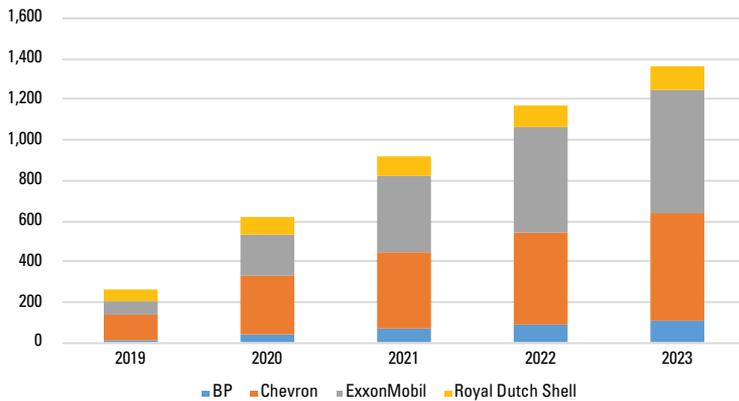
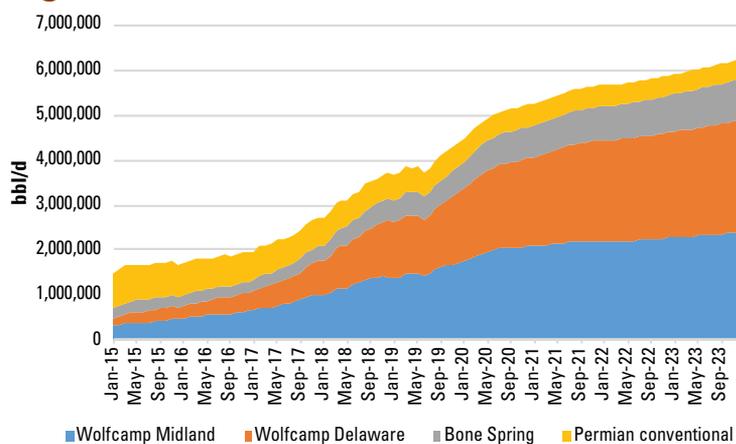


Figure 7: Permian Basin Production Forecast



capacity constraints and a perception that operators are not providing enough returns to investors.

The industry has pivoted to address the issues. It dispensed first with the takeaway capacity issues, and it is now focusing on providing solid financial returns instead of simply production growth. Operators in the basin are touting “visibility to positive cash flow” and consistently lowering spending outlooks.

This has also led to further consolidation as operators focus on efficiency and cost, which leads to scale. Many of the Permian’s mid-sized companies are gone through mergers and more are likely.

The play has attracted the attention of the supermajors, which are setting aggressive production targets and mobilizing large teams. (See Figure 6.) The No. 1 operator in the Permian is now ExxonMobil Corp., with 55 rigs operating. Still the independents will retain the title of being the largest producers, at least for now.

In the long term, the Permian Basin will be the sole source of U.S. supply growth, as other unconventional face headwinds, creating an environment where they cannot compete for capital. Now unrestrained in pipeline capacity, Permian production is set to reach 6.25 MMbbl/d by the end of 2023, and though growth will slow considerably, it will continue through the end of the decade. (See Figure 7.) Operators continue to optimize well and completion activities, more infrastructure is under construction, and efficiencies consistently increase. In short, the sun shines as brightly over the Permian as it ever has. 100

1941

The number of fields in Andrews County continued to grow, with the discovery of Fullerton Field. Abroad, the U.S. entered World War II. Its oil helped fuel the Allied armies.

1942

Welch Field was discovered in Dawson County.

1942-1944

The Big Inch and Little Big Inch pipelines were completed as a wartime measure to ensure secure, interior petroleum transportation from Texas to the northeastern states.

1943

Russell Field was discovered in Gaines County.

FROM HUMBLE BEGINNINGS TO LEADING CAPITAL PROVIDER

Stephens Inc. started with a vision to help business owners, and now they have closed a multitude of substantial transactions, many to the benefit of Permian Basin operators.

Stephens Inc., headquartered in Little Rock, Arkansas, was founded in 1933 by Wilton R. Stephens. Affectionately known as Mr. Witt, he bought Arkansas highway bonds selling at Depression era prices. Eventually, the bonds paid off at par, and the small firm grew steadily. Jackson T. Stephens, Mr. Witt's brother, and Warren Stephens' Dad, joined the firm as an equal partner in 1946.

On their handshake partnership, they built the powerhouse investment firm, Stephens Inc., which grew to become the largest such firm outside of Wall Street. They realized they could make money by becoming financial partners with business owners who needed capital. One area of focus for this merchant banking activity was the oil and gas industry.

After acquiring natural gas interests in the Arkoma Basin during the 1940s, Stephens bought the Oklahoma Production Company in 1953. This served as the foundation for a new natural gas exploration company, Stephens Production Company. The following year, the Stephens expanded their natural gas interests when they acquired the Arkansas Louisiana Gas Company (Arkla).

Today, Warren Stephens is the sole owner of Stephens Inc. and serves as chairman, president and CEO. The Stephens Energy Investment Banking team is based in Dallas, where the firm opened an office in 1992. Keith Behrens serves as managing director and head of the energy group.

Stephens' Energy Investment Banking practice is focused on raising private and public equity and debt capital for both private and public companies in the energy sector. The group also advises on corporate M&A transactions and the sale of asset packages. Since 2009, the group has closed 160 transactions with aggregate transaction volume of around \$47 billion.

The practice has been active in recent years advising Permian Basin-focused companies. Several of the group's recent transactions include serving as placement agent in a capital raise for an established minerals company; serving as advisor to a private company in the acquisition of Midland Basin assets from a public company; serving as underwriter on a follow-on offering for a minerals and royalties company; and providing a fairness opinion for a merger of two Delaware Ba-



Warren A. Stephens
Chairman, President and
CEO, Stephens Inc.



sin private-equity-backed companies. Stephens is also currently working on several engagements in the basin, including engagements involving a water infrastructure business; a Midland Basin operating company; and a minerals and royalties business in the Midland Basin.

Regarding the future, Mr. Behrens stated, "We believe there will continue to be opportunities for energy companies and capital providers in the Permian Basin. Recently, we have seen public investors pull back from investing in the sector, which has created issues not just in the Permian but in plays nationwide. With this lack of capital, the A&D market has slowed, compelling certain companies to merge in an effort to reduce overhead and create efficiencies. We see this lack of public capital as an issue that may persist, but believe there are still significant opportunities for private capital transactions that can be beneficial to all parties involved." ■

Stephens Inc.
Corporate
Headquarters,
Little Rock,
Arkansas

Stephens Inc.

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CHAPTER 4 | CURRENT ACTIVITY



Photo by Tom Fox



Photo by Steve Tom

ALL ROADS LEAD TO THE PERMIAN

BY LESLIE HAINES,
HART ENERGY

You can't talk about U.S. energy without talking about the Permian Basin. Here's a look at what some companies are up to today.

From the University of Texas at Austin, authors of the Bureau of Economic Geology's Tight Oil Resource Assessment (TORA) recently made quite a statement: There are still roughly 100,000 more wells that can be drilled in the Permian Basin, based on the size of the resource that is technically recoverable. The USGS says the Wolfcamp Formation alone has 46.3 billion barrels recoverable—more than the Permian Basin has produced in its first 100 years.

To that, Permian operators would say, "We're on it."

In third-quarter 2019 in the Delaware Basin, although there was a downturn of 8.8% from the

prior quarter, they drilled 812 wells, according to Enverus. They drilled 804 wells in the Midland Basin. The total Permian share of all U.S. wells drilled was 39%.

Various estimates put the number of E&P players with drilling permits throughout the basin at 350 companies, as production heads towards 4.6 million barrels a day (MMbbl/d)—and beyond. Some expect it to hit 5 MMbbl/d in 2020.

U.S. production may increase by 1.15 MMbbl/d in 2020, according to research firm Rystad Energy. Most of that growth is coming right out of the Permian.

There is much to say grace over. An April 2019 report by Jefferies said the best-return plays are the northern Delaware Wolfcamp and Bone Spring, and the state-line Wolfcamp and Avalon. Operators are pursuing the San Andres, Barnett Shale, Yeso, and that old standby that started it all, the Spraberry.

A slowdown in drilling and completions is apparent as most E&P companies pledged to move forward more cautiously for technical and financial reasons. But the Permian continues to host about half of all rigs working in the country—and it still produces up to 32% of its crude oil and condensate. Time and again Permian players have bounced back from commodity price lows, the lure of other basins or even other countries. All roads lead back to the Permian.



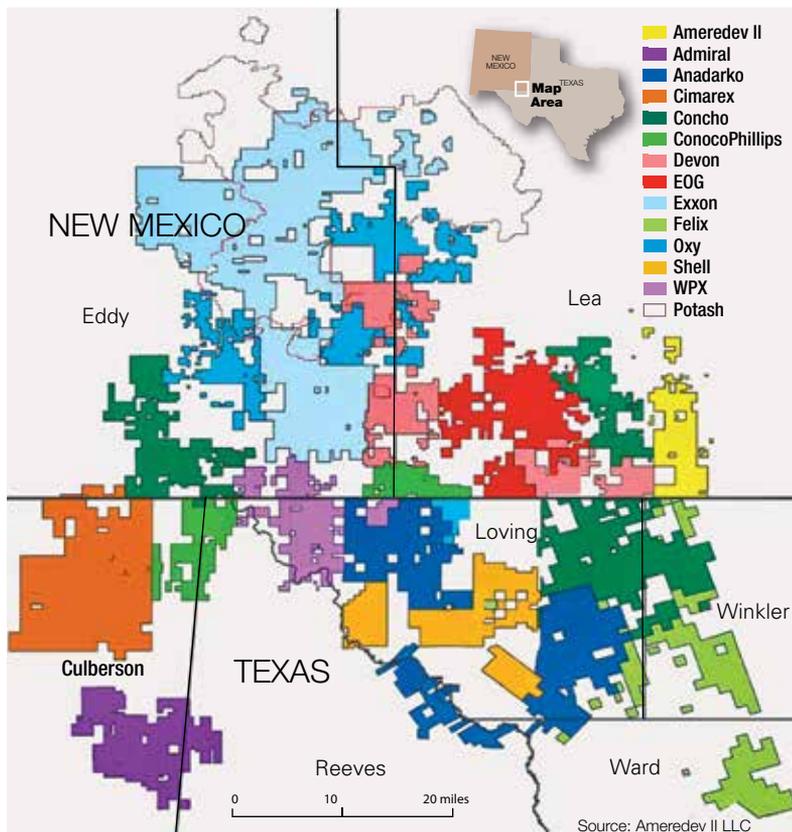
Staae Gjervik
President
XTO Energy Inc.

“It takes scale to do this, specifically as many as eight drilling rigs and six completion crews on location at a single time. It also takes confidence, courage and conviction as we’re using this strategy at multiple locations. Our approach and investment strategy will take time, but we’re convinced it will bear fruit. We’re not chasing headline-grabbing IPs, although at times those can be nice, too.”

“The Permian is the U.S. oil business,” said Ted Patton, managing director of Hastings Equity Partners. “You can’t talk about the U.S. energy industry without talking about the Permian Basin. As the Permian goes, so goes the industry.”

Hastings teamed up with the University of Houston in 2019 to research the future of the Permian Basin, especially regarding exports. It anticipates production up to 7 MMbbl/d by 2023, which demands exports to soak up many of those barrels.

NORTHERN DELAWARE BASIN SUPERBLOCKS



The full potential of the basin’s many stacked formations can be produced through new technology, so the question becomes one of timing driven by corporate strategy and commodity prices. The industry mantra has changed, but it will take a while for E&Ps to change direction. All say they plan to tap the breaks, keep reducing costs and generate free cash flow within current commodity price limits.

Drilling has to continue though, as the median base decline rate of 39 E&Ps covered by BMO Capital Markets is between 30% and 40% in the first year of production.

Majors, majors

The Permian budgets of the bellwether major oil companies will depend on applying technology and data analytics in a manufacturing mode that comes with scale.

“For the first time in years, these oil giants appear to have overtaken smaller independents in terms of well performance in the Permian Basin, contradicting claims that regional productivity couldn’t go any higher,” research firm Rystad Energy said in a note in 2019. Oil majors are pumping more than 1,300 barrels of oil equivalent per day (boe/d) from their new wells, which is about 100 boe/d more than the top 10 shale independents, according to Rystad’s analysis.

Pundits and independents watch the majors for indications of where the opportunities are and how the industry will proceed.

For example, ExxonMobil, Chevron Corp. and ConocoPhillips each sold out of the North Sea in 2019 to focus elsewhere. It’s no secret that they are deploying more in the Permian.

According to an IHS Markit report in mid-2018, the supermajors must spend nearly \$30 billion through 2020 if they are to meet their stated Permian goals.

ExxonMobil’s Permian charge is led by XTO Energy Inc., which aims to produce 1 MMboe/d in the Permian within five years. During its second-quarter 2019 earnings call, ExxonMobil reported a 90% year-on-year increase in its Permian production to 274,000 boe/d. This follows its \$6 billion purchase of the Bass family assets, including those in the Permian. In the first nine months of 2019, XTO Energy filed for about 500 drilling permits on the Texas side of the basin alone, according to the Texas Railroad Commission. And in 2019, it managed to reduce costs dramatically, to as low as \$15/bbl.

XTO is shifting to a long-term value focus from a short-cycle approach, president Staae Gjervik said at Hart Energy’s Executive Oil Conference in

STAYING AHEAD OF THE CURVE IN THE DELAWARE BASIN

At every level, Caza Petroleum plans ahead to generate value and work toward operating out of cash flow.

Focusing successfully on the Delaware Basin in southeast New Mexico, Caza Petroleum employs the philosophy of planning ahead at every step to anticipate changes needed to maintain its success. As a result, the company has a respected reputation as one of the Top 20 producers in southeast New Mexico.

Caza Petroleum was founded in 2006 and today focuses on oil, natural gas and NGL exploration, development and production. Three years ago, the private equity firm Talara Capital Management opted to back the company and its management team. This synergistic relationship has resulted in Caza increasing its production numbers and corporate value every year.

“Careful planning, knowledge of the area and successful techniques contribute to Caza’s success,” said W. Michael Ford, CEO and president.

Talara’s backing has enabled the company to enjoy steady growth while it continually increases key value metrics. “At the time of the Talara transaction,” Ford said, “Caza had a PDP value of \$22 million and total proved reserves of \$88 million. Today, the PDP value is \$191 million, and the total proved reserve value is \$382 million with approximately 48,000 net effective mineral acres.”

Caza continuously operates a one-rig program with plans to contract a second rig in 2020. The 2019 budget of \$85 million will increase to \$120 million in 2020. “Our objective is to convert our PUD reserves to PDP reserves and our probable reserves to PUD reserves,” Ford said.

“Despite our robust drilling plan, by 2021,” he noted, “Caza should be operating solely out of cash flow.”

Safety and compliance in all areas comprise part of Caza’s focus. With 16 employees—many with 30-plus years of experience—safety is one factor that is consistently updated.

With operations based in Lea and Eddy counties, New Mexico, the company monitors both State of New Mexico and U.S. federal regulations. “The political environment is fluid, and as a prudent operator, we strive to be compliant with both state and federal regulations, while always being good stewards of the environment,” Ford said.

Current concerns include water supply and take-away. “Water supply and water disposal are issues that



“Careful planning, knowledge of the area and successful techniques contribute to Caza’s success.”

—W. Michael Ford,
CEO & President, Caza Petroleum

have our attention, and I see them as being hurdles for this industry for the foreseeable future,” Ford said. Takeaway of what Caza’s wells produce is also on the list. “We have up to a 20,000 barrel per day reservation in the new EPIC pipeline, which is now open.”

For Caza, planning ahead is critical. Ford said his experienced staff “performs pre-drill modeling on our wells. We understand the rock. We watch industry closely and adopt new but tested ideas for our operations. I like to say we want to be the second mouse to the cheese, not the first.

“For the next three years, we will be working on pad-site development and zipper frack completions to capture more efficiencies. We are looking to eliminate the parent-child issues with drilling and producing wells, and we think our efforts will result in cost savings of up to \$1 million per well. By drilling six to eight wells off one pad site, we are creating efficiencies, while also reducing our environmental footprint.”

Other cost-saving measures include more efficient drilling methods. In addition, hedging ahead of the drill bit to protect committed capital will mitigate the effects of a possible recession and lower commodity prices.

“We love being in the Delaware Basin,” Ford said. “It’s a premium basin that keeps on giving.” ■





Wendy King
Vice President
ConocoPhillips

“We’ve been in the Permian over 100 years through our legacy companies, and today we’re big in the Stateline area; we have 88,000 net acres in the Delaware. My first job was in Hobbs 30 years ago, and now here we are again. I believe collaboration across the industry can be a rising tide that lifts all boats, and we’re using predictive data analytics to improve completions and reduce costs. We have a very bright future in the Permian.”

Midland in November. A complex resource with multiple benches demands great focus on capital efficiency and technical applications, he said, and courage. To reach its target by 2024 it has close to 10,000 employees, 55 rigs, 12 frack crews and 50 construction sites across the Permian.

It is working from wellhead to the coast, expanding its Cowboy Central Delaware Plant in New Mexico to handle 600,000 bbl/d, the largest plant in the area. Its new unit at the Beaumont refinery will hike capacity by 65% to take more light crude from its Permian holdings.

“We need new 2 Bcf/d-gas plants every nine months! That is something we’ve never seen before in any basin,” Gjervik said.

During the next 40 years, XTO plans to drill about 6,500 wells on more than 400,000 acres in the New Mexico section of the basin, according to a study by Impact Data Source of Austin, commissioned by Exxon. It has 1.6 million Permian acres.

“By 2025, ExxonMobil’s oil production could reach 550,000 barrels per day and the company’s natural gas production could reach 2.4 Bcf/d, which is comparable to the cumulative production of some U.S. states,” the study said.

Meanwhile, Chevron said it expects to produce 900,000 boe/d, by year-end 2023, by consistently run 20 rigs until then. Its Permian production rose 55% on the year to 421,000 barrels of oil equivalent per day (boe/d.) in the third quarter of 2019.

“The Permian overweight is undeniably needle-moving, reaching 15% of the company’s [global] production mix,” said a Raymond James report when Chevron reported third-quarter 2019 results.

Growing free cash flow and corporate returns remain a priority for all companies, with “the Permian representing the best asset in Chevron’s portfolio to do so,” according to a roadshow that the company conducted with Tudor, Pickering, Holt & Co. Securities LLC. “Scale matters given corporate capital employed of about \$190 billion vs. \$3.5- to \$4 billion per year of Permian spend, which leads the conversation towards M&A.”

ConocoPhillips said at its analyst day in November that it plans phased and consistent investments across the global portfolio, including in the Permian, where it expects to operate six Delaware rigs and four in the Midland Basin or Northwest Shelf in New Mexico by 2024. It will be recycling 90% of its water by third-quarter 2020. It has an estimated 2,000 to 2,400 high-quality locations on its Permian acreage, said Dominic Macklon, president, Lower 48.

Occidental also has big plans, recently forming a joint venture with Ecopetrol, the Colombian company, to develop 97,000 net acres in the Midland Basin. Occidental will operate the venture and remain the majority owner, while Ecopetrol will pay \$750 million in cash, plus \$750 million of carried capital for a 49% stake. “Ecopetrol leaned in and this deal was well received by the market,” said Andy Rapp, managing director, Petrie Partners, which worked on the deal.

In Lea County, N.M., Occidental reported an outstanding well, the 031 H Taco Cat, which flowed 3,000 bbl/d and 5.2 MMcf/d from a Wolfcamp zone.

BPX Energy’s Permian position also has grown in importance. In 2012, Alaska contributed about 25% of its U.S. production, but by 2018 that changed: Contributions from U.S. shale-tight oil increased from around 10% in 2012 and will rise past 50% of BP’s U.S. production within the next few years, according to Rystad. BPX has 83,000 acres in the Delaware.

“Our goal is that by 2021, our acquired assets [from

1944

Two Andrews County discoveries occurred: Mabee and Midland Farms fields. Also, in Ector County, TXL Devonian Field was discovered.

1945

The prolific Levelland Field, in Cochran and Hockley counties, was discovered.

1946

Andector Field was discovered in Ector County.

1948

A discovery well in Scurry County was the first of several major developments in that region. The Horseshoe Atoll Reef Trend near Snyder, Texas, was discovered and led to the great Kelly Snyder Field.

MORIAH GROUP CELEBRATES 28 YEARS IN THE PERMIAN BASIN

Through several ventures, including Petroleum Strategies Inc. and the diversified Moriah Group, the Brown family has created value in the Permian, at a business and a community level.

In 1972, Dale Brown moved his family from San Diego to Midland, Texas, to begin his work in the oil business. Since then, the Brown family has founded and sold several oil and gas companies, hired hundreds of employees and given back to the local community by donating millions of dollars to hospitals, schools, churches and non-profits that help at-risk children.

Founded in 1991 by Dale Brown, Petroleum Strategies Inc. (PSI) conducts oil and gas A&D services. The company has conducted \$37 billion in 1031 like-kind exchange transactions.

“PSI is the intermediary and helps facilitate tax savings for the owners of oil and gas properties,” said Cary Brown. “Our company is the leading expert in oil and gas like-kind exchanges.”

PSI was the first such company conducting these transactions, IRS section 1031 exchanges, dedicated to the oil and gas industry. Before the company was founded, it was difficult for the oil and gas property owners to sell their assets and reinvest in them because the tax consequences were “pretty high,” Brown said.

The 1031 exchange transactions deferred or eliminated the tax, and the structure “opened many opportunities for oil and gas properties,” Brown said. “Petroleum Strategies became the leader and helped educate many in the industry on the great tax saving opportunities within like-kind exchanges.”

The company now facilitates approximately \$1 billion in transactions annually.

In 1992, the family founded another company, Moriah Resources, to acquire oil and natural gas reserves.

Three years later, they founded and organized the Executive Oil Conference, which is held in Midland annually, originally drawing more than 300 industry professionals each year to discuss trends and deals. Now a Hart Energy program, the conference draws over 1,300 energy executives.

“The conference came out of doing work for our customers in the like-kind exchange industry,” Brown said. “It’s easier to do deals with people that you know. We created a conference to connect people who are interested in finding mutually beneficial deals.”

The Brown family continues to operate several oil companies through the Moriah Group, a diversified



From left to right, Alan, Cary, Dale and Tod Brown

holding company that includes a real estate portfolio, Petroleum Strategies, technology and construction subsidiaries. The real estate investment portfolio includes multi-family, office, warehouse, hotel, and ground-up development in Texas, Oklahoma, Arkansas, South Carolina and Florida.

“Along with several equity partners in the Permian Basin we have invested \$1.7 billion in real estate in the US,” he said. “We continue today to find people with good ideas and help provide the capital to make those good ideas a reality.”

The Brown family office, which includes Dale Brown’s sons, Cary, Tod and Alan, aspires to help people reach their goals. The family’s goal is to be “good stewards of time, talent and treasure,” Brown said.

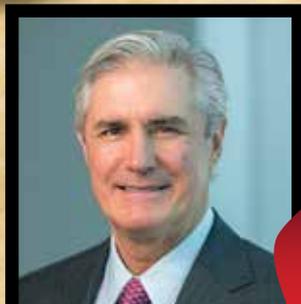
When Dale Brown moved to Midland with his wife Rita and their oldest five children, he had few assets—only his car and his education. In the ensuing decades, the family and business flourished. Today, four of Dale and Rita’s six children and their families reside in Midland.

“We came with nothing,” he said. “Midland has been a wonderful community and a great blessing for our family.” ■

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Tim Leach
 Chairman & CEO
 Concho Resources Inc.

“I’ve always thought of growth being an output of good execution and efficiency, so, I don’t start with a targeted growth number. We’ve targeted a lower commodity price that we could operate on, and have free cash flow ... at lower oil prices. That’s the starting point.

“For our industry to start attracting capital again, we’re going to have to offer an investment thesis that is

different than what we’ve done in the past.

“The main takeaway ought to be that regardless of the ultimate well spacing density, we expect to have an inventory life measured in multiple decades. But clearly, in 2020 we will move towards a more meaningful up-spacing program than we’ve had in the past, than what we had in 2019.”

BHP Petroleum in 2018] need to generate \$1 billion in free cash flow, so a lot of high-powered effort is going into the Permian and Eagle Ford to achieve this,” said Mohit Singh, BPX vice president, speaking at the Executive Oil Conference in Midland.

Independents shine

The roll call of independents active throughout the Permian is a who’s who of public and private operators, many whose Permian budgets exceed \$1 billion per year, but a sea change is underway in how that money is spent. Drilling to speed up NAV and prove acreage has instead become full-field development done at a more consistent pace, a true manufacturing process where spending is kept within cash flow.

Producers have fine-tuned drilling and completions and begun to address well spacing issues. Morgan Stanley analyst Devin McDermott said in a note that well communication and increased downtime from “frack hits” have been met with sharply negative stock price performance for the public Permian companies. “We believe such logistical and operational issues may become more common in the Permian as operators continue drilling bigger pads that more frequently offset large amounts of producing wells,” he warned.

Costs continue to come down. The biggest savings are from advanced completions and improved water handling, whether sourcing, recycling or disposing. In the past two years, more than a dozen local sand mines have opened, offering further savings.

A Bernstein report last September said that if oil were \$60/bbl, after-tax internal rates of return at the asset level would range from 20% to 58%, depending on the operator and quality of acreage.

The next big thing to be addressed is the environmental impact of flaring and methane leaks from a



U.S. Vice President Mike Pence toured this rig drilling for Concho Resources Inc. in the Midland area in April 2019. Photo courtesy James Durbin

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Jason Pigott
CEO
Laredo Petroleum Inc.

“One of the advantages of operating in the Permian is the quality of the people. You have multi-generational oilfield families that know the business and what it means to work in the oil fields. We strive every day to be a company that our employees are proud of. From being good stewards of the environment to giving back to our communities, we want everybody at Laredo to make a difference.”

surge in natural gas production throughout the basin.

“One of the key things is, we do not connect any new horizontal wells to production unless the gas line is already in place. I think that’s something that should be adopted by all oil producers in the Permian Basin,” said Pioneer Natural Resources Co. president and CEO Scott Sheffield on the third-quarter conference call.

“Also, we’re one of the few companies where 100% of our facilities are early monitored for leak detection and repair. We do it through aerial flying at about 3,000 to 5,000 feet. We do it once a year. It’s a very, very important practice to determine

A SNAPSHOT OF PERMIAN DRILLING ACTIVITY

Company	3Q Permian production (bbl/d) or (boe/d)	Permian rigs running	Net Permian acres	D/CBP/M*
Apache Corp.	222,000 boe/d	10	~1,500,000	D/M
BPX Energy, a division of BP	N/A	3	~83,000	D
Callon Petroleum Corp.	37,800 boe/d	5	~85,000	D/M
Centennial Resource Development Inc.	42,250 bbl/d	5	~80,100	D
Chevron Corp.	455,000 boe/d	20	~2,200,000	D/CBP/M
Cimarex Energy Co.	198,600 boe/d	8	~300,000	D
Concho Resources Inc.	330,000 boe/d	19	570,000	D/M
ConocoPhillips	N/A	N/A	800,000	D/CBP/M
Devon Energy Corp.	127,000 boe/d	N/A	280,000	D
Diamondback Energy Inc.	~215,000 bbl/d	15	~342,000	D/M
Ovintiv Inc. (Encana Corp.)	111,000 boe/d	N/A	115,000	M
Endeavor Energy Resources LP	133,600 boe/d	10	~376,000	M
EOG Resources Inc.	N/A	18	579,000	D
Fleur de Lis Energy LLC	~21,400 boe/d	1	~140,000	M
Matador Resources Co.	~69,600 boe/d	6	~132,700	D
Mewbourne Oil Co.	~100,000 bbl/d	11	~225,000	D
Noble Energy Inc.	70,000 boe/d	3	94,000	D
Occidental Petroleum Corp.	~457,000 boe/d	N/A	1,700,000 unconv. & 1,400,000 conv.	D/CBP/M
Parsley Energy Inc.	142,000 boe/d	11	N/A	D/M
Pioneer Natural Resources Co.	~351,000 boe/d	21	~680,000	M
Surge Energy Inc.	N/A	N/A	~85,000	M
WPX Energy Inc.	~365,000 boe/d	N/A	~130,000	D

Note: *Delaware Basin, Central Basin Platform, Midland Basin

This snapshot of Permian operators, as of 3Q 2019, shows the variety of companies involved in the basin. Source: Company reports, E&P

1949

The Seaboard Oil Co.’s Seaboard No. 2 came in at 349 bbls of oil a day, one of the first successful showings of the Spraberry Trend in the Midland Basin.

1949

In Scurry County, Cogdell Area Field was discovered, and in Upton-Midland County, the Pegasus Field was discovered.

1949

Halliburton performs the first commercial frack job on an oil well in Oklahoma.

1951

TIME Magazine labeled the Spraberry as “The World’s Largest Uneconomic Oil Field.” Production now exceeds 1 billion bbls.

where your methane leaks are and fix those as soon as possible.”

Pioneer expected to bring 290 wells online in 2019, spending about \$3.1 billion. It anticipates running at least 20 rigs in 2020, hoping to double oil production between now and 2024 from over 200,000 bbl/d net to over 400,000 bbl/d.

In third-quarter 2019, Concho Resources Inc. reported approximately 20% lower costs in the Midland Basin, down to \$791 per lateral foot vs. \$977 in third-quarter 2018. It has multiple decades of inventory. CEO Tim Leach said he expects the company to grow production 10% to 15% in 2020 yet stay within a similar budget to 2019, reflecting new efficiencies. It was operating 18 rigs and two frack crews last fall.

Concho used its first electric frack fleet in the third quarter, leading to further savings. It also used local compressed natural gas (CNG) to power operations.

Key Banc Capital Markets analyst Leo Mariani had this to say: “Concho clearly owned the problem with downspacing in 2019, as activity in 2020 will reflect a more conservative approach, which should average six to seven wells per project in 2020, vs. seven to eight wells per project in 2019, with no real outlier ultra-large projects. CXO also expects to see six to eight wells per DSU per reservoir in 2020 vs. 8 to 12 in 2019.”

While improving their operations, independents also keep finding new opportunities. EOG Resources, for one, announced two new targets for its vast Delaware Basin holdings, the Wolfcamp M and Third Bone Spring, adding 1,700 net premier locations and 1.6 Bboe of additional reserve potential to an already robust inventory. In 2019 it reported 740 net completions.

Laredo Petroleum Inc., a pure-play Permian operator, is revisiting its acreage on the eastern side of the Midland Basin, where it had been exploring the Cline Shale. It produces about 80,000 boe/d from its 130,000 net acres and is operating three rigs and one completion crew. Additionally, it owns and operates oil, gas and water gathering infrastructure and three water recycling facilities on its leasehold.

“Laredo has been operating in the Midland Basin for more than 10 years, and we’re now expanding on our inherent advantage of being one of the most efficient operators—we have among the lowest, if not the lowest, drilling and completion costs per foot and lease operating expense per boe in the basin,” CEO Jason Pigott told Hart Energy.

Laredo’s purchase of Tier 1 acreage in Howard County is expected to drive increased capital efficiency and higher margins in 2020 as it shifts development to oiler acreage, he said.

The Delaware Basin remains Devon Energy Corp.’s hottest asset, particularly along the so-called Stateline area, with 15 recent Leonard Shale wells delivering an average IP-30 of 2,200 boe/d (71% oil), at an average well cost of \$7.5 million in third-quarter 2019. Analysts also pointed to results from its Cat Scratch Fever 2.0 project of 10 wells in the Todd area in New Mexico. Ten wells there delivered an average IP-30 of 3,600 boe/d (facility constrained).

PDC Energy Inc. entered the Delaware Basin with a \$1.6 billion acquisition in December 2016. Since then, it’s focused on two areas in Reeves Coun-



Scott Sheffield
President & CEO
Pioneer Natural Resources Co.

“I’ve been on public record talking about how the Permian is going to slow down significantly over the next several years. A lot of it has to do with the free cash flow model that public independents are adopting, the issues private equity firms are going through in regards to consolidation and reducing activity. The reduction of NGL prices is significant; we’ve deviated long-term from about 70% to 50% of WTI, so that is lost revenue.

“The strained balance sheets a lot of the companies have, the parent-child relationships that companies are having, people drilling a lot of Tier 2 acreage. So I’m probably getting much more optimistic about 2021 to 2025 now in regard to oil price.

“I don’t think OPEC has to worry that much more about U.S. shale growth long-term. And all that is very beneficial. So we are probably going to be more careful in the years 2021 to 2025.”

1953

The Texas Railroad Commission merged numerous smaller fields into what from then on has been known as the Midland Basin.

1953

Future U.S. president George H.W. Bush formed the Zapata Petroleum company with wildcatters John and Hugh Liedtke.

1953

The Wolfcamp Formation was discovered, now understood to be one of the most important discoveries in the Permian.

1953

Boy Scouts of America created its Geology merit badge.

FOUNDED WITH A WILDCAT MENTALITY

Thanks to a world-class asset and a tenacious team, Endeavor Energy Resources LP has grown into one of the Permian's largest and most prolific private E&Ps.

The history of the Permian Basin and its evolution over the past century have been an inspiration around the world. The wildcat mentality of courage, grit and tenacity has been part of the Permian Basin's roots for decades. People have flocked to the dusty fields of the Permian in pursuit of their dreams, and Autry C. Stephens is no exception.

Before venturing west, Stephens grew up on a farm in DeLeon, Texas, where his family worked hard to raise peanuts and a variety of fruits, including watermelons, peaches and cantaloupes. Here Stephens learned first-hand the value of hard work. He also developed a love of adventure and the freedom of being outdoors, which sparked an early interest in the petroleum industry.

After graduating with Master and Bachelor of Science degrees in petroleum engineering from the University of Texas at Austin, Stephens started his career with Humble Oil and Refining Co. in 1962. After working three months, he took a two-year leave of absence

to fulfill his military obligation. He served as a platoon leader in the Army Corps of Engineers overseeing small construction projects on a NATO fuel pipeline that ran from the coast of France to Germany. Following his service, Stephens resumed his position at Humble for another five years before leaving the company. Little did he know, this decision would forever change the landscape of the Permian Basin.

Once in Midland, Stephens began working as a reservoir engineer at a local bank and was exposed to various business deals with entrepreneurs and bank leadership. This set a new trajectory for Stephens' future, and in 1979, he formed a sole proprietorship. Having the spirit of a true entrepreneur, Stephens immediately recognized opportunities and began strategically purchasing mineral rights and drilling vertical wells one-by-one while remaining focused, determined and fearless. As others fled the market during downturns, Stephens bought additional leasehold and corporate acquisitions, adding tremendous value to his portfolio.

Endeavor drills to the Spraberry in Midland County.





“Don’t let fear of failure keep you from following your dream.”

—Autry C. Stephens,
Founder & General Partner,
Endeavor Energy Resources LP

Stephens’ continued focus on acquisitions led to the purchase and integration of multiple service companies that include drilling, fracking, trucking, roustabout, well service, wireline, vehicle maintenance and construction services. This vertical integration business model has consistently provided steady access to services and exclusive pricing at lower than market costs for his drilling and production operations.

“Hats off to Autry for a lifetime of achievement. His tenacity through the ups and downs of the industry has ultimately resulted in a world-class asset.”

—Chuck Meloy,
CEO, Endeavor Energy Resources LP

In 2000, Stephens transformed his sole proprietorship into Endeavor Energy Resources LP, focused primarily on drilling vertical Midland Basin Spraberry Trend wells. In 2016, new leadership, including CEO Chuck Meloy, joined Endeavor, and collectively they have reinvented the company with the goal of building a top-tier Midland Basin horizontal operator. Endeavor Energy Resources LP is now one of the largest private employers in Midland and has grown to be one of the largest private oil producers in America, with current daily oil production in excess of 130,000 barrels of oil per day.

“Hats off to Autry for a lifetime of achievement. His tenacity through the ups and downs of the industry has ultimately resulted in a world-class asset,” said Chuck Meloy. “As a result of his vision and leadership, our team has done a tremendous job building the company’s production and execution capabilities into one of the largest private operators and an extraordinary company.”

Since January 1, 2016, the company has completed more than 300 gross operated horizontal wells targeting the Wolfcamp and Spraberry formations in the Midland Basin. Holding more than 370,000 net acres primarily in Midland, Martin, Howard, Glasscock, Upton, and Reagan counties, Endeavor currently has one of the largest land positions in the Midland Basin. Along with its other acreage in the Delaware Basin and other states, Endeavor has only scratched the surface of its drillable inventory.

“Autry Stephens is a Spraberry legend who has operated under the radar for decades. An oilman contrarian, Autry took advantage of acquiring Spraberry rights when his competition ran from it,” said Bryan Sheffield, founder and executive chairman of Parsley Energy. “There are many big hats that have come out of the Spraberry Field, but if it were a measured race, Autry has easily won by a large margin.” ■



endeavorenergylp.com



Experienced crews help Permian operators grow increasingly efficient.
Photo by Tom Fox

ty, Texas, referred to as North Central, in western Reeves, and Block 4 in eastern Reeves, near Pecos. At year-end 2018, the company estimated it had 365 gross locations with an average lateral length of approximately 7,900 feet in the Wolfcamp A, B & C horizons. The company is also testing the Third Bone Spring horizon.

Its first well was turned-in-line in second-quarter 2019, and subsequent wells will be drilled and turned-in-line in 2020. After lease expirations, trades and an acreage sale, the company expected its year-end 2019 position to be approximately 33,500 net acres.

PDC's preliminary 2020 capital program calls for two rigs for the full year and one completion crew for

seven or eight months. At this drilling pace, the company has more than a decade of drilling inventory.

SM Energy has operated in the Permian Basin since 1997, building a position through several acquisitions. It now has about 81,500 net acres and nearly 900 operated wells—more than 330 are horizontals it completed since 2013. Analysts say the company is delivering some of the best-performing wells at lowest quartile cost. In 2007 it opened a regional office in Midland, where there are currently about 160 employees.

Deals included acres located primarily in Howard County; all of its current assets are in the Midland Basin. Its 2019 program included an average lateral length of approximately 10,500 feet, but it has drilled laterals as long as 15,500 feet.

Since 2013, its net production in the Permian has grown more than 550%. Third-party research has shown SM's wells are among the most productive in terms of cumulative production per lateral foot (based on every well completed since 2013).

One of the big success stories in the Midland Basin has been the private companies run by John Sellers and Cody Campbell, both natives of West Texas, which Campbell calls "the best basin in the world. The economics are really solid." Their previous company, Double Eagle Energy Permian II and affiliates, was sold to Parsley Energy Inc. in 2017 for \$2.8 billion.

In addition to continuing to buy minerals, they're co-CEOs and founders of privately held



George Solich
Executive Chairman
DoublePoint Energy LLC

“It’s interesting when you look back at the progression of the shale revolution, that the Permian was one of the later plays to fully emerge. I guess you can say we saved the best for last! We are excited to be partnering with Double Eagle Energy in the Midland Basin. DoublePoint is building a world-class, oil dominated asset on acreage that has been virtually void of horizontal drilling. With our focused five-rig development program on this Tier 1 acreage, we expect to profitably grow production and cash flow at industry leading rates.

“On the minerals side, our strategy for building a durable and sustainable company, LongPoint Minerals, has been much like that of an E&P company: target the best rocks. Even as vast as the Midland and Delaware basins are, it is very competitive when it comes to buying minerals, but with a good subsurface model, good analytics, and of course solid relationships, we’re able to continue to grow our near-term, medium-term and long-term development opportunities.”

DoublePoint Energy LLC, a new pure-play that has over 100,000 acres in the Midland Basin. It plans to add a fifth rig in January 2020 and continue with two frack crews.

Sellers and Campbell employ about 160 people between their minerals and operating companies. “We buy minerals in the Permian every day. There is a high premium on quality; if you have minerals in the core, it’s very competitive,” Sellers said.

The chief industry challenge they see is how the overall business is financed in every basin, they told Hart Energy. DoublePoint, however, is well funded by several private equity companies, so its challenge is maintaining the scale needed to achieve its goals. It is drilling Wolfcamp, Spraberry and Jo Mills wells, and a few Cline Shale wells. “We’ve seen some good early results from the Cline, so we think it’s a bench that will be more developed and it will be there for us in the future,” Campbell said.

“The real challenge here in the Midland Basin, and it’s a good one to have, is there are so many benches that can be developed. It’s such a great opportunity.”

Paul Nunley, senior vice president, land, for Windy Cove Energy II LLC, which is backed by Yorktown Partners, sums up the Permian’s staying power.

“I’ve worked in the Permian for almost 20 years; formerly with Kinder Morgan. Now we’re operating some production in Yoakum County as Windy Cove, doing horizontal San Andres development. Just look at the Denver Unit in Wasson Field: You talk about staying power! It used to be owned by Shell and now it’s owned by Occidental; it’s been on CO₂ flood forever.

“I remember a Wall Street Journal article back in 1999 said, ‘The last one in the Permian Basin, turn out the lights.’ We all thought it was done, but it just blows and goes. It’s very cyclical, so you want to be the windshield and not the bug.”

Apache Corp. has about 2.9 million acres in the Permian. Last fall it had five rigs working in the Alpine High area and five in the Midland Basin and Central Basin Platform. Like many E&Ps, it is adapting in response to oil and gas prices and investor demands. It has redirected capital from the gassy Alpine High back to its core areas which deliver stronger returns.

Chairman and CEO John Christmann told Hart Energy a while ago, “You can’t help but be excited by the Permian. It’s been around for 100 years and it’s getting better as we go. It’s chock-full of zones that 20 years ago you never would have thought would be economic today. We’re bringing on wells at rates we never dreamed of.” 



Continued production growth from horizontal activity shows that the Permian still holds surprises. Photo by Tom Fox

WHY HIRE VETERANS?

BY LEN VERMILLION,
HART ENERGY

With a training ground backed by billions of dollars in investment, today's veterans are highly skilled, dedicated and primed for success.



To understand why military veterans make great employees for the energy sector, consider this: There's likely no better training ground for pressure-filled, highly technical jobs anywhere in the world. Want proof?

Every year, about \$17 billion is spent on military training and education. But what military personnel are learning with that investment is what makes them ideal for jobs in oil and gas, including positions ranging from roustabouts on rigs and field supervisors to engineers and executives.

Kayne Anderson

Energy Funds

"Today's transitioning veterans are highly skilled, dedicated and adaptable individuals with an unparalleled work ethic," according to information provided to Hart Energy by NextOp, a specialty firm that recruits, trains and places military veterans in industrial careers.

"[They are] conditioned to operate differently than a non-veteran candidate; they possess the ability to thrive in any industry and have a great deal to offer civilian employers," the statement goes on to say.

Nowhere is that success more evident than in the 25 military veterans who were honored at the 25 Impactful Veterans in Energy Luncheon held by Hart Energy in Houston on Dec. 5. Represented in the honorees were veterans of campaigns as far back as the Vietnam era and as recently as the global war on terror. Many have risen to the ranks of CEO at their companies.

For instance, Ann Fox, honored at the luncheon and also one of Hart Energy's 25 Influential Women In Energy, served three tours in Iraq, eventually reporting to Gen. David Petraeus, and she is now CEO of Nine Oilfield Service Inc.

"We'll show up early, we'll stay late, we'll learn things three times as fast," said John Boerstler, a U.S. Marine Corps veteran and CEO of Combined Arms, a nonprofit that helps accelerate the transition from military to civilian life.

"We'll do things safely, and we'll do things respectfully, as we do it in the military," he added.

Firms such as Combined Arms and NextOp have been integral in matching recently separated veterans with ideal opportunities in the energy industry. NextOp has placed 2,015 veterans into careers in less than five years, according to Mia Garcia, programs director at NextOp, and a veteran of the U.S. Marine Corps.



John Boerstler
CEO
Combined Arms



Mia Garcia
Programs Director
NextOp

Garcia said 25% (507) of those placements have been energy positions, with 64% of those hires in the upstream sector, 20% in downstream and 16% in midstream.

The industry has already seen material results from these recently separated veterans, evidenced by several younger individuals recognized with Hart Energy's 2019 Forty Under 40 award.

To name but one veteran honoree: Julia Margaret Klingensmith, a U.S. Navy veteran and chief digital officer for Flywheel Energy LLC, has proved instrumental in Flywheel's digital integration effort, successfully integrating the operational assets from the company's \$1.865 billion Fayetteville acquisition in 2018.

In tandem with efforts from placement firms and nonprofits, energy companies have started their own veteran-oriented initiatives. Chevron Corp., for instance, reports that it has worked closely with NextOp to hire veterans.

Additionally, service companies Halliburton and Schlumberger each actively hire at military bases and job fairs, with the latter being recognized as having the only U.S. Department of Labor-approved apprenticeship program for veterans in the industry.

And with the success of those veterans who are already working in the industry, those numbers are sure to rise.

Graciously underwritten by Kayne Anderson, in support of veterans.

Among the characteristics most cited by employers of veterans, according to NextOp, are:

- Exceptional performance under pressure;
- Ingrained leadership qualities;
- High degree of accountability;
- Accelerated learning curve;
- Mission/results-oriented mindset;
- Team-oriented approach;
- High adaptability; and
- Diversity

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Delivering efficiency and profitability with mobile power units

Siemens Unconventional Oil & Gas Solutions (offered as SEAM™) are powered by efficient gas turbine generators and can generate up to 3x hydraulic horsepower per trailer, reduce fuel costs up to 80 percent and reduce fleet maintenance costs approximately 60 percent. With sophisticated diagnostic technology, the electric solution allows integration of valuable digital controls and real-time data analytics. This enables safer operations, lower emissions, and increased profitability.



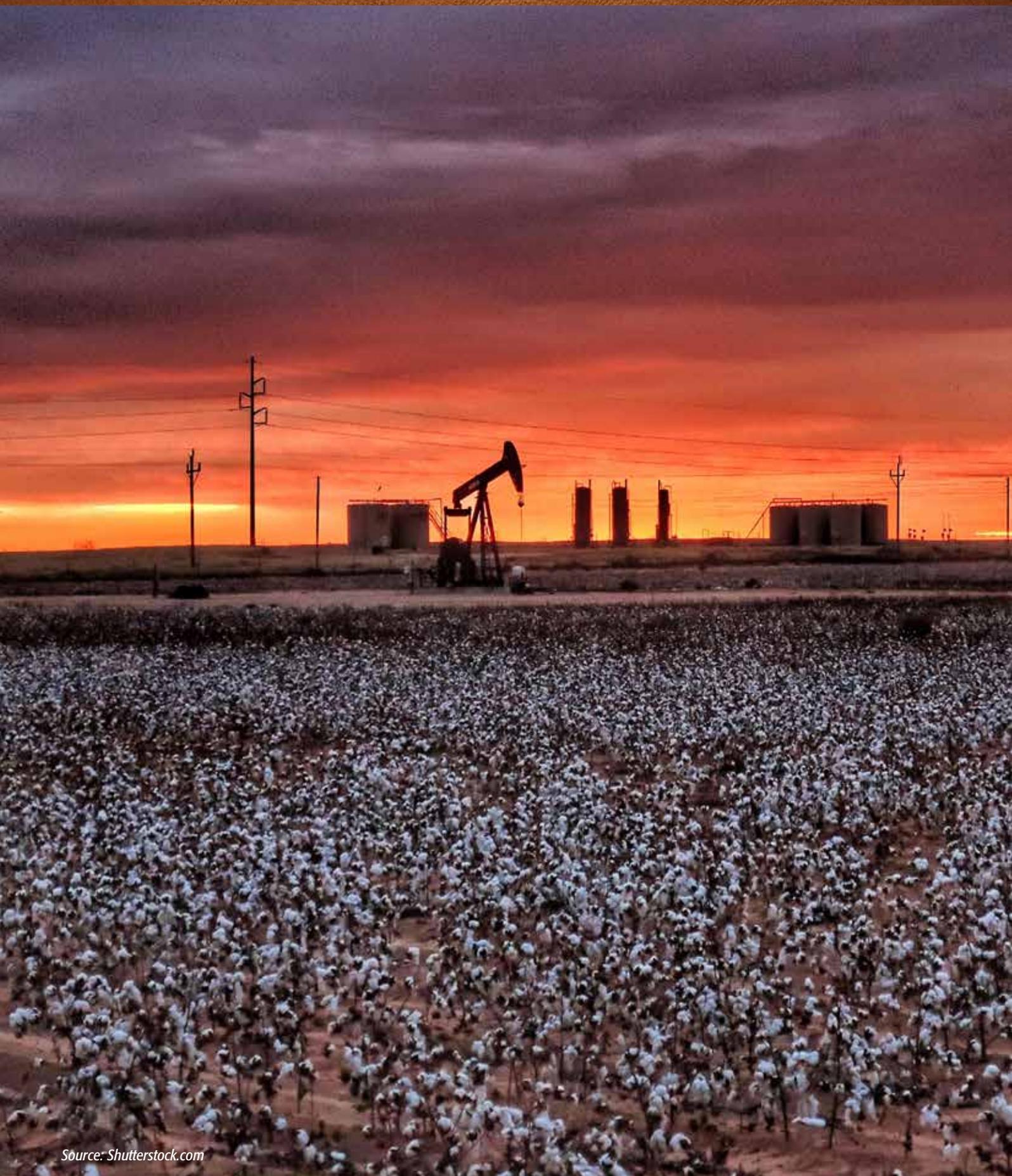
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HALLIBURTON

CHAPTER 5 | SERVING UP TECHNOLOGY



Photo courtesy Halliburton Co.



Source: Shutterstock.com

PERMIAN TECH AT THE CUTTING EDGE

BY RICHARD MASON,
HART ENERGY

Tremendous technical advancements have allowed the Permian Basin's operators to extract more resources, in less time and with less cost.

In the days of the Spanish Entrada, explorers spread across the globe discovering new lands, creating an era of economic growth and stimulating civilizations' progress. In our era, another great narrative of global exploration is underway in the drought-humbled landscape of the Permian Basin.

It commenced 100 years ago, and from the start it involved a three-dimensional journey through the earth's crust. Today, drilling, completion and industrial-scale technology stretching from water handling to proppant use has created another Permian Basin iteration, this one responsible for the energy renaissance that moves West Texas to the forefront of global energy production.

The story begins when the first geologists saw the Permian Basin as a petroleum province. This was no easy feat in a sparsely settled region 40 years removed from the frontier. It took decades of artful detective work via detailed surface mapping, careful study of well cuttings and, later, electric logs and well cores which led to stratigraphic correlation. This geologic investigation revealed a complex and

wondrous set of subsurface circumstances that still makes the Permian Basin one of the most significant energy provinces on earth.

Geologists, by fits and starts, developed a conceptual model of the Capitan Reef complex from its spectacular summit at Guadalupe Peak, tilting down into the earth near Carlsbad where the reef arced underground between Artesia and Carlsbad, N.M., to the Texas-New Mexico state line. The reef in various iterations followed the spine of Texas south along the western edge of a buried feature later identified as the Central Basin Platform. The Capitan Reef paralleled the location of the early great Guadalupian era conventional oil discoveries in the 1920s and 1930s.

In Permian times, recurring episodes of reef generation took place at the edge of a shallow shelf which, at the time, was near the earth's equator.

That deep basin alternated between periods when sea levels rose and periods when land-based sediments filled basinward. Those variations created thick layers of organic rich facies later identified as the Wolfcamp Shale. Episodes of accreting land sediments were named as the Bone Spring, based on the type locality on the west side of the 5,000-foot Guadalupe Peak cliff face.

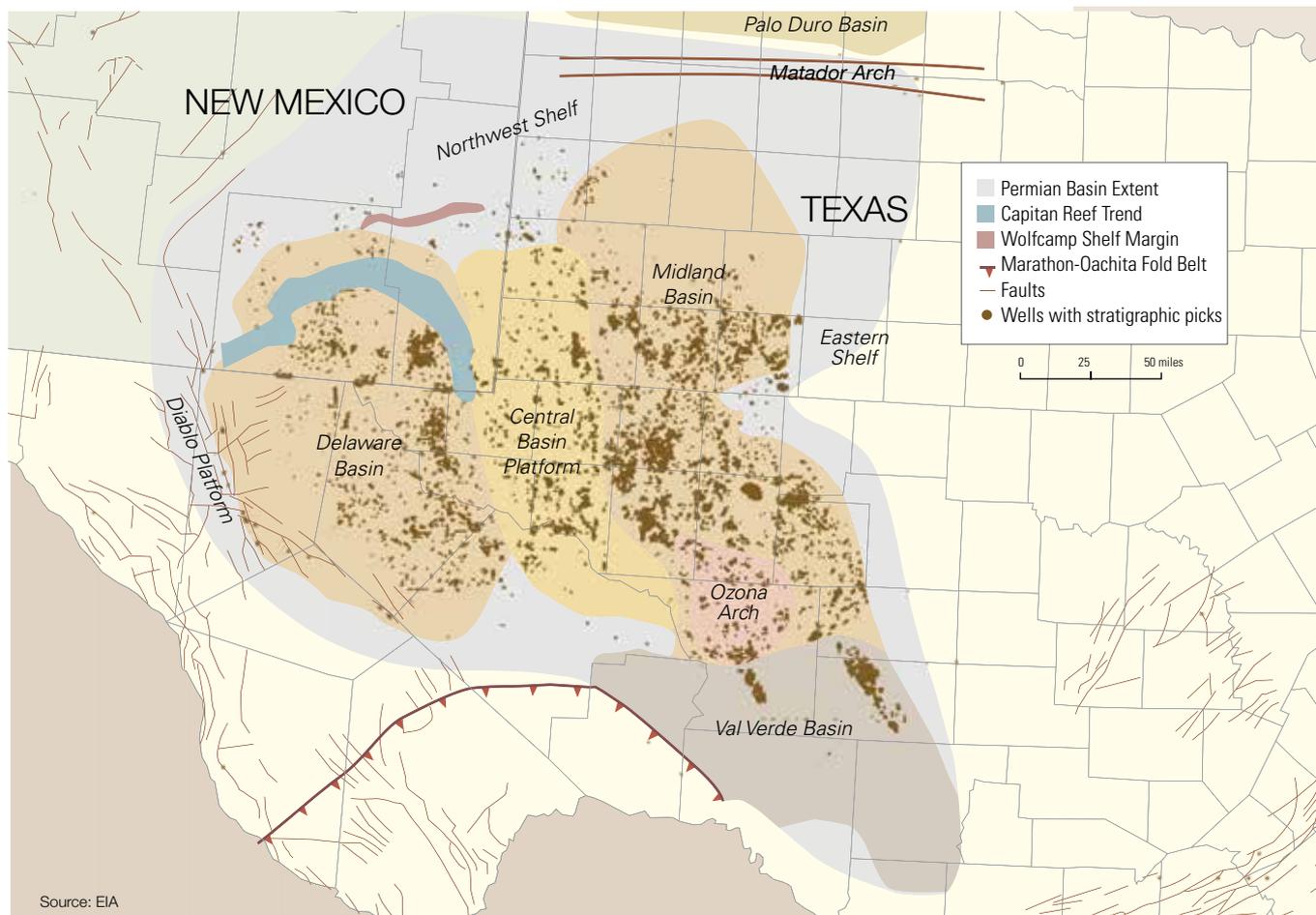
Similar processes were underway in the Midland Basin. Thus, the Spraberry Formation, overlying the Wolfcamp Shale, was a contemporaneous and geologic twin to the Bone Spring. The Central Basin Platform—think of an island like Taiwan or Madagascar—separated the Midland and Delaware basins into a butterfly shaped oil province covering 86,000 square miles.

Era of the engineer

A second wave of technology enabled the Permian to reach its early potential: Enter the engineer. First,



PERMIAN SUBSURFACE



The Permian Basin encompasses a number of subsurface geologic features associated with a near-shore to deep basin model. Both the Midland and Delaware basins are the current site of tight formation development, while the Central Basin Platform hosted the historic shelf edge conventional oil fields. Source: U.S. Energy Information Administration

this entailed gathering basic data via gauges to piece together a three-dimensional reservoir schematic. This also served to prevent aggressive developmental practices that depleted reservoirs, created commercial waste and stranded oil.

Over many years, engineers created a large basket of basic science and mathematical compilation. Those first scientific efforts buttressed creation of a proration state regulatory regime by the late 1920s. At the local level, proration limited the rate of production to the capabilities of the reservoir; at the state level, proration restricted production to the demands of the marketplace. Producers were left with

limits on the rate of oil production and the number of days each month the fields could produce.

Proration prevented oil prices from collapsing. The first proration voluntary efforts took place in the legendary Yates Field in Pecos County, Texas. The policy evolved through multiple pilot projects in the Permian Basin but eventually made the State of Texas the most significant arbiter of petroleum markets globally for the ensuing 40 years.

Proration encouraged operators to develop reservoirs for maximum recovery without crippling the petroleum system. This had not been accomplished in the 70 years following Pennsylvania's 1859 Drake

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1957
Robert O. Anderson discovered the huge Empire-Abo Field in Eddy County, N.M.

1957
Frank R. Clark, the geologist responsible for locating Yates Field, receives the American Petroleum Institute's Certificate of Appreciation in December.

1958
The original walking beam and other equipment of the Santa Rita No. 1 well was moved to the University of Texas at Austin main campus.

TO COMPLETE THE MISSION, RELY ON SIEMENS

Compression, automation and mobile power solutions support customers throughout the Permian Basin.

Q. How long has Siemens been doing business in the region?

A. We've been part of the Permian for decades, supplying equipment through distributors and integrators, and more recently offering turnkey solutions and products directly in the region.

Siemens supplies electrical and automation solutions for artificial lift, pumping stations, compression and drilling rigs, and power generation to processing plants and production facilities. Our components supplied to the Permian are housed to accommodate the harsh environmental requirements.

In the last few years, we've worked with service companies in shale basins, including the Permian, to electrify frack fleets. We deliver highly mobile power generation (scalable power plants that can be set up in a few hours) and other electrical system components to support the power needs in the basin.

Q. What are most important services/products you offer for this region?

A. First and foremost, we launched our Odessa Customer Support Center. It provides local inventory for mission-critical parts (e.g., for compressors, power generation equipment, etc.), and a location for strategic service personnel and field crews working in the area.

Siemens' portfolio includes the following:

Compression for gas processing and transmission.

We offer rotating equipment (centrifugal and high-speed reciprocating compressors) for gas lift, injection, and gathering. We have many compressor configurations for gas transmission and compression that are appropriately fitted based on plant capacity. These are mechanically driven by gas turbines or by electric motors and variable speed drives powered by a local gas turbine-based power plant.

Mobile power for fast electricity supply to the region.

Siemens Electric and Mechanical Solutions (SEAM™) offer power generation and distribution solutions, designed from the ground up for faster mobilization and to be exceptionally rugged. Our new 7.9MW, SGT-300 mobile power unit can be operating just a few hours

after arriving on site. Whether for production or treatment facilities, or to power a complete frack fleet, our turnkey electrical solutions eliminate guesswork.

For pressure pumpers, we can deploy more powerful pump units (e.g., electric frack) with less redundancy and fewer on-site workers. This enhances safety and reduces fuel and maintenance costs, and the equipment lasts up to five times longer.

Using natural gas reduces the carbon footprint compared to diesel equipment. Replacing one diesel fleet with electric can equate to removing approximately 500 cars off the road per year. With more than 400 fleets in the U.S., this is a meaningful reduction.

Digital solutions for less nonproductive time

We have been pioneers in remote monitoring and asset analytics; we are taking things further with artificial intelligence (AI), bringing AI4ESP (AI for Electric Submersible Pumps) to the region. Monitoring ESP performance is a challenge and downtime is costly. AI4ESP is an autonomous, well surveillance solution that has enabled operators to predict ESP failures up to 12 days in advance and reduced production downtime by roughly one-third.

Q. What is your outlook on future Permian opportunities?

A. We see strong opportunities ahead to further optimize our customers' operations and improve efficiency. Electrification is essential for delivering savings to the industry and reducing emissions. Sustainability and reducing environmental impact will continue to be a top priority. This is fertile ground for gas turbines that can burn excess wellhead gas as fuel and provide usable energy to the region. ■



Matthew Wilhoit
VP, Unconventional
Oil & Gas, Siemens

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Universal provides unsurpassed pressure pumping, cementing, acidizing and reservoir enhancement services to the oil and gas industries. From planning to execution, Universal Pressure Pumping coordinates state-of-the-art pressure-pumping equipment, and highly trained crews so you can get better production from every stage.



Universal Pressure Pumping, Inc., in partnership with Cummins, Inc., designed a dual fuel, diesel and natural gas, injection system implemented in early 2013.

patenergy.com/universal

SETTING THE PRESSURE PUMPING STANDARD



Teams of engineers and geologists monitor Matador Resources Co.'s six-rig drilling program in the northern Delaware Basin 24 hours per day. *Photo courtesy Matador Resources Co.*

Well discovery. Sub-optimal recovery rates and rapid depletion followed the industry through Pennsylvania, Ohio, Illinois and Oklahoma prior to 1920. The oil industry was sustained at the time only by the next big discovery.

That changed in West Texas. Noteworthy discoveries, such as Hendricks (1926), Yates (1926), Cowden (1933), Wasson (1936) and Levelland/Slaughter (1936), generated oil in such prolific volumes that science and engineering—technology—were essential for reservoir management. When flush discoveries spiraled towards depletion, engineers conceived of the waterfloods that sustained Permian Basin production from the 1930s through the 1960s at a time when the U.S. dominated the global petroleum industry.

As much oil was produced during the “era of the engineer” as had been found in the original discoveries. When waterfloods faded in effectiveness, engineers developed in the Permian the globe’s first large-scale project for carbon dioxide miscible flood, or tertiary recovery.

This combination of human intellect and practical mechanical skills has taken something hidden, opaque and buried and made it abundantly and economically available, not just in West Texas, but within the greater U.S. and now, thanks to hydrocarbon exports, across the globe.

Today’s digital oil patch

No one in oil and gas objects to reminiscence, and their recollections show just how far technology has come.

“When we started, rig hands were throwing the chains on 1,000 horsepower rigs,” Joe Foran, founder, chairman and CEO of Matador Resources Co., told a meeting of the Independent Petroleum Association of America in August 2019. “You don’t have that anymore. Those guys sit in a seat with joysticks

and it is very different. We started out with the old cone bit and now you have PDC bits. Instead of five days to get through the chert, we’re doing it in five hours. It’s a tremendous reduction in cost and the rate of penetration gets better every year.”

Foran has seen firsthand the changes that have come to the industry. The Dallas, Texas-based company he founded in 2003 was running six rigs in southeast New Mexico in the Delaware Basin last fall. The company has expanded its Delaware holdings from 7,500 net acres in 2012 to 132,700 net acres in 2019 at an average cost of \$11,000 per acre. Despite larger inputs of sand, stages, and fluid, Matador’s cost per foot for well stimulation dropped 22%, to \$650 versus 2018, while rates of penetration have improved more than 105% since 2014.

Operators throughout the Permian have reported similar improvements.

So how does a smaller independent company compete in an age where capital for an aggressive unconventional drilling program has grown scarce and commodity prices falter at the threshold of profitability? At Matador, the transition to laterals longer than one mile (from 9% of wells in 2018 to 90% in 2020), increased pad development and the migration to using nearby in-basin sand supply allows the company to generate more production per dollar spent each year at the well site.

Foran witnessed the step-change about two years ago. During a remodel at corporate headquarters, Matador had prepared a new room for board meetings. One afternoon, operations personnel suggested another use. The group wanted Foran to convert the room into an operations center—MAXCOM—where engineers and geologists could monitor rig performance.

“You have engineers and geologists in there 24/7 that, in real time, are looking over all the wells that are drilling so that in the middle of the night, no



Matador Resources Co. CEO Joe Foran recalls the improvements in drilling practices over the last 25 years. Matador has adapted many to improve the economics of oil and gas extraction. *Photo courtesy Matador Resources Co.*

FREEMYER INDUSTRIAL PRESSURE LP; POSITIONED FOR CONTINUED GROWTH

With a team of over 150 years of oil and gas experience, Freemyer keeps pace with the industry's developing oilfield needs.

How does a 20-year-old equipment manufacturer survive the many up and down cycles of the oil and gas industry year after year? And do it at a profit?

Len Freemyer, CEO of Freemyer Industrial Pressure LP, credits four crucial actions: strong customer relationships, an experienced problem-solving management team, international diversification and always looking for opportunities that others may not see.

Freemyer formed Freemyer Company Inc. in 1988 and, through organic growth and the acquisition of three competing companies, grew it into five divisions. By the end of 1999, he successfully sold three of these, reorganized and established Freemyer Industrial Pressure LP (FIP) in early 2000.

FIP initially purchased used oilfield equipment throughout South America, refurbished it and then sold it to oilfield companies around the world. Freemyer quickly realized that FIP would maintain a strong global presence. "Having a diverse customer base that includes international companies is one of the reasons our company remains strong regardless of the various business cycles presented by the oil busi-

ness," said Freemyer. Today FIP does business in nearly 30 countries including Canada, Mexico, Brazil, the U.K., Russia, China, India and Indonesia, accounting for 30% of the company's revenue.

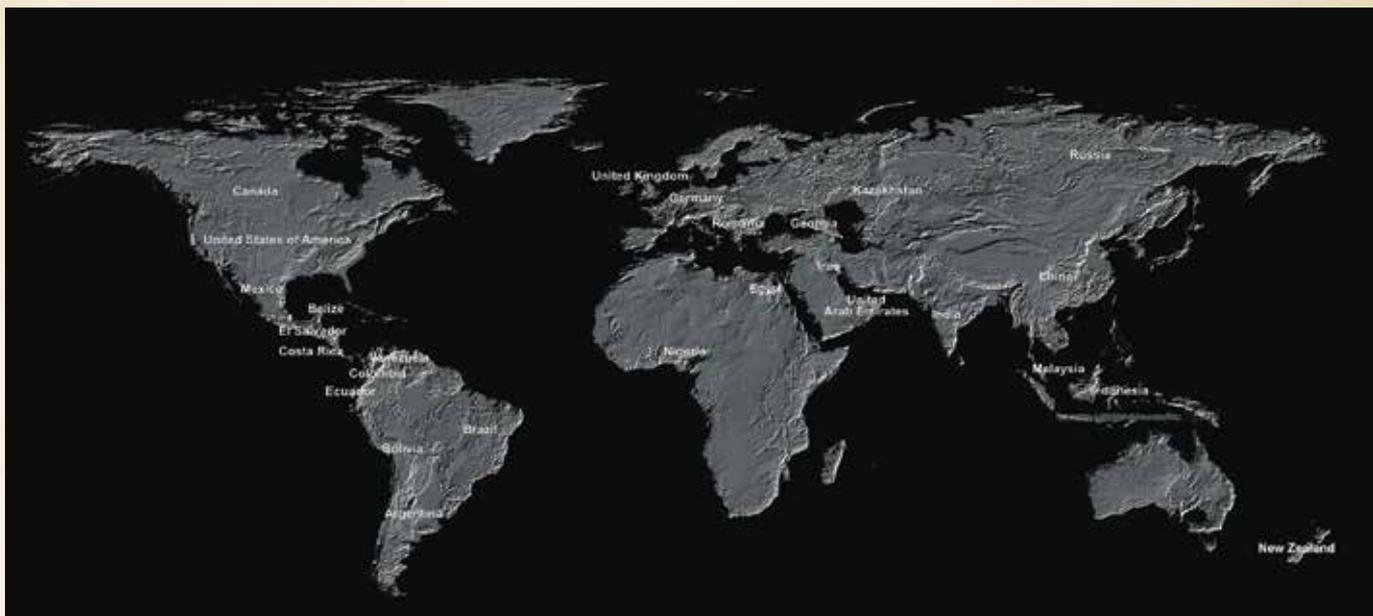
In 2011, the shale revolution was growing exponentially across the United States. Independents were exploiting the various basins, and Freemyer grabbed the opportunity to help his customers grow and save costs. Today, 70% of the company's business comes from the U.S., with 50% from the Permian Basin. Freemyer and his employees are proud to contribute their part to U.S. energy independence.

FIP's management team has over 150 years of combined experience in the oil and gas industry. With 60 employees, a history of no layoffs, and a CEO that believes in always improving his company's efficiency and product line, FIP has remained stable even when competitors are struggling. "Because of my team's diverse skills and experience and our focus on customer service after the sale, we call on each other for unique customer solutions. Also, it's a matter of pride that we've never lowered salaries. It's this philosophy that has made employees loyal and my company profitable for 20 years."



"We see today's market environment as an opportunity to build a better, stronger, more diverse international company."

—Len Freemyer,
CEO, Freemyer Industrial Pressure LP



FIP manufactures, maintains, rents and sells modern equipment for well stimulation, pumps for fracking and cementing, and fire suppression. It holds several patents on the technology. But even though he is proud of this technical success, Freemyer says that customer relationships are more important than money. “Never stop learning and improving to stay at the front of the pack,” he said. “The work never ends when it comes to improving equipment and helping our customers to succeed.”

Freemyer, along with his team, has a long history in the oil and gas industry. “The biggest change I’ve seen over my career is the way they drill wells and the huge amount of pay zone they can frack,” Freemyer said. “Today E&Ps frack 24/7 and it’s like a city out there with the amount of equipment they use and the size—it takes a lot of planning. They can be on one well pad for months at a time. We plan with them.” This is where Freemyer sees continued opportunities for his company to grow. Part of its success in today’s environment is FIP’s top priority in ensuring that its equipment performs above customers’ expectations.

Back in the day when fracturing a well, crews often used animal fat and lease crude to carry the sand or proppant and companies were more exposed to the risk of fire. Today, the manner in which companies stimulate their wells is very advanced. It is this continuous advancement of technology that drives the leadership team at FIP.

“We are all committed to staying abreast of the next generation of technology so our customers can count on our equipment doing what it needs to do, quickly and efficiently,” said Freemyer. FIP not only has an award-winning cementing system; it has also built some of the most sophisticated automated control

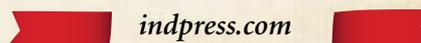
systems seen on the market. Recently, the company introduced a Virtual Reality training system for its cementing equipment.

Freemyer can’t stop building the business. He recently purchased an 18-acre property near the Fort Worth city limits, in Bridgeport, Texas, and has moved a new fabrication facility to the location. This investment secures his company a solid foundation to meet the equipment needs of the oil and gas industry today and in the future.

Freemyer and his team know that a sale is just the beginning of a partnership. “It’s one of the values that kept us afloat,” he said. “We hunkered down, never lowered a salary and our employees stayed. We were able to meet the needs of our customers, as we have always done.” The experienced team provides employee training as well as handling service, maintenance, restoration and refurbishing on all equipment, and it will retrofit its systems on other companies’ equipment.

Meanwhile, he said the company is focused on the opportunities this market provides for growth. Assets are still being drilled, and equipment is still being leased and bought. With the hard-earned wisdom learned over the years by the CEO and management team, Freemyer Industrial Pressure is here to help make it profitable for everyone. ■

Freemyer’s business operations span countries across the world.



one has to wake up the geologist, who has to call somebody else,” he said. “You can make real-time decisions instead of waiting three or four hours, and you drill another 300 or 400 feet and that helps you stay in zone.”

The new Permian oil patch is a combination of digital sensors on super-spec rigs, modern high-speed satellite communications, and geographically diverse computer networks that connect the rig floor in the dusty Delaware Basin to an air-conditioned operations center in Dallas. When coupled with 3D seismic, companies like Matador gain confidence that the horizontal wellbore on a \$6 million horizontal well, 475 miles away and a mile or more beneath the subsurface, stays in a preferred landing zone of 10 to 20 feet and taps the

very best rock for increased rates of penetration and greater permeability.

“With these high-tech rigs you can run bigger pipe, which helps on your fracking,” Foran says. “It’s not very glamorous, but it is one of those things that is keeping our head above water in making better wells for less money, and drilling them faster.”

Matador set 54 new drilling records with the advent of MAXCOM, coupled with improvements in geo-steering. Its integrated approach to full field development in the Permian also includes San Mateo Midstream, a subsidiary which combines gas gathering and processing, water gathering and disposal, and oil gathering and transportation in a vertically integrated, capital efficient business model.

Pinnacle Reefs

Larry Oldham and his wife, Sandy, started Parallel Petroleum Corp. in Midland in 1980 and soon took the company public. During the 1980s, Parallel worked the standard exploration model of detailed surface research, packaging drilling prospects for investment, and generating vertical wells. The results varied. In 1985, for example, Parallel drilled 16 prospects. Of these, 14 were dry holes.

But serendipity came with a step-level change in technology that prompted increased activity during the 1990s that spread across the Permian Basin. In 1993, working off traditional subsurface information on an east-west seismic line near the Pennsylvanian-aged Horseshoe Atoll, Parallel drilled a Fusselman discovery in Howard County northwest of Big Spring called the Big Bad Wolf No. 1. The company then drilled a due-south offset called the McNew No. 1 looking for the Fusselman, but instead hit a pinnacle reef, a tall but relatively aerially isolated carbonate platform. In September 1994, Parallel stepped out to the southwest and hit a second pinnacle reef pay in the Noret Jones No. 1 well.

Parallel had been hunting for Fusselman targets, a Silurian-aged shallow water carbonate that lay beneath the Devonian-Era Woodford Shale. Sometimes Fusselman wells featured a karst-like cave, generating substantial production. In Parallel’s case, the penetration of pinnacle reefs was adjacent to, and in alignment with, the Horseshoe Atoll Reef Trend near Snyder, Texas. The trend, discovered in 1948, was highlighted by the Kelly-Snyder Field, which is the third-largest conventional oil field in the Permian Basin. Within two years, oil and gas operators had drilled 2,500 wells in the Snyder area, the last great boom for conventional resources in the Permian.

The Horseshoe Atoll arcs for 175 miles across the northern Midland Basin, from northeast of Snyder into Terry County, Texas, southwest of Lubbock. The name derives from the shape of the reef complex. Carbonate platforms contributed significantly to historical Permian



Larry Oldham
Founder
Parallel Petroleum Corp.

Basin oil production, generating more than 16 billion barrels of oil to date with the majority of fields associated with the San Andres and Grayburg formations along the Central Basin Platform.

To understand the serendipity of Parallel’s discoveries, previous operators had drilled two neighboring wells in 1953 and 1964 adjacent to Parallel’s future discoveries. Both were drilled between two pinnacle reefs. Both were dry holes.

Fortunately, these submarine reefs became electronically visible thanks to 3D seismic, which provided exponentially greater sub-surface data. Initially, it was used to determine porosity and reservoir conditions in the Austin Chalk carbonate, but by the early 1990s, it had come to West Texas, where it was first tested on existing pinnacle reef discoveries. Those initial projects also pinpointed two potential undrilled reefs, hinting

at a potential regional oil play.

Oldham heard about the technology and approached seismic contractor Dawson Geophysical Co., which had organized as a Midland-based geophysics firm in 1952. Parallel engaged Dawson to design and shoot a postage stamp 3D survey over the Big Bad Wolf No. 1 well and McNew No. 1 well. The survey revealed a pinnacle reef to the southwest, which was drilled with the Noret Jones well.

The resurgence in Permian exploration

Parallel Petroleum now had a model for identifying pinnacle reefs. It engaged Dawson Geophysical to design and shoot a large 3D survey and Dr. Peter Duncan and Doug Nester of 3DX Technology to interpret the data. Parallel acquired 960 lease-acres in Howard County and, in total, invested \$3.3 million in seismic, drilling and completion costs, ultimately netting \$9.45 million from a project that identified eight additional reef prospects.

The McNew No. 1 initially produced more than 1,500 bbl/d and eventually settled in at 300 bbl/d. It was produced wide open until

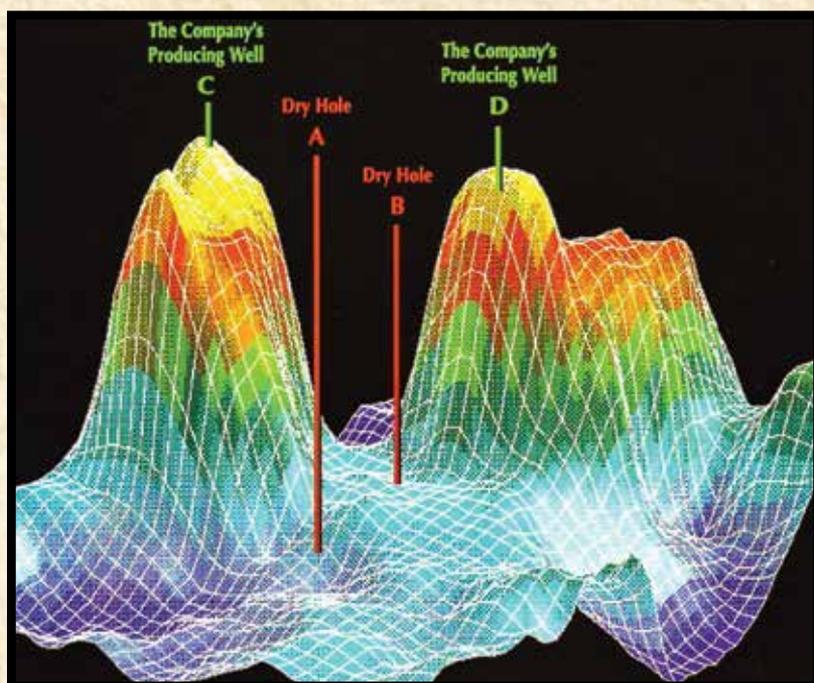
And Matador is not alone. Operations centers are found among a majority of operators, both big and small, active in the Permian. For example, Occidental Petroleum Corp., the largest oil producer in the Permian, cites a 147% improvement in 180-day cumulative oil production from 2015 to 2018 due to a combination of 4D fracture modeling, seismic, and an emphasis on local geologic characteristics. It is all about doing more with less. Cumulative oil production on Occidental wells exceeded 160,000 barrels on average in the first 90 days, a 22% increase year-over-year and a 220% increase over the last four years.

The lights of Loving County

Four hundred and fifty miles west of Dallas, the sun

drops toward the mountainous silhouette on the horizon another 85 miles west of Mentone, county seat of the least populated county in Texas. The southern terminus of the darkening ridge features Guadalupe Peak, which, at 8,750 feet, is the highest point in Texas and serves as the focal point for a review of technology in Permian Basin oil and gas.

Along State Highway 302, a persistent parade of trucks laden with sand, drill pipe, produced water, casing, and industrial equipment rolls up east into the spreading darkness, or is visible in the rearview mirror heading west toward the Pecos River valley. This sparsely settled corner of West Texas now sees a commercial traffic intensity than can approach 1,000 vehicles per hour. In some areas, waits exceed 45 minutes at rural four-way stops.



3D Seismic revolutionized exploration in the early 1990s. This image shows Parallel Petroleum Corp.'s landmark pinnacle reef discoveries. Source: Parallel Petroleum LLC

water showed in the production profile. This was a valuable lesson. Water encroachment was an issue in carbonates, so Parallel placed subsequent wells near the top of each structure and choked back production to roughly 70 bbl/d to maintain balance in the GOR and prevent an uneven drop in bottomhole pressure and water encroachment. The company drilled vertical wells to the top of a reef, ran casing, and cemented it in place. The wells were then deepened into the reef and completed open hole.

"We kept the results of the Noret Jones well pretty tight as best we could," Oldham recalled. "And then, we shot a large 3D survey south and southwest of that area. We drilled five pinnacles and we were five for five. I mean, it worked."

Parallel's pinnacle reef efforts prompted a resurgence in Permian

exploration during the 1990s with the industry using 3D seismic to identify anomalies.

"Everybody went crazy shooting 3D and looking for pinnacle reefs," Oldham said, "What happened was we all realized there were not that many pinnacle reefs and you had to really be lucky to have any oil column in those reefs—and really lucky to make any money."

Ultimately, Parallel was successful on eight of 10 pinnacle reef producers, targeting anomalies that were roughly 80 acres in extent.

Tim Parker, now EVP for operations for Houston-based Encino Resources, which focuses on Ohio's Utica play, was a young explorationist in Midland in 1984, working for Santa Fe Energy Resources Corp. The company enjoyed stable cash flow from drilling San Andres conventional targets, but also drilled Bone Spring vertical wells in southeastern New Mexico.

In 1991, Santa Fe acquired Midland independent Adobe Resources Corp. and substantial free cash flow along with Spraberry Trend acreage.

"We took a different approach," Parker recalls. "We shot a very large 3D seismic survey over much of Martin County. It was a technological marvel," he recalls. "The top of the Devonian features many different subcrops depending on where you are in the basin. Along that surface were some incredibly economic individual wells and, in some cases, a few larger fields. There was a big effort to go find those smaller bumps. Our logic was that 2D seismic hadn't found all of them. We were able to put together, with a couple operators, a 200-square mile survey, one of the largest seismic surveys in the world at that point."

Parker said the project produced one impressive finding. "The incredible population of geoscientists who had worked on the Permian Basin from the 1920s through the 1950s had done an incredible job of finding a lot of what was available. We found a few things, but we didn't find anything near the magnitude that we thought might be there." ■

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Microseismic Comes Of Age

Call it flat. Call it featureless. The landscape near the western border of Texas and New Mexico allows an unobstructed view of the horizon 25 miles in any direction.

Few ever think to look down. But that's where the scenery gets interesting. Roughly 5,000 feet below the surface the San Andres and Grayburg formations line the western edge of the Central Basin Platform. Today, technology enables oil and gas operators to see and understand how to squeeze additional oil and gas from one of the more intensively drilled areas on Earth.

Microseismic well monitoring allows companies to monitor the hydraulic fracture process and see the seismic events that illustrate the impacts of fracture stimulation.

The main benefit is that the theoretical model of fracking, which postulates a perpendicular set of isolated wings around the well bore, is in reality a fractal event where fractures follow their own geophysics underground. It has become apparent that the seismic events captured via microseismic illustrated the geographic progression of induced fractures but did not indicate where proppant was placed.

In 2018, Midland-based Element Petroleum completed a horizontal San Andres well on a Cochran County, Texas, parcel the company planned to sell. What made this well different from the hundreds of others in the region was integration of microseismic monitoring to build a reservoir model that could be adjusted in real-time, while completing adjacent lateral wells to extract bypassed oil and gas.

Normally petroleum engineers develop a field on arbitrarily derived concepts of well spacing in a statistical model. The industry has since learned that this contributes to well interference, a vexatious problem for modern oil and gas. Well interference cannibalizes reserves rather than expanding their recovery.

In the intervening years after the Barnett Shale ran its course, Houston-based MicroSeismic Inc. recast the microseismic concept to determine where proppant was placed, which led to the company developing proprietary reservoir modeling that ties permeability of stimulated rock, stimulation inputs, and matrix contributions to generate accurate projections of reservoir drainage volume.

Replicating the findings from the first fracture-stimulated well across a larger acreage package allows E&Ps to craft the right stimulation recipe on the fly and to define the proper number of wells per drilling unit to maximize economic production.

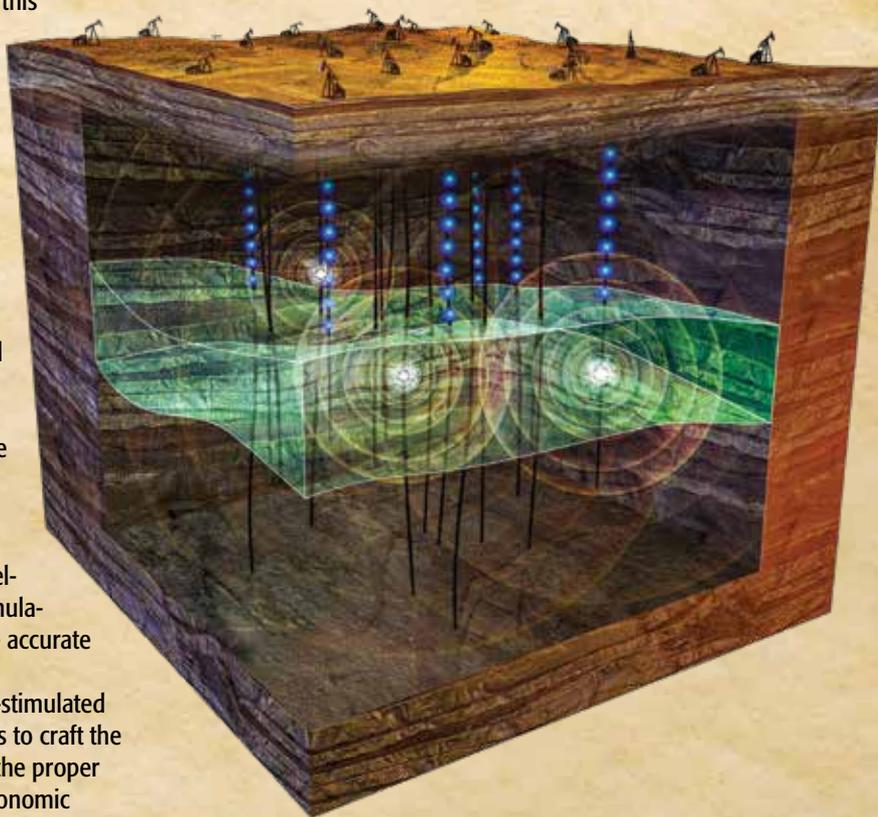
Element's original model called for four wells per section.

"When we modeled to have six wells per section, indeed they saw an uplift in production of almost 50%, which makes sense," MicroSeismic Inc. CEO Dr. Peter Duncan told attendees at Hart Energy's Well Interference Forum in San Antonio in September 2019. "But that's not where you stop. You have to do the economics to see whether drilling those extra wells is going to pay for itself."

For example, Element found a 28% uplift in net present value (NPV) by adding the two additional wells.

"We tried an eight-well scenario," Duncan said. "It was a bust. Element would get another 20% increase in reserves but a negative NPV. Moving from six to eight wells didn't produce enough hydrocarbons to pay for themselves," Duncan told attendees.

"You're doing a real-time lab experiment in what really happens in your rocks with the way you pump. If you can interpret that correctly, you can then say: 'Now, assuming that rock is the same 500 feet away, this is how I should be pumping the well,'" Duncan said. "If you monitor the next well in real time and you see it changing, then you can turn the knob and cook it just right." ■



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A growing footprint in the Permian Basin allows TETRA Technologies to address producers' varied fluids and water management needs.

The oil and gas industry can live without many things, but water isn't among them. It's no secret the natural resource plays an indispensable role in well fracking, production and refining. And when it comes to completion fluids and water management in the Permian Basin, TETRA Technologies has a reputation for providing superior service.

"In terms of the economics, the dramatic increase in unconventional shale development means operators are now confronted with higher water management costs and more environmental and operational risks than ever before," said Brady Murphy, TETRA's CEO and president. "The challenges are sourcing freshwater, incurring higher volumes of produced water, and sand flow back. Scaling up services to meet these challenges and trucking produced water from the well fracturing site to another site for disposal further compounds the cost and exposure to risk.

"We address these challenges with our closed-loop automation services to provide our customers with the lowest cost-per-barrel water management solution. Using this solution controlled by our BlueLinx™ automated control system, we can fully integrate and automate every step in the process, from water transfer to de-sanding, treatment and recycling, blending, storage and distribution."

Market hold

Since launching in 1981, TETRA has grown into a geographically-diversified company that specializ-

es in completion fluids and aqueous chemistry to a leading provider in numerous oil and gas service categories, including water management, well testing, completion fluids, early production facilities and services and compression-based production enhancement. The Texas-based company operates in 13 countries.

But the Permian Basin is where the company reaps some of its greatest rewards. After all, it is home to 45% of the country's drilling and completion activity, and customers observe the lowest breakeven prices there.

TETRA has made financial investments in the Permian to support client operations and help them lower their cost per barrel of water.

It strengthened its footprint in the area in March 2018 when it acquired SwiftWater Energy Services, a leading provider of water management services. This strategic acquisition helped TETRA expand its service capabilities, which include water transfer, treatment, produced water recycling, pipeline and polypipe construction, pit lining, and containment services.

"The additional services capabilities acquired through SwiftWater allowed us to develop a fully integrated water management solution for our clients," Murphy said. "A closed-loop water management system provides greater efficiency and control over blending and fluid quality because it lends itself to more seamless integration and computer-controlled automation."



"We address these challenges with our closed-loop automation services to provide our customers with the lowest cost-per-barrel water management solution."

—Brady Murphy,
CEO & President, TETRA Technologies

All is well

TETRA also offers production testing services, including surface well testing to identify and establish a reservoir’s potential. Using surface well testing equipment and solids management systems, it also provides the necessary components to remove abrasive solids from the well effluent, thus protecting production assets while allowing the recovered hydrocarbons to be further processed.

When a well goes into production, TETRA manages the volume of water and sand that returns to the surface. Its sand separators are designed to capture all solid particles that flow through its system.

TETRA is the only oilfield service provider that manufactures its own calcium chloride and heavy brines, which ensures consistent quality and security of supply for customers. Calcium-based fluids minimize formation damage caused by solid invasion and shale dispersion.

“We use dry salt weighing material to increase the density of a single salt fluid that has been diluted, or if additional hydrostatic pressure is needed to control a well,” Murphy said. “When our client’s data suggests that extraordinary conditions may exist in a well or producing zone or in the operating environment, we will specially formulate a completion fluid to address individual formation properties that help maximize well productivity and/or address environmental concerns.”

On challenges

Increased industry activity in and around the Permian presents numerous logistical challenges. It is difficult to transport high volumes of fresh water to job sites, move produced water from job sites to disposal sites, and coordinate the phases of transportation in a timely and consistently reliable fashion. Increased truck traffic can also increase operational costs while increasing the potential for safety incidents.

TETRA has answers for these challenges.

“Much of the solution is to recycle more of the produced water ‘on-the-fly’ to reduce the volumes of fresh water needed for an optimal frack fluid, integrate the steps of the water management process for more efficiency, and automate these steps for greater control and better allocation of personnel,” Murphy said.

“Our closed-loop water management solution addresses these needs. Automated water recycling systems can process different types of produced water on the fly, with blending and treatment technologies that eliminate bacteria, sulfides and other suspended solids, and ensure a consistently high-quality frack fluid throughout completion operations.”

Industry outlook

TETRA is optimistic regarding future growth potential in the Permian, which is no surprise given it’s the



world’s largest oil production basin. Additionally, the year-over-year decline in well drilling and completion activity in the Permian is lower than most other U.S. shale plays. Some other basins have suffered activity declines of more than 40%, but the Permian was currently down just 14% year-over-year.

“It all speaks to a communal faith in the region,” said Murphy.

“The higher level of investment in the Permian Basin historically is a testament to the quality of the reservoirs and existing infrastructure to support oil and gas development.”

Oil production isn’t the only thing that’s going strong in the Permian. Wells produce up to 10 barrels of water for each barrel of oil, meaning the volume of produced water is enough to support future fracking projects. It’s a better alternative to fresh water, which is better suited for municipal and agricultural uses.

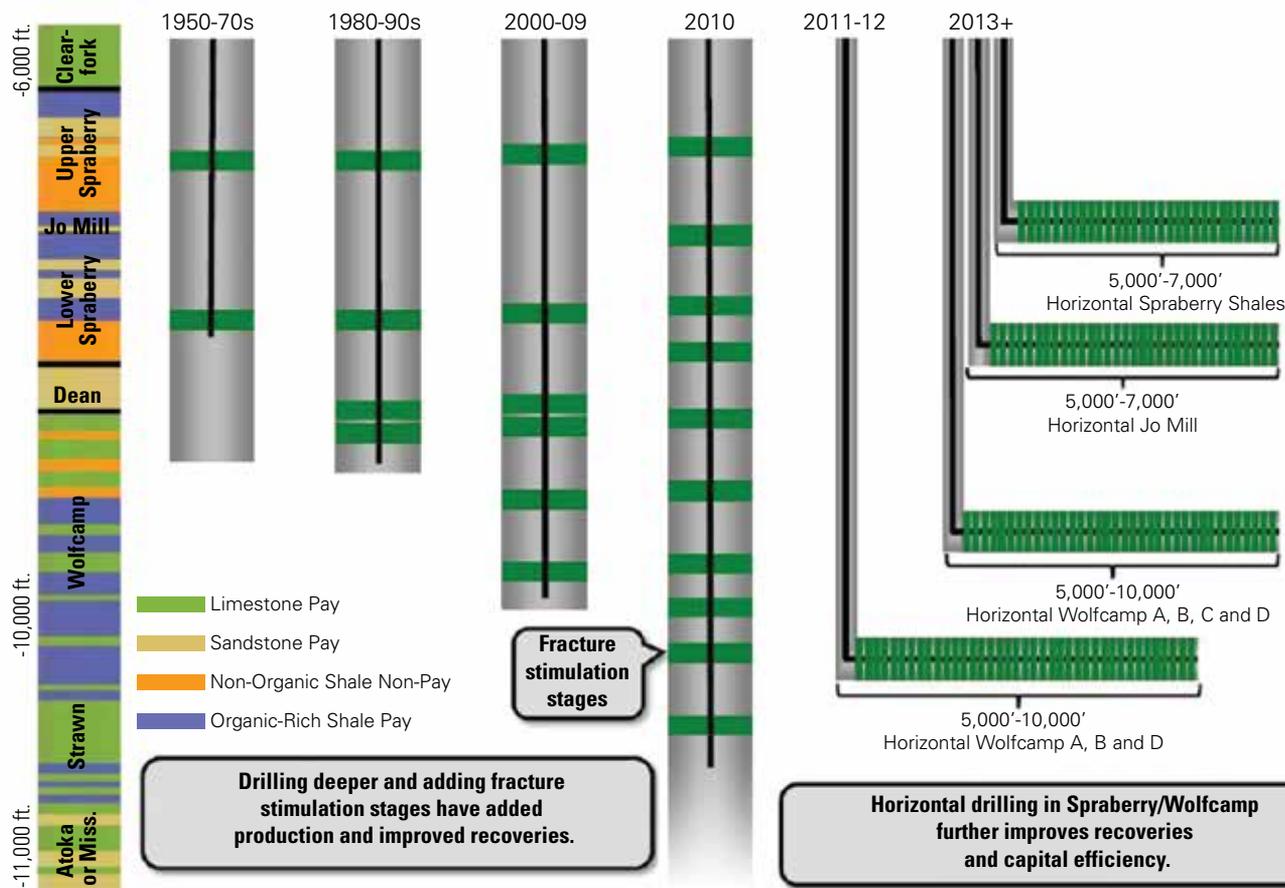
Said Murphy: “Our closed-loop water management capability through our BlueLink automated control system further improves the economics of produced water reuse, while proving transparency in moving, storing, treating, blending and distributing water to the frack site.” ■

TETRA’s facilities provide critical water services to Permian operators.



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HOW TECHNOLOGY EVOLVED



This schematic shows the evolution of the tight formation play in the Midland Basin, from early developments to the later integration of multistage fracking and horizontal drilling, what became true unconventional activity. Source: Pioneer Natural Resources Co.

Five miles west of Mentone, the road turns north on US. Highway 285 to crossroads at Orla, once a handful of decaying wood buildings marking a previous oil boom but now a major industrial intersection featuring water disposal sites, a perennially busy convenience store and various food truck choices. The New Mexico state line is not far ahead. This is the heart of the Delaware Basin oil play.

As dusk deepens, the landscape on either side of the highway sprouts isolated towers of light as far as the eye can see. Those lights mark the drilling rigs, well stimulation spreads and the ever-present gas flares above production sites so numerous as to be visible from space.

On either side of the New Mexico state line, a competitive consortia of public independents, majors and privately-held independents are drilling

the Wolfcamp Shale and, in New Mexico, the overlying Bone Spring Formation.

E&Ps drilled 2,300 such wells in 2018, according to FracFocus.org, with tens of thousands more on the drawing board over the next decade. An identical story is underway in the Midland Basin 140 miles to the east, where E&Ps completed 2,400 horizontal wells in 2018.

The reserve of undrilled Wolfcamp wells promises 35 billion barrels of technically recoverable oil, according to the U.S. Geological Survey, more new oil than the Permian Basin has produced in its first 100 years, giving hope to regional leadership that this time—they will finally get this Permian Basin boom right.

Technology assists operators to get more done with fewer resources. Today's Permian wellbores are drilled from multi-well pads using super-spec

1958

The first well in history to go below 25,000 ft. was in the Permian: Phillip's Petroleum Co.'s University EE No. 1, drilled near Fort Stockton, in Pecos County, Texas.

1960

The Organization of Petroleum Exporting countries (OPEC) was founded in Vienna with five charter members: Iran, Iraq, Kuwait, Saudi Arabia and Venezuela.

1961

The Permian Basin Petroleum Association (PBPA) was founded with fewer than 20 members. Now it represents the interests of over 1,000 petroleum companies in West Texas and New Mexico in regulatory matters.

1964

T. Boone Pickens, the soon-to-become legendary Texas oilman, renamed his company Mesa Petroleum and led it in an IPO, starting the official legacy of a company that would become famous for his aggressive acquisition strategy.



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The Horizontal San Andres

CO₂ EOR technology was instrumental in the San Andres revival on the Northwest Shelf and the Central Basin Platform in the 21st century after operators sought new oil in deeper intervals below existing fields. Operators targeted residual oil zones (ROZ), or oil left behind after natural water flooding by mother nature, basically in the same fashion tertiary CO₂ EOR follows the engineer's water floods. In 2014, there were 15 projects across eight fields (18 projects in 2019) targeting the ROZ in the Permian San Andres.

Estimates of original oil in place for the previously undeveloped transitional zone (TZ) plus the ROZ, or the mixed zone below the oil/water contacts identified 30.7 billion barrels in 56 fields, or as much oil as had been produced in the Permian Basin over the previous century. Of that, 11.9 billion barrels were identified as technically recoverable. With the exception of ten Pennsylvanian-aged fields in the Horseshoe Atoll, ROZ targets in the Permian Basin, including Texas and New Mexico, were associated with the Guadalupian-aged San Andres and Grayburg formations.

Large miscible CO₂ projects include Chevron Corp. at the Vacuum San Andres Grayburg Unit in Lea County, New Mexico; Hess Corp. with three projects in the Seminole ROZ in Gaines County, Texas; and Occidental Petroleum Corp. in the Wasson Field in Yoakum and Gaines counties as well as the Levelland/Slaughter fields in Cochran and Hockley counties.

The intersection of CO₂ EOR and ROZ illustrates once again how technology renews a 100-year old oil play through new insights. Texans who have stood atop Guadalupe Peak understand all water flows away from the prominence. One ROZ theory incorporates the general tilt of geology away from the western uplift and the slow downslope flow of fossilized meteoric water passing in geologic time across 80 miles of subterranean porous Permian-era reefs to the Texas and New Mexico border. From here, the water arcs east and south along the western edge of the Midland Basin creating the natural waterflood sweeps that partially filled the original (paleo) San Andres and Grayburg oil reservoirs.

The ROZ concept illuminated a mystery. Major oil companies working on the Central Basin Platform frequently encountered thick hydrocarbon shows while extending wellbores down through the oil-water contact in the 1990s. Conceptually, this fell within the transitional zone model. However, transition zones around the globe range from a few inches to 50 feet in thickness. The Permian Basin was an anomaly. Hydrocarbon thicknesses below the oil and water contact extended 300 or 400 feet. Companies such as Hess Corp., which originated the Residual Oil Zone terminology, Shell and Mobil sought explanations for the anomaly even as each employed CO₂ injection pilots to harvest the oil economically.

The conceptual breakthrough dates to a 2001 West Texas Geological Society presentation that outlined Permian Basin subsurface tectonics. The study examined tilted oil/water contacts in unitized fields along the Central Basin Platform. Later, two oil companies cooperated with Midland consultant Steve Melzer to develop a model for the concept, including an assessment of residual oil economics.

In 2006, the work gained financial support from the U.S. Department of Energy and the Research Partnership to Secure Energy for America (RPSEA). The release of the last report in 2015 was timed in conjunction with a ground-breaking horizontal San Andres well on the Northwest Shelf in Yoakum County, Texas.

The well, drilled by Roswell-based Manzano Energy Partners II, added yet another twist. The company was adapting shale play technology to a carbonate environment. For the first month after completion, the well generated 2000 barrels of water per day. It requires patience, faith and luck to withstand the mounting expense. On the 31st day, the first oil cut showed and soon grew to 250 bbl/d, leading to a horizontal San Andres play where Manzano had previously drilled 10 uneconomic vertical wells beginning in 2013 to test an area 45 miles by 30 miles west of the Brahaney San Andres Field mostly in Yoakum County. The Brahaney Field produced 5.5 million barrels of oil after discovery in 1954 and another 10.6 million barrels of oil following waterflood in 1965. Manzano and Walsh Petroleum began developing outside the Brahaney Field using a new, high water cut manner with horizontal wells in what is now the Platang Field.

As it happened, Manzano's management had visited with an Oklahoma operator involved in a similar project who mentioned it was necessary at times to drain significant volumes of water and reduce formation pressures from the reservoir before the oil cut appeared. Manzano subsequently landed 34 laterals in the high permeability Brahaney C zone of the San Andres through 2016, reporting EURs of 329,000 barrels of oil on a one-mile length lateral and 483,000 barrels of oil on a 1.5 mile lateral.

"Since then, operators have drilled 600 wells," Steve Melzer, principal of Midland-based Melzer Consulting, said. "The industry put together a whole new play based on the TZ/ROZ concept." Out of whole cloth, that new play was generating 40,000 bbl/d from the Permian ROZ areas with another 20,000 bbl/d from CO₂ EOR in ROZ intervals below existing fields in 2018.

Momentum increased in the horizontal San Andres during 2016 after Frisco, Texas-based Steward Energy II acquired Manzano Petroleum II in a \$225 million transaction. Steward completed 45 wells in the Horizontal San Andres between 2014 and 2017 to lead all 13 operators in the play. They are followed by privately held and private equity-backed Walsh Petroleum, operator for the Brahaney Field, and Riley Exploration-Permian LLC. While Anadarko Petroleum Corp. and Apache Corp. drilled tests, the horizontal San Andres has remained a province for innovative smaller independents.

Why the draw for independents? Steward Energy in a corporate presentation, cited the nature of the play and lingering concerns over commodity price instability and the cost structure of participating in unconventional (shale) plays. Company management views the Horizontal San Andres as economic in a \$40 per barrel environment through the application of unconventional developmental techniques in a "conventional" oil field. This "conventional" reservoir attribute may serve as new opportunity for follow-on CO₂ EOR in the expanse of horizontal ROZ development. ■



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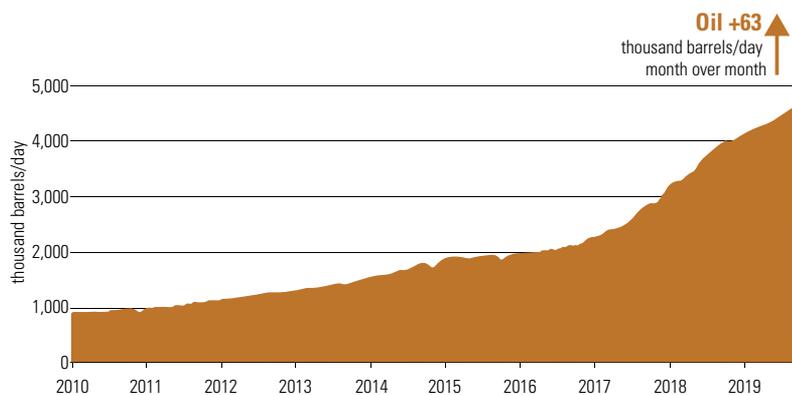
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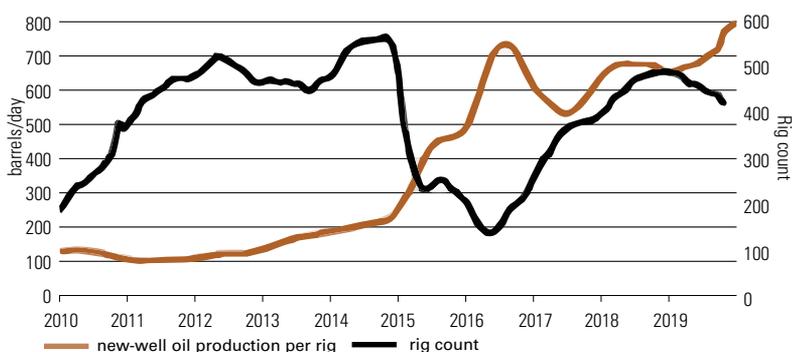
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PERMIAN REGION OIL PRODUCTION



PERMIAN REGION NEW-WELL OIL PRODUCTION PER RIG



The advent of horizontal drilling and multistage fracture stimulation has quadrupled Permian Basin oil production (top). Greater efficiencies in the field involving drillers and pressure pumpers have kept new oil production per rig at high levels despite gradually declining rig counts. *Source: U.S. Energy Information Administration*

rigs, many featuring self-mobilizing walking packages that enable the rig to move nimbly around an industrial well site.

Where once it took a week to move and rig up on a new well, these walking rigs spud new wells in half a day after rig release, reducing non-productive idle time and improving capital efficiency. The 1,500 horsepower rigs feature 750,000 pounds of hoist, 7,500 psi mud systems that use three supersized pumps to circulate fluids on horizontal laterals that exceed 10,000 feet and total measured depth beyond 20,000 feet. The rigs ferry 25,000 feet of fully racked drill pipe well to well on the pad. They are fully mobile, multimillion-dollar portable industrial systems working in a remote environment.

Top drives and 90-foot pipe stands have eliminated the old Kelly table for rotating drill string—invariably 5-inch pipe these days—for stouter downhole access.

Drill days, or the time from spud to wellbore termination, have dropped inordinately. It once took nearly a month to drill a vertical well in the Spra-

berry. Today’s 7,500 foot horizontal wells now reach rig release in less than two weeks.

Technology also extends to the rig floor. Industrial-level “iron roughnecks” have replaced the hazardous spinning chain. Drillers operate highly automated rigs with digital controls and monitoring stations from air-conditioned cabins offering expansive views of the rig floor.

The human intuitive interface of the driller and the rig, seasoned by a decade or more experience on a rig floor, has given way to a stream of digital data transferred from the rig in real time to monitoring operations centers, further reducing unexpected nonproductive time and providing instant access to seasoned engineers in the event an issue develops at the well site.

Below the rig, sophisticated software, now operated remotely, guides the bottomhole assembly through a narrow window in the very best rock, creating faster, more productive wellbores featuring less tortuosity and lateral undulations.

There are more than 160 such units operating in the Delaware Basin, and a similar number in the Midland Basin. More than 380 rigs were drilling horizontally in the Permian Basin in the third-quarter 2019, down from a peak above 400 in 2018, but still above the oil and gas industry’s most recent peak in 2014 when oil prices exceeded \$100 per barrel.

The fact is the industry generates more wells and converts more reserves while employing less than half the rigs active five years ago. In 2012, 20% of rigs were drilling horizontal wells in the Permian Basin. By 2016, that share grew to more than 85% of rigs on a higher rig count.

Yet none of the technology matters unless it serves a purpose. Permian oil and gas remains a people business after one hundred years. The one thing that hasn’t changed is the significance of the crew. While oil and gas creates wealth in stunning volumes, and oil and gas supply with global implications, nothing happens until the individuals on the rig crew, from the motorman to the derrickman, to the roustabout and to the driller, show up at the well site for work.

Rig technology impresses

The first rotary rig arrived in the Permian Basin in 1935. That rig, the J.T. McElroy No. 103, used rotary bits and a rotating Kelly table to create a well bore by churning through the earth. The technology was far more efficient than the hammer dropping cable tool unit that chipped its way downhole a few inches at a time. Where the cable tool rig characterized oil and gas, including the Permian Basin, from the 19th century into the 1930s, the nascent mechanical rotary rig and the use of fluids to circulate cuttings

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and create well control in the drilling process increased efficiency exponentially—shortening well bore creation from months to weeks—and dominated Permian Basin drilling activity for the balance of the 20th century.

After 1935, the new mechanical rigs produced a sea-change of opportunity providing the industry the ability to deepen vertical wells from the 5,000-foot limits of the cable tool era to 8,000 feet or more. Despite limitations for cable tool rigs, these units witnessed the exploitation of the Permian-aged shallow San Andres and Grayburg formations along the Central Basin Platform, which were responsible for the greatest conventional oilfield discoveries in Texas history. Cumulative production is measured in billions of barrels.

The new rotary rig and its mud-based well construction technique enabled operators to discover the deeper Spraberry Trend in the Midland Basin and, simultaneously, the Pennsylvanian-aged Horseshoe Atoll in Snyder as a second chapter of Permian discovery got underway following World War II.

The progression of drilling technology in the 21st century has led to AC-VFD units capable of drilling multiple horizontal laterals from a single pad and creating the wellbores to harvest substantial quantities of new oil and gas after the shale revolution arrived in the Permian in 2012.

Permian Basin oil production rose from a low of 690,000 barrels of oil per day (bbl/d) in 2008 to 4.5 million bbl/d in 2019. More is on the way.

These new rigs use many continuous improvements in downhole tools and motors, including PDC bits that can bore thousands of feet before requiring a change. Geosteering systems and software-operated directional drilling lands the wellbore in the proper window for lateral placement. Many operate as dual-fuel rigs that can offset expensive diesel consumption by using natural gas from the field itself.

The ever-expanding pad sites create the demand that draws the long line of trucks and commercial traffic throughout the Permian. That demand governs traffic along U.S. Interstate 20 as well.

Conventional oil: technology sustains production

Finding oil was one thing; getting it out of the ground

was another. Even the best conventional fields recovered less than 20% of the oil in place. Oil flowed at first under natural pressures until depletion impacted the producing mechanism in the reservoir. Engineers saw opportunity to extend recovery in the great Permian Basin San Andres reservoirs.

The first efforts involved pressure maintenance, typically through reinjecting natural gas into solution gas-drive reservoirs. This began soon after the initial discovery. Next, engineers turned to secondary recovery initiatives. Their first efforts involved waterfloods, or injecting water to sweep oil towards an extraction point. Waterfloods were underway in the Permian Basin as early as the 1930s, reaching peak use in conventional Permian oil fields after World War II. These projects, some quite large, were undertaken by bigger companies with sizeable engineering staffs.

“Waterfloods were a huge development in the ’50s and ’60s,” said Steve Melzer, principal for Midland-based Melzer Consulting. “It involved a heck of a lot of manpower to unitize fields and put together units for flooding.”

New waterflood starts in the Permian peaked at 100 projects in 1966 before declining in volume to 20 new starts in 1980. The San Andres and Grayburg formations were the primary targets. These formations represent 30% of Permian Basin waterfloods through 1980 and produced 44% of the new oil.

Primary recovery of 18% of the original oil in place during primary production grew to 40% via secondary recovery efforts within two decades. Waterfloods were applied in both shelf and basinal reservoirs. Examples include the Wasson San Andres Field where waterflooding began in the 1960s. Primary recovery in the Denver City, Texas, unit was 16% of original oil in place, but waterflooding recovered an additional 22% of original oil in place. Later the field was put on CO₂ injection. By 2000, the Wasson San Andres had produced 1.85 billion barrels of oil out of the 4 billion of original oil in place—and 2 billion barrels of oil by 2017.

The advent of tertiary recovery

Meanwhile, discussions continued over how to extend recovery further. Of several theoretical technologies in the 1960s, the most desirable to emerge

1967

A federal team detonated Gasbuggy, a 29-kiloton nuclear device, in northern N.M. as part of an experiment to develop a nuclear-powered fracking method. Radiation contamination discontinued the effort.

1968

Waterflooding was started in the Yates Field as part of Marathon Oil Co.'s enhanced recovery program in the Permian. The use of this technology increased pressure in the field and allowed for greater oil recovery.

1972

The Guadalupe Mountains National Park in Texas was established with 76,293 acres.

1973

When Arab nations suspended exports to the U.S. and other nations that supported Israel during the Yom Kippur War, the U.S. experienced a severe gasoline price increase and shortage. The price of oil nearly quadrupled.



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Holli Ladhani
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Select Energy Services

“We continue to be energized by the rate of innovation we see in the industry. As the Permian continues to mature, there’s a paradigm shift occurring that’s driving the industry to recycle more and more water. As volumes continue to increase, produced water management is a significant opportunity for companies like Select that are up to the

task, and an area in which we’re growing, as evidenced by our most recent acquisition of a water treatment business from Baker Hughes.

“The scale of operations in the Permian in particular is changing the way we do business. Jobs utilizing produced water can be complex, often requiring multiple water sources of varying quality. Offering solutions to automate processes for frack water logistics is really driving efficiency and improving safety on location.”

was a carbon dioxide (CO₂) miscible flood. The process injects compressed, nearly pure CO₂ into reservoirs, which fills pore spaces and displaces bypassed oil. A water slug subsequently assisted the CO₂ to spread out in the reservoir and flush newly released oil to an extraction well.

The first large-scale CO₂ enhanced oil recovery project (EOR) started in January 1972 at Snyder, Texas. By happenstance, the multi-year effort predated the rise in petroleum prices following the first Arab Oil Embargo in 1973. The pilot sought 230 million barrels of oil via the injection of 630 billion cubic feet of CO₂ over a nine-year period at a turn-key cost of \$175 million.

Tertiary recovery became the next crucial step in reservoir conservation. The project operator, the Snyder Area Canyon Reef Operating Committee (SACROC), oversaw a field 35-miles long and 5-miles wide that had been the scene of more than 2,000 wells within two years of the 1948 Horseshoe Atoll discovery. Widespread and rapid drilling resulted in steep pressure declines in the field.

To avoid sub-optimal recovery and stranded reserves, operators unitized the field into a single operating unit and installed a centerline water injection program in 1954 down the spine of the Pennsylvanian-Aged Canyon Reef, which capped the eastern sweet spot of the play.

Operators identified a CO₂ source 200 miles south in the Val Verde Basin. SACROC created a

pipeline subsidiary to build a 180-mile high pressure pipeline to McCamey, Texas, using specialized pipe to handle high pressure transmission in a first-of-its-kind project. A second line carried the CO₂ to Snyder, where compressors delivered 220,000 Mcf of CO₂ at 2,400 psi for injection into the reef. Water from nearby Lake Thomas was used to sweep the newly generated oil towards an extraction point.

The Texas Railroad Commission incentivized this effort by effectively eliminating restrictions on the field’s allowable production to be made effective the first day of CO₂ pipeline construction. The Railroad Commission also allowed SACROC unit wells to increase the one-day per month pumping allowable to 30 days monthly to finance the effort.

“The Railroad Commission provided a huge incentive for operators to unitize and develop a strategy for keeping pressures up in the reservoir, because what the Railroad Commission saw was that production caused pressures to drop below the bubble point and, of course, this was going to strand a lot of oil in the reservoir,” Melzer said. “That wouldn’t be good for operators and it wouldn’t be good for the state.”

For various reasons, the pilot failed to achieve early expectations but was expanded field-wide in the mid-1970s coupled with tighter 20-acre infill drilling. This time it worked. New sources of CO₂ were developed in Colorado and New Mexico. By the early 1980s, the Permian Basin led the nation in new CO₂ EOR projects as tertiary recovery evolved. Another surge in CO₂ EOR occurred in the mid-1990s with further maturation of the tertiary recovery technology.

The scale is significant. During a period of declining production, hydrocarbon harvest in the Permian Basin using CO₂ grew from less than 10 million barrels of oil in 1987, or 27,000 bbl/d, to 60 million barrels, or 164,000 bbl/d, by 2012. The Permian was self-sufficient in CO₂ production through 2004 even as CO₂ demand rose above 1.5 Bcf/d on the basis of miscible floods below the oil/water contact in the newly identified Residual Oil Zones (ROZ) near the New Mexico state line.

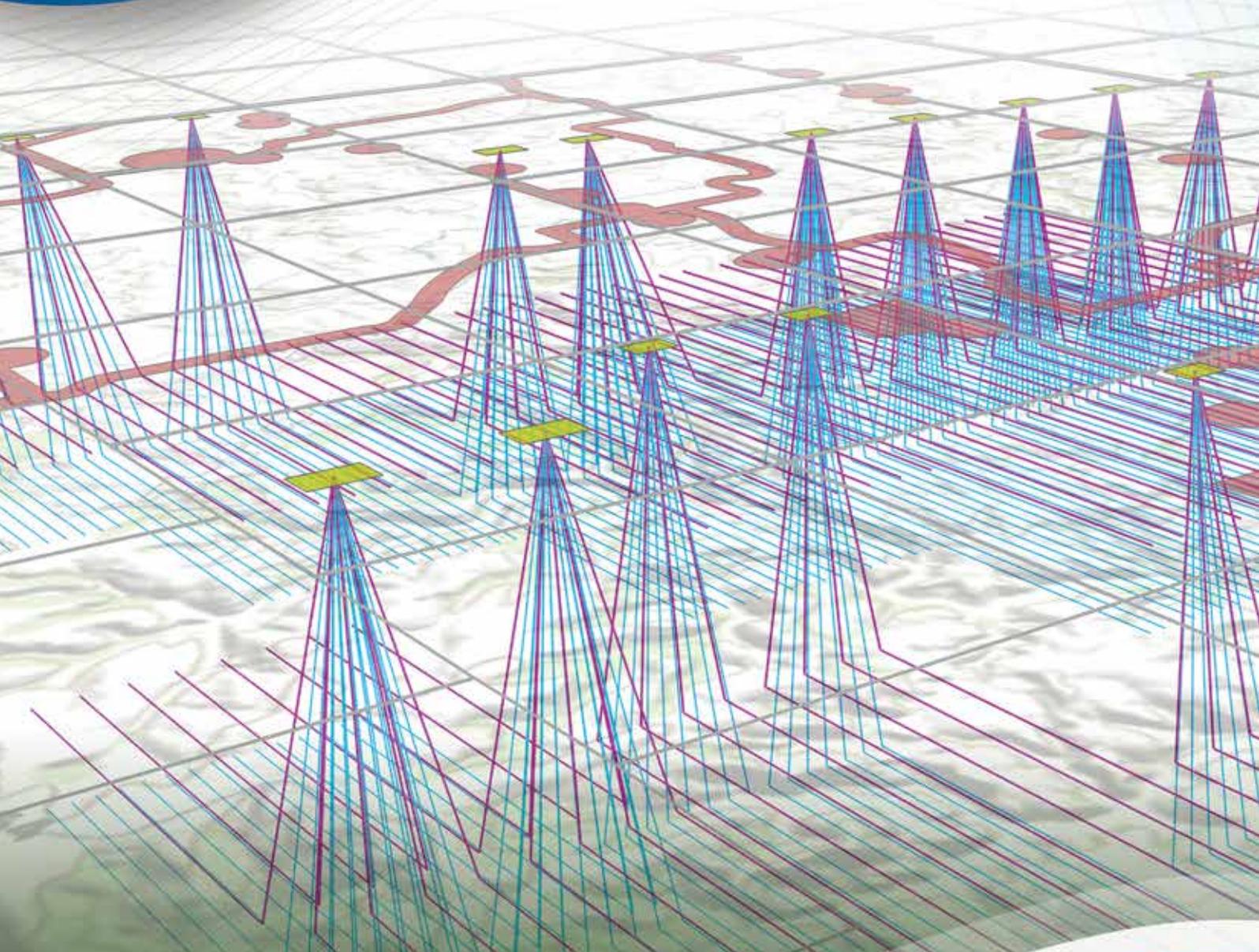
At Snyder, tertiary recovery produced 215,000 bbl/d at peak in March 1974. By 2013, SACROC had injected 4.9 Tcf of CO₂ into the reservoir and recovered for recycling 2.99 Tcf, along with 1.36 billion barrels of cumulative oil, essentially doubling the reservoir’s yield.

Houston-based Kinder Morgan Inc. purchased the SACROC unit in 2000. The company expanded the project, applying horizontal drilling for injection. Production grew from 10,000 bbl/d in 2000 to 30,000 bbl/d by 2004. It remains near 29,000



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U.S. WELL SERVICES INNOVATES FRACK FLEETS

Hydraulic fracturing revitalized Permian Basin production, and new developments of the technology are taking it to the next level.

Operators in the Permian Basin grew used to seeing diesel-powered frack fleets and diesel tankers traveling up and down its roads from pad to pad. Drilling and completion technology has advanced dramatically since the Permian boom started: testing the limits by drilling longer horizontals, increasing the number of wells per pad, pumping more sand into the formation, perfecting the zipper frack, and developing chemical packages to advance the production, just to name a few.

Until recently, equipment used to complete the hydraulic fracturing process had essentially gone unchanged. Higher pressures and more barrels per minute required more horsepower, but it was mainly done with the conventional diesel-powered engines.

“As we begin the next 100 years of development in the Permian Basin, U.S. Well Services looks to continue the evolution of the hydraulic fracturing industry.”

Enter U.S. Well Services (USWS) to the hydraulic fracturing industry. Founded in 2012, USWS began operations in the Marcellus and Utica shale plays in West Virginia. The startup company aimed to become the leader in a crowded hydraulic fracturing sector dominated by big companies, so it patented an idea that was ahead of its time: a fully electric frack fleet.

In July 2014, USWS deployed its first Clean Fleet in the mountains of West Virginia for Antero Resources. Utilizing field gas to fuel the turbine generators and supply power to the first of its kind electric frack fleet, USWS successfully completed its first stage using the multi-patented technology. Fast forward to 2019;

USWS has completed more than 10,000 stages with its all-electric frack fleets.

The milestone 10,000th stage was done in the Permian Basin for a major E&P.

USWS continues to be a pioneer of the electric frack revolution. A pump truck from the latest generation Clean Fleet debuted at Hart Energy's Executive Oil Conference in Midland in November 2019. The redesigned electric pump truck will be part of a fleet heading to the Permian Basin in the first quarter of 2020 for Shell.

The most noticeable difference of the current Clean Fleet, when compared to the earlier generation, is that it is 23% shorter. The design and advancement of technology in this next generation testifies to USWS' leadership in the electric frack space. Having utilized the technology for over five years, and completing over 10,000 stages in multiple basins and formations, USWS continues to use its knowledge and infield experience to further advance each new-build electric fleet in an effort to be the best and most reliable in the industry.

Efficiencies gained over recent years have led to more pumping hours and completion of more stages per day. Even with the increased lateral lengths and multiple wells per pad, the increase in efficiencies has resulted in more frequent pad moves. USWS patented and deployed its Power Path technology that provides high voltage, 13,800V electrical power to pads up to three miles away. USWS proudly implemented this patented remote fracturing process first in the Permian Basin. Power Path allows the 30mW turbine generator to deploy to a central location and then only need to move the frack equipment from pad to pad. This micro-grid also eliminates the need for each pad to have existing field gas pipelined to it before wells are stimulated.

By using a high voltage electrical system, the power generated by the turbine is capable of being sent multiple miles without power losses that come from low- and medium voltage systems.

USWS implemented a predictive maintenance program called FracMD in 2014 in an effort to reduce



U.S. Well Services has several patents for its fully electric frack fleet. It also provides high-voltage power to drill pads and prevents downtime.

non-productive time (NPT) and increase the number of safe stages-per-day by mitigating premature failures of equipment and maximizing operating parameters.

Sensors on the frack equipment collect real-time data that is used to determine when repairs are needed. Over the years, USWS has accumulated billions of data points and built a best-in-class maintenance program. By listening to what the equipment is doing, USWS is able to increase reliability, safety and predictability, all of which reduces downtime. The real-time data collected also helps determine root causes of failure, enabling the company to improve on current methods.

As the Permian continues to advance with efficiencies, better technology and equipment are vital for pressure pumpers to eliminate non-productive time. USWS developed an Advanced Iron Management program to analyze data in an effort to improve the iron packages and decrease vibrations, to minimize NPT caused by iron failures. In 2018, the company began utilizing a large-bore iron package on its fleets. The 7" monoline iron package from the missile to the wellhead decreases rig-in times by over 15% and reduces the number of hammer union connections by 50%, which leads to fewer opportunities for hand injuries and fluid leaks.

As of October 2019, over 18,000 stages and 8.5 billion pounds of sand have been pumped through the large-bore packages with no exceptions during operations and zero failures during OEM inspections. Our Advanced Iron Management program continues

to work with vendors to develop the most fit-for-purpose iron packages to withstand the rates and pressures and minimize unnecessary NPT time caused by iron failures.

As we begin the next 100 years of development in the Permian Basin, U.S. Well Services looks to continue the evolution of the hydraulic fracturing industry. Transitioning away from diesel to natural gas-powered electric frack fleets is the next frontier for the industry. More environmentally friendly completion practices are a growing need across all basins and a topic of discussion from local municipalities to the federal government. Other fracturing fleets on the market today mask noise by enclosing the deck engine or using a gas blending method with diesel and natural gas in an effort to reduce emissions. These fleets, though an upgrade from traditional diesel fleets, are not the long-term solution, but a temporary fix.

Electrically powered frack fleets decrease noise and emissions to levels that conventional diesel or blended fuel fleets are not able to achieve. ■



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Alastair McClean
President & CEO
Enventure Global Technology Inc.

“**E**nventure is very active in the Permian Basin with more than 200 solid expandable installations in recent years. Permian Basin operations teams are located all over the United States, and we currently service these accounts from our corporate headquarters in Houston.

“The Permian Basin continues to be a high focus area for Enventure. Over

the past few years, trends in drilling, completion and recompletion have seen the use of our technology in well construction, remediation and recompletion applications. The use of expandable technology is impacted by the rise and fall of the West Texas Intermediate (WTI). Low WTI typically results in an increase in recompletion and remediation whereas high WTI results in an increase in well construction applications. Even with high WTI, pricing pressure from operators remains a challenge.

“During the downturn from 2014 to 2016, rig count in U.S. land dropped 70% while our refrack liner installations increased 200 percent in the same time period. Now in 2019 with a decline in drilling activity, the opportunities for refracturing using mechanical isolation are increasing as operators look to increase production from older wells as a way of improving their balance sheet.

“We continually monitor the trends and rely on our solid relationships with our clients to adapt our business forecasts in the Permian Basin. The next step change for our business to set up for growth in the basin would be to increase local presence with sales, service and equipment.”

it into sustaining oil and gas production. Occidental rebranded its EOR business as a Lower Carbon business strategy in conjunction with the Anadarko acquisition. The program is designed to capture 500 kilotons of CO₂ directly from the atmosphere each year to increase recovery on EOR projects, while storing CO₂ underground.

Construction on Oxy’s West Texas plant will begin in 2021 with operations scheduled for 2023. The project is a joint venture with Canada’s Carbon Engineering, which claims it has developed a way to capture CO₂ from the atmosphere and convert it into clean fuels. Meanwhile, Occidental is using green technology to lower cost by implementing solar as a transitional step to reduce field electrical cost while supplying a pure stream of CO₂ for enhanced recovery.

Operators are also using tight formation techniques today to squeeze additional oil from the reservoir. Horizontal drilling has been successfully applied to produce oil not in communication with vertical wells in compartmentalized reservoirs and to produce oil that was unswept by previous waterfloods and CO₂ EOR in mature reservoirs.

Spraberry, Wolfberry, Wolfcamp

The first Spraberry well in 1942 was named for the Dawson County farmer who owned the land parcel. Little attention was given though, until Seaboard Oil Co. drilled a second Dawson County well in the Spraberry Deep Field in January 1949. Over the next two years, operators drilled 2,234 vertical wells in a play that expanded to incorporate 400,000 acres southeast of Midland near the Glasscock, Midland, Upton, and Reagan county intersections.

It was the largest oil field in the world in terms of geographic extent. At the beginning of 1952, more than 235 rotary rigs were drilling vertical wells, each taking 25 to 30 days. The Spraberry featured initial flush production out of a fractured reservoir, though output declined quickly. Recoveries were less than 10% of the original oil in place. This led to the wry Time magazine article in 1951 labeling the Spraberry as “the world’s largest uneconomic oil field.” Despite a reputation for stingy production, the Spraberry generated 45 million barrels of oil by 1953.

bbl/d today. SACROC was a significant evolutionary step that required multiple engineering disciplines including civil, mechanical, chemical, processing, petroleum and metallurgical.

By 2019, the Permian Basin was moving tertiary recovery forward in a world concerned with climate change. The merger between Anadarko Petroleum Corp. and Occidental Petroleum Corp. in 2019 created the largest producer of CO₂ EOR projects in the U.S.

The company injects 2.6 Bcf of CO₂ into Permian oil fields and is in the design phase of a pilot project to capture anthropogenic CO₂ and recycle

1973

With the encouragement and aid of oil philanthropists, The University of Texas of the Permian Basin (UTPB) was founded. It continues to grow thanks to the region’s oil industry prosperity.

1975

Pres. Gerald Ford visited Midland to dedicate the Permian Basin Petroleum Museum, Library and Hall of Fame. Some 400 guests attended.

1979

The Texas Legislature authorized commingled production from multiple reservoirs through the same wellbore.

1980

George P. Mitchell, founder of Mitchell Energy & Development Corp., successfully experimented with hydraulic fracturing techniques in the Barnett Shale. Often called the “Father of Fracking,” Mitchell was instrumental in preparing for the shale boom.

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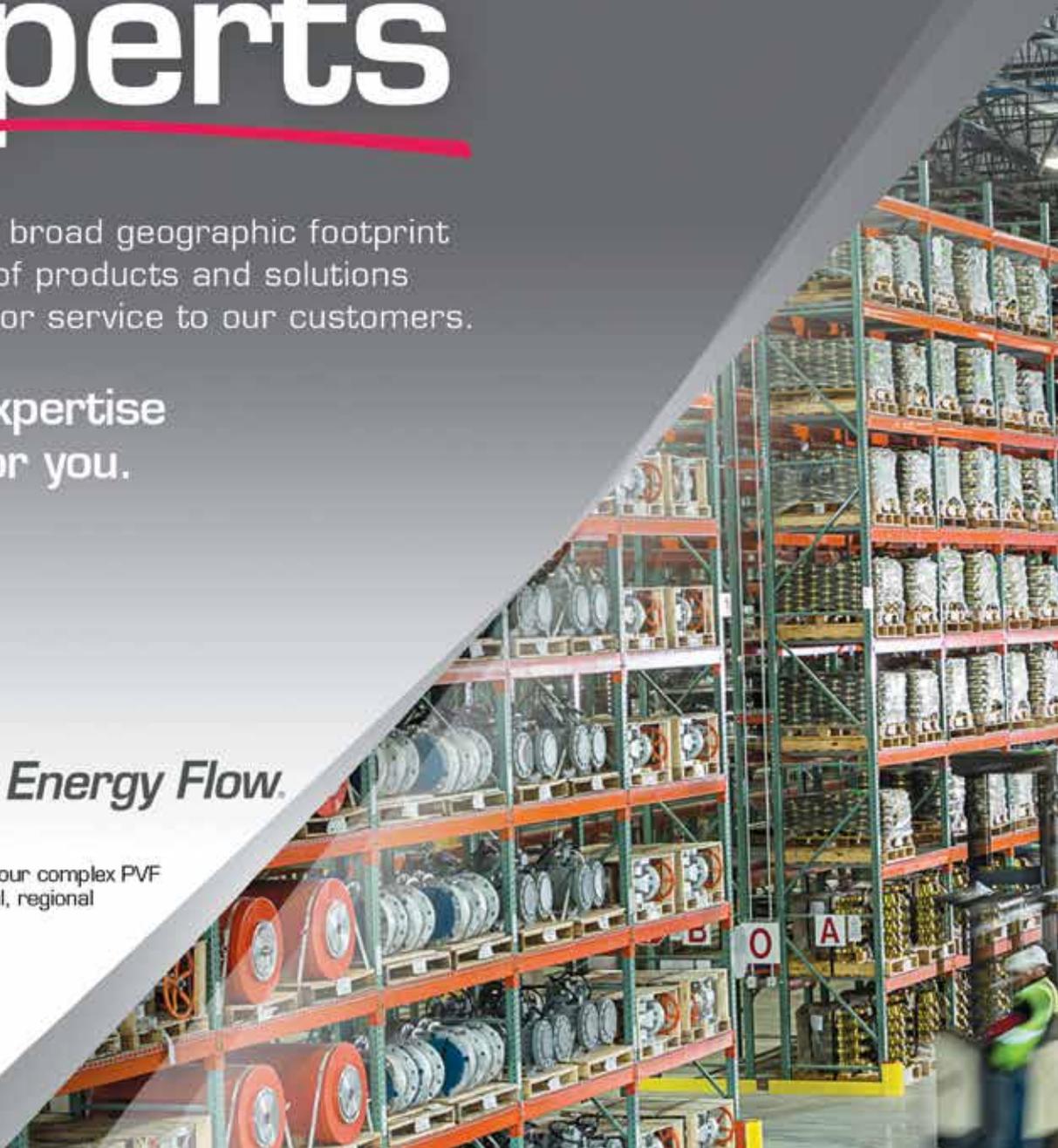
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The 2,000 HP SCAN Quest super-spec rig went to work for Concho Resources in southeast New Mexico. Since then, in continuous employment for Concho, it has drilled 18 wells and 538,842 feet, or just shy of 30,000 feet per well. The rig, with its modern technology, exemplifies northern Delaware Basin's super-spec rigs. *Photo by Richard Mason*

Quietly, persistently, the Spraberry worked its way into being the fifth largest producing field in Texas as the 20th century closed. Production over five decades exceeds 1.13 billion barrels of oil. But the Spraberry is also important because it presaged the stacked formation play that is the root of today's Permian renaissance. Operators exploited the Spraberry by fracture stimulating stacked formations.

In 1979 the Texas legislature authorized commingled production from multiple reservoirs through the same wellbore as a conservation measure. This became integral to Spraberry development and then, during the first decade of the 21st century, was a crucial component for the Wolfberry Play.

As the great San Andres and Greyburg conventional fields on the Central Basin Platform entered terminal decline, the Spraberry kept Texas production steady. In the 12-year period ending in 2005, the Spraberry, standing at the threshold of a future tight formation play, produced 15 million barrels per year (41,000 bbl/d). By 2011, on the cusp of the horizontal drilling era, commingled production captured through the Wolfberry Play increased Spraberry numbers to 41 million barrels (112,000 bbl/d).

This compared to the four largest conventional plays in the Wasson, Yates, Levelland and Slaughter fields where aggregate production declined from 200,000 bbl/d in 1997 to 115,000 bbl/d in 2011.

Spraberry well completions were technologically intensive. Even before the advent of horizontal drilling, fracturing them was necessary. Fracture stimulation in the late 1940s involved shooting nitroglycerin torpedoes. Later, operators adapted a safer technology—hydraulic fracturing—which pumped a gelatinous mix of soap and kerosene under pressure into a well bore to stimulate the reservoir.

One important Spraberry characteristic is its role as a resource play, subject to the scale benefits of a manufacturing model. Between 1950 and 1990, operators drilled 27,114 vertical Spraberry wells. Meanwhile, larger oil companies initiated Spraberry waterfloods post-1950, though these experienced limited success because of the tight formation. The collapse in oil prices in 1986 prompted larger companies to divest Permian acreage, opening a path for homegrown independents to take the lead in shaping the region's destiny.

'Pretty simple stuff'

New Mexico native Danny Kellum graduated from Texas Tech University in Lubbock with a degree in





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petroleum engineering in the late 1970s and went to work for Mobil Corp. Mobil wanted to transfer him to the reservoir engineering department in Houston, but Kellum didn't want to leave West Texas, so he was hired on as the 8th employee of Parker and Parsley, a Midland-based independent that was formed in 1962. It packaged wells into limited partnerships to finance a continuous drilling program. In 1981 when Kellum signed on, Parker and Parsley had 100 Spraberry wells.

As the company's first operations engineer, Kellum oversaw vertical drilling that targeted the Spraberry and Dean formations. Later, the company added Upper Spraberry as a target after the play went to 80-acre spacing.

"It was pretty simple stuff," Kellum said. "These were 9,000-foot vertical wells with three stage frack jobs. You could get a frack job done in a day. We were drilling those wells in about 12 to 14 days."

Two things happened. First, Parker and Parsley began deepening wells into the Upper Wolfcamp. Second, the company began consolidating the play.

"The majors gave up on it," Kellum said. "That's what put Parker and Parsley, and the early Pioneer on the map. (Pioneer Natural Resources Co. was created through the merger of Parker and Parsley and Boone Pickens' Mesa Petroleum in 2000). We went through a lot of acquisitions and mergers in the Spraberry, buying out smaller companies. But one of the biggest acquisitions that put us on the map was when we acquired the big Spraberry waterflood units from Mobil Oil [now ExxonMobil]."

Exxon's Midkiff unit demonstrates the value small independents brought to the Spraberry. At the time Exxon sold to Parker and Parsley, the package had 20 producing wells making 150 barrels a day.

"We started developing on 80-acre spacing with the vertical Spraberry Dean wells and within a two-year period we took production up to about 6,500 barrels a day," Kellum said. Parker and Parsley holdings eventually extended to 900,000 acres, including sweet spot acreage in the deepest portion of the Midland Basin.

The Spraberry Trend evolved into a multi-layered field that encompassed the Spraberry and unofficially included the Wolfcamp, Strawn and lower Pennsylvanian-aged targets. By the 1990s, vertical

wells in the Spraberry were reaching 11,000 feet and incorporating 10 stages of fracture stimulation.

"At one time we had 40 drilling rigs, and we would drill 800 wells a year," Kellum said. "We were doing as many as 25 frack jobs a week. Well, I'll tell you how crazy it was. On any given day, we would have 250 trucks hauling frack sand from Brady out to West Texas."

'We knew we had something huge'

Conceptually, the Wolfberry—a combination of Wolfcamp and Spraberry production—demonstrated the potential in the region's tight formations. The model consists of a layer cake productive column more than 1,300 feet thick with commingled production from multiple layers. Midland-based Henry Petroleum assembled acreage along the western edge of the Midland Basin where a series of slump blocks basinward from the Central Basin Platform provide greater porosity and permeability. Henry and his partner, Bob Landenberger, started their own company in 1969, picked up a job from Skelly Oil in the Spraberry and eventually became Spraberry specialists who developed a steady clientele of investors.

"The Spraberry is a sandstone, very, very tight, interbedded with shales," CEO Jim Henry explained in a 2015 Hart Energy video. "It was only productive when you learned how to frack wells. When I drilled my first well in December 1971, it was in the Spraberry. We frack in three different zones, maybe the upper Spraberry, the lower Spraberry, and the Dean. Even in those days, 1971, we did a multi-stage frack."

In 2000, ARCO (the Atlantic Richfield Co.) started a Spraberry program. After 300 wells with mixed results, the company began experimenting by drilling first into the underlying Wolfcamp and later all the way through the Wolfcamp. ARCO adapted the slickwater frack developed by George Mitchell in the Barnett Shale, the first of the great unconventional shale plays. When BP acquired ARCO in 2000, Henry Petroleum obtained a farmout for 14 wells in Upton County. As it wound through the inventory, Henry moved locations closer to the shelf edge of the Midland Basin and drilled a well in the Sweetie Peck Field using Mitchell's frack technique. The well was completed

1980

The Wink Sink 1, a large sinkhole in the Permian, formed as the probable result of water injections at the nearby Hendrick No. 10-A well. It measured 110m across and 34m deep before it collapsed.

1981

Pres. Reagan deregulated the prices of crude oil, refined petroleum products and natural gas with the signing of Executive Order 12287. Production soared, a glut followed and prices collapsed.

1981

In December, Baker Hughes recorded 4,530 active rigs in the U.S., setting the current record for the highest active rig count.

1983

T. Boone Pickens targeted Gulf Oil in one of his most famous "corporate raids." The showdown saw Pickens assemble a sizeable stake in Gulf and agitate the board until Chevron acquired the company for \$13 billion.

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at 100 bbl/d. Henry next drilled the Beverly No. 1, which also came in 100 bbl/d.

“We moved 17 miles and knew we had something huge here. Two good wells. So we started developing around those wells using the new frack technique that ARCO had developed, which we tweaked,” Henry said. The company assembled 330,000 acres in the western part of the Midland Basin beginning in 2003 and eventually drilled more than 350 Wolfberry wells, with Chevron as a financial partner.

“We were one of the first to realize that George Mitchell’s new frack technique had application here and actually put money into it,” Henry said. Wolfberry wells provided a high water cut and rapid decline in oil, but they settled out to a steady production rate and turned out to be economic.

“In about 2005, after about two years, the industry started catching on that we weren’t just drilling the usual Spraberry wells like we had for the past 30 years,” Henry said.

By 2007, operators had drilled 2,000 vertical Wolfberry wells. These wells produced 80 to 100 boe/d with EURs of 120,000 to 150,000 boe. Concho Resources Inc. acquired Henry Petroleum for \$545 million in the summer of 2008. Within five years, Wolfberry-themed property transactions in the Permian reached \$13 billion in aggregate.

Step-level changes

Mobil Corp. drilled the first horizontal well targeting the Lower Spraberry and incorporated five fractured stages in 1988. It was intriguing science, though the future implications of the technology were not evident at the time.

In September 2010, Broad Oak Resources, Approach Resources Inc., EOG Resources Inc., and EP Energy were drilling horizontal Wolfcamp tests at the southern, gassier end of the Midland Basin. However, Pioneer Natural Resources Co., the corporate descendant of Parker and Parsley, jump-started the transition to the modern horizontal play.

“The first two horizontal wells we drilled were actually going to be water injection wells,” Danny Kellum said. “They were lower Spraberry in the sweet spot of the Jo Mill section. I think the laterals were only 600 or 800 feet. We fracked those two wells, and they came in at about 200 barrels a day. They were no longer water injection wells, they were oil wells. That is what caught everybody’s attention; that’s when we started really getting after horizontal drilling.”

In the lineage of tight formation history, vertical Spraberry begat vertical Wolfberry after 50 years, which accessed stacked formation targets via multi-stage fracture stimulation, which begat horizontal Wolfcamp Shale wells after 10 years and, after 2012,

spread across the unconventional shale play in the Midland and Delaware basins.

While the Barnett Shale demonstrated the efficacy of the horizontal slickwater technique for exploiting tight formation gas, the Permian Basin served as the laboratory for extending the technique to oil. Current technology incorporates a horizontal wellbore and multi-stage fracture stimulation typically in a multi-well pad configuration.

The commodity price decline in 2014 forced operators to explore capital-efficient field work. Operators found ways for the play to work economically, partially on the basis of an initial 70% decline in service costs, but also through growing efficiency via well site processes.

The sum of those efforts converged in the second half of 2018, as the Permian Basin witnessed a step-level change in fracture stimulation efficiency. Despite larger completions in terms of volume per stage in fluid and proppant, stage count per crew (a measure of efficiency) rose 35% after mid-2018, versus the average during the previous half decade as operators converted to pad-based development. They used zipper fracks, a completion method that alternates between stages on adjacent laterals. While designed to eliminate downtime for crews on the well site, zipper fracks provided an unexpected consequence: improved oil recovery.

Global players such as Halliburton and Schlumberger dominate the Permian market in terms of fleet numbers, but an ancillary cast now includes Basic Energy Services, Cudd Pressure Pumping, C&J Energy Services (now part of the Keane Group), Calfrac, Liberty Oilfield Services and Superior Energy Services. Local stimulation firms such as ProPetro also provide 50,000 units of hydraulic horsepower (HHP) per stimulation fleet, usually in 2,500 HHP pumping units, often capable of dual fuel use involving either diesel or field generated natural gas.

Operators now seek to reduce emissions at the well site and explore natural gas-powered, smaller footprint electric fracture stimulation fleets. It is worth noting that almost half of the prototypes of this new technology nationwide are employed in the Permian Basin.

Today, Permian operators stimulate up to 50 stages on horizontal laterals that extend 10,000 feet, pumping 18 to 20 million pounds of fine mesh sand, a majority sourced with 40/70 and 100 mesh proppant from the dune field stretching between Crane, Texas, and the New Mexico state line. Friction reducing chemicals assist the fine-grained proppant to the far end of the well bore in a plug and perforate completion methodology that stimulates rock nearest the wellbore. More than 180 stimu-

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Hunter Wallace
Chief Operating Officer
Atlas Sand Co. LLC

“The market has asked us as an industry to show a return in value for the billions of dollars we have been putting to work, and in my opinion, they are absolutely justified in doing so. The days of being allowed to spend an exorbitant amount of capital poking around trying to find the best shale basins and best areas within each of those shale basins is over.

“The best of the best has been found and vindicated/strengthened through two downturns—it is the Permian Basin.

“Now that there has been this shift in priority to produce cash flow, those operators

fortunate enough to have Permian acreage in their portfolios are actively high grading their capital spending towards its best in class economics.

“This increased focus on the Permian by operators, and the knowledge that there are decades upon decades of drilling left to do out there, has in turn driven an increased focus and capital spending from the service side of our industry as well. This has resulted in something of a snowball effect, where the already superior economics of the Permian are actually becoming even more remarkable! I believe this powerful trend will continue, and the Permian will only further its dominance as the premier economic basin in the world over time.”

lation crews work across the Permian Basin, 45% of the nation’s capacity.

The significance of horizontal drilling and multi-stage fracture stimulation is evident in the formation targets. The Wolfcamp Shale in the Midland and Delaware basins accounts for more than 50% of all horizontal wells. Adding Permian Leonard geology, or the Bone Spring in the Delaware Basin and Spraberry in the Midland Basin accounted for another 23% of horizontal wells. Basically, the Top 5 geological targets generated 85% of horizontal drilling, with Permian era formations representing the lion’s share of that total. And all of this unfolded in the last decade. Permian horizontal wells first moved above 1,000 per year in 2012 and peaked at 5,500 annually in 2018.



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Shale plays undergo a classic development arc from discovery to delineation to optimization to full-field development. The Midland Basin is the more advanced of the two major Permian tight formation plays. Full-field development involved experiments by Energen Corp. (later acquired by Diamondback Energy), Encana, and Concho Resources to attempt simultaneous well development across a square mile or more of acreage. Those programs incorporate up to three dozen wells accessing stacked formations and simultaneous fracking of multiple wells at one time. This effort can exceed \$180 million with nine or more months passing before first production is turned in line.

The results from the early full-field development programs suggest the pilots over-drilled the acreage. However, operators are addressing the well interference and resource cannibalization that occurs when laterals are placed too closely together. Interest was growing in 2019 in an earlier pilot project by QEP Resources Inc. That project used a pressure front on succeeding batteries of wells that are drilled simultaneously, idled, and completed simultaneously in waves across acreage, to prevent well interference. QEP Resources referred to the

effort as tank development.

It is one more example of the industry adapting technology a step at a time to overcome issues of sub-optimal harvest and economic inefficiency.

It took a variety of technologies to get where the Permian is today. It will take additional technologies to move the Permian forward as it faces the question of whether it is possible in a commodity-based economy to extend predictability to the boom and bust oil and gas business. As the industry moves into manufacturing mode, the question is whether the industry can maintain a sustainable level of development.

This issue ultimately touches schools, highways, community, safety and a host of ancillary issues. Economic history has not been kind to communities that took on public debt with a multi-decade payoff to expand infrastructure, only to have the oil and gas price turn the wrong way, prompting the industry to vanish. It was true of the gold and silver booms of the American West and, later, the cattle industry. But history is not always destiny. The region is banking on overcoming boom-bust cyclicity and creating a sustainable future for Permian oil production. 

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CHAPTER 6 | CAPITAL INVESTMENT

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DEALS THAT MADE THE PERMIAN

BY DARREN BARBEE,
HART ENERGY

Today's Permian Basin is filled with legendary operators, and a number of them came to be through historic mergers and acquisitions.

The Oct. 22, 1920, edition of the Breckenridge American newspaper gives a snapshot of pre-Depression Era Texas on the eve of great change in West Texas.

A proverbial loaf of bread cost 10 cents. Dr. Stephen E. Smith advertised his general surgery practice, which offered a cure for piles “without the knife.” Help wanted ads sought young ladies for work at Southwestern Bell Telephone Co.

In another advertisement, an oil company solicited investors, cajoling them not to miss an opportunity that “will last but a few days. Over half way down the hole.”

On an inside page, the paper ran a story about two wells that, improbably, had produced oil in Mitchell County, Texas. Geologists, the article said, had presumed that a drill would never be able to penetrate the oil sands in the county. They were estimated to be up to 4,500 feet thick in the “Permian formation.”

At the time, the Mitchell County oil discovery was like the breaking of the sound barrier. At a cost of roughly \$30,000—a time when the me-

dian price for a home in Dallas was \$5,550—oil was discovered.

As the Breckenridge newspaper put it, “if this theory [of no oil in West Texas] actually existed in the minds of the competent geologists, it has been thoroughly disproven.”

Where there is oil, deals are sure to follow.

Since the first oil discovery, hundreds of transactions have built up, torn down and rearranged the operator landscape. While the details of the earliest Permian deals are hard to piece together, or lost to history altogether, in the past century some of the largest transactions in the oil and gas industry have touched or been directly tied to the Permian.

The advent of shale and hydraulic fracturing only served to further whet the appetites of the oil and gas fraternity.

Roughly six decades later, in February 1984, Texaco Inc. announced what was then the largest corporate transaction in U.S. history, buying Getty Oil Co. from family members for \$10.1 billion (roughly \$25 billion in 2019 dollars). Getty itself had an office in Midland, Texas.

Though Texaco's interests were far-flung, it was Texaco (in 1920 called The Texas Co.) that leased mineral rights from plantation land owned by William H. Abrams, a railroad official, in Mitchell County.

In July 1920, a key Permian discovery well—the W.H. Abrams No. 1—violently ejected oil and gas from a 2,754-foot deep well. After refinement, in a little more than five months the well's 26,000 barrel per day production grossed \$5 million, according to a 1923 publication of the Oil Trade Journal.

Abrams reportedly purchased his land for about \$5 per acre. After the oil discovery, land values shot up like a Silicon Valley neighborhood. After the initial discovery, big companies purchased one-sixth royalty interests for \$2,500 to \$5,000 per acre, a November

DE ROODE AND LOCKTON HELPING COMPANIES BETTER MANAGE RISK IN THE PERMIAN

The leadership of Lockton Companies help ensure the safety and success of clients across the upstream, midstream and downstream sectors of the oil and gas industry.

In the constantly evolving oil and gas industry that is challenged by supply and demand cycles, economic pressures and constrained infrastructure, energy companies are seeking ways to better mitigate, manage and efficiently finance their risks. While energy companies continue to deal with traditional operating risks, they are also dealing with growing negative public sentiment as well as newer emerging risks such as cyber disruption and crime.

David de Roode, a partner and executive vice president with Lockton in Houston, works exclusively with privately-held and publicly-traded exploration and production companies; drilling, completion, production, intervention and abandonment service companies; midstream companies and 18 energy-focused private equity sponsors. Lockton's Energy practice represents over a thousand clients in the upstream, midstream and downstream sectors of the oil and gas industry and employs over 150 Energy specialists from its Houston office.

de Roode works with numerous companies that are headquartered or operating in the greater Permian

Basin and provides deep industry-focused, experiential knowledge and guidance to them around their unique operational, contractual, intellectual property, financial, IT, transactional, employee, cultural and regulatory risks, as well as the appropriate types and levels of insurance to finance those risks.

de Roode shared that one of the biggest risks facing companies operating in the Permian Basin today is transportation. "As an industry, we used to be most concerned about geological risk, mechanical risk, wellsite risk, pollution, etc. However, experienced employees are increasingly hard to find and recruit to the basin, and the current infrastructure cannot adequately handle the level of activity the Permian is experiencing. When you combine those factors with the number of driving distractions found in vehicles today, like touchscreen navigation systems, cell phones, etc., you create a recipe for disaster.

"MOTRAN, an alliance between members of the Odessa and Midland communities that has been instrumental in raising funds for and improving the infrastructure of the Permian Basin area, unfortunately



"While the Permian Basin has become the largest oil and gas producing region in the world, it has developed a number of unique risk challenges for companies operating in the region."

—David de Roode,
Partner & Executive Vice President,
Lockton Companies

has the data to support these statements. We are seeing hundreds of preventable motor vehicle accidents a year with an unfortunate number of associated fatalities.”

“As of November 2019, I have had 39 fatalities in my client portfolio, 35 of which were transportation related, including 34 fatalities that occurred in the Permian Basin. Twenty of those cases are in various states of litigation.”

When we asked de Roode what could be done about this, he said “greater awareness; anyone getting behind the wheel of a vehicle today is a risk to themselves and to the public. We have the benefit of learning how and why these accidents occur as we are involved with the insurance claims as well as the litigation that often ensues, regardless of fault. As a result, we are not just procuring insurance for our clients and saying good luck but are helping our clients manage and mitigate this risk by helping them refine their hiring practices, driver selection criteria and their corporate driving policies.

“We are helping our clients implement driver training programs as well as driver behavior monitoring and coaching technologies. We are also helping these companies develop dynamic route planning strategies as well as preventative maintenance and pre- and post-trip inspections programs. Traditional insurance agents and brokers don’t do this.”

Lockton provides decades of expertise in the oil and gas industry.

“Every company is unique and has its own challenges even though risks can be common,” he said. “Given the sheer size of Lockton’s oil and gas practice and the number of clients we represent, we are able to have a much deeper and more meaningful conversation with our clients around their operations, people and contracts. We help these companies better understand, qualify and quantify their own risks and potential issues.

“In addition, we guide them with their data and our observations to develop a strategy to insure and or to self-insure those risks in the most capital-efficient way without unnecessarily exposing their corporate balance sheet to unmitigated or unmanaged risk.”

Insurance is often a contractual requirement for various contracts and agreements. These agreements have indemnity provisions, and insurance is sought as the primary financing mechanism for funding those indemnities.

Not only does Lockton assist with reviewing contracts with customers by examining the indemnities, warranties, etc., the company also points out areas where changes should be considered with legal counsel.

“We point out quickly what works and does not work in terms of where the insurance flanges up with the indemnities and where it doesn’t,” de Roode said.

“We also discuss contracting trends and anecdotal issues that have led to negative outcomes.

“When companies can adjust contractual and operational issues and mitigate them, they can build a more efficient company. Lockton can add a lot of value by helping companies review their operations and operate with a greater awareness of safety, making them more efficient and more profitable, which is paramount.”

“Given the sheer size of Lockton’s oil and gas practice and the number of clients we represent, we are able to have a much deeper and more meaningful conversation with our clients around their operations, people and contracts.”

de Roode is an active member and financial supporter of the following organizations focused on the Permian Basin, including the Permian Basin Petroleum Association, the New Mexico Oil & Gas Association, the Texas Oil & Gas Association, the MOTRAN Alliance, the Permian Road Safety Coalition, the Domestic Energy Producers Alliance, the Independent Petroleum Association of America, the Petroleum Equipment & Services Association, the Association of Energy Service Companies and the International Association of Drilling Contractors.

“The importance of being involved in these groups is to bring awareness to local, state and federal officials about the economic impact the industry makes to the community and the infrastructure that is desperately needed,” he said. “Not only do I care about the industry that I work in, it’s about being aware of the micro and macro issues my clients face and how we think about the business and risks they have.” ■



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Permian M&A, The Key Deals of 100 Years

Year	Amount (\$MM)	Buyer	Seller	Comments
1923	\$10	Marland Oil Co.	Texon Oil and Land Co.	Purchase of the University 1-B and related acreage.
1925	Notes	Southern Crude Oil Purchasing (Standard Oil)	Westbrook and Co.	Southern Crude paid \$510,000 for Mitchell County leases.
1929	Stock	Continental Oil and Transportation Co.	Marland Oil Co.	Combination of early Permian operators creates the predecessor to Conoco.
1929	Notes	Simms Oil Co.	Red Bank Oil Co.	The \$307,500 deal was the "first of consequence" in Pecos County, according to the Big Lake Wildcat newspaper.
1956	\$450	Gulf Oil Corp.	Warren Petroleum	Combination of early Permian drillers.
1962	Stock	Ohio Oil (Marathon Oil)	Plymouth Oil Co.	Plymouth's Big Lake Oil Co., was the longest-operating Permian company when sold.
1981	\$7,400	DuPont	Conoco	At the time, largest merger in U.S. history.
1984	\$13,200	Chevron (Standard Oil of California)	Gulf Oil	Gulf was a leading oil producer in West Texas.
1991	\$250	Ashland Oil Inc. (ARCO)	Permian Corp.	Combined Texas oil and pipeline assets.
1996	\$250	Devon Energy	Kerr-McGee Corp.	Devon acquired assets in the Permian and elsewhere, increasing reserves by 46%.
1997	\$4,200	Parker & Parsley	Mesa Inc.	Merger formed Pioneer Natural Resources Co.
1998	\$2,470	Atlantic Richfield Co. (ARCO Permian)	Union Texas Petroleum Holdings	Building block deal for Atlantic Richfield Co., also called ARCO, leading to its acquisition two years later by BP Plc.
1999	N/A	Chevron Corp.	Atlantic Richfield Co.	Created one of the largest operators in West Texas and New Mexico.
1999	\$82,000	Exxon Corp.	Mobil Corp.	Created largest publicly traded company.
2000	\$27,000	BP Amoco Plc.	Atlantic Richfield Co.	BP's acquisition of Atlantic Richfield Co. (ARCO) created modern day BP Plc., which changed its name following the merger.
2001	\$39,500	Chevron Corp.	Texaco Inc.	Created fourth largest oil company in the world at the time.
2008	\$1,250	Occidental Petroleum Corp.	Plains Exploration & Production Co.	Purchased Permian, Piceance basin assets in TX, NM, CO, gaining 13,000 boe/d, 92 MMBoe proved.
2009	\$483	Apollo Global Management LLC	Parallel Petroleum Corp.	Acquired company with interests in TX Permian Basin, Barnett Shale, NM, UT & CO, gaining 33.2 MMBoe proved, 6,744 boe/d.
2010	\$3,900	Apache Corp.; Storm Cat Energy (USA) Corp.	Mariner Energy Inc.	Bought company with assets in the Gulf of Mexico, TX & NM Permian Basin, WY & ND, gaining 63,000 boe/d, 171 MMBoe proved.
2010	\$1,600	Energen Resources Corp.; Noble Energy Inc.; SandRidge Energy Inc.	Arena Resources Inc.	Acquired company with assets in W TX & NM Permian Basin, gaining 69.3 boe proved, 8,500 boe/d.
2010	\$345	CCMP Capital Advisors LLC	Chaparral Energy Inc.	Acquired stake in company with interests in Permian, Midcontinent.
2014	\$2,500	American Energy Partners LP	Enduring Resources LLC	Permian Basin acquisition by Aubrey McClendon's company.
2014	\$114	Diamondback Energy Inc.	Undisclosed	Midland Basin acquisition.
2014	\$183	Diamondback Energy Inc.	Undisclosed	Midland Basin acquisition.
2014	\$133	Parsley Energy Inc.	Undisclosed	Permian acquisition.
2015	\$3,900	Noble Energy Inc.	Rosetta Resources Inc.	To acquire in a merger Houston-based Rosetta, which has core acreage in the Permian Basin and Eagle Ford Shale in TX.
2015	\$2,750	WPX Energy Inc.	RKI Exploration & Production LLC	Acquired in a merger the privately held Oklahoma City-based company; includes Permian Basin leasehold in Loving County, TX, and Eddy County, NM.
2016	\$2,500	EOG Resources Inc.	Yates Petroleum Corp.; Abo Petroleum Corp.; MYCO Industries Inc.	To acquire the privately held company, combining large acreage positions in the Delaware and Powder River basins; includes 29,600 boe/d of net production with 48% crude oil.
2016	\$2,000	Occidental Petroleum Corp.	Browning Oil Co.	Acquired 35,000 net Delaware Basin acres in Reeves and Pecos counties in W TX; includes other Permian Basin interests.
2016	\$1,625	Concho Resources Inc.	Reliance Energy	To acquire 40,000 net acres in the Midland Basin, bringing Concho's position to 150,000 acres.

Year	Amount (\$MM)	Buyer	Seller	Comments
2016	\$1,500	PDC Energy Inc.	Kimmeridge Energy Management Co.; Arris Petroleum Corp.; 299 Resources LLC	To acquire two privately held companies, gaining about 57,000 net acres in the Delaware Basin in Reeves and Culberson counties, TX, and about 7,000 boe/d of current net production.
2016	\$1,100	SM Energy Co.	QStar LLC; EnCap Investments LP	To acquire 35,700 net acres within the Midland Basin in Howard and Martin counties in W TX; includes about 2,400 boe/d net production. (Expected to close December)
2016	\$1,000	Silver Run Acquisition Corp.	Centennial Resource Development LLC; Riverstone Holdings LLC; Riverstone Energy Ltd.	Acquired a majority stake in Centennial, which has Delaware Basin assets in Reeves, Ward and Pecos counties, TX.
2016	\$980	SM Energy Co.	Rock Oil Holdings LLC; Riverstone Holdings LLC	To acquire 100% ownership interests in Rock Oil, which holds 24,783 net acres in Howard County, TX, in the Midland Basin with 4,900 boe/d of net production and 6 MMBoe of PDP reserves.
2016	\$600	QEP Resources Inc.; QEP Energy Co.	RK Petroleum	To acquire from multiple parties Permian assets covering about 9,400 net acres in N Midland Basin; includes about 1,400 boe/d (83% oil), 430 horizontal drilling locations.
2016	\$560	Diamondback Energy Inc.	Luxe Energy LLC	To acquire leasehold interests and related assets primarily in Reeves and Ward counties, TX, in the Delaware Basin; includes about 38,765 gross (19,180 net) acres and 1,000 boe/d current net production.
2016	\$552	Undisclosed	Energen Corp.	To purchase, in separate transactions with multiple, undisclosed buyers, about 55,00 net acres in the Delaware Basin and San Juan Basin assets; includes 9,000 boe/d of production in April 2016 (34% oil).
2017	\$6,600	ExxonMobil Corp.	BOPCO LP	Acquired Bass family-owned companies, based in Fort Worth, TX; includes about 275,000 acres, of which 250,000 are Permian leasehold in NM.
2017	\$3,200	Noble Energy Inc.	Clayton Williams Energy Inc.	Acquired co., which includes 71,000 net acres and 2,400 gross drilling locations in the core Delaware Basin in W TX.
2017	\$2,800	Parsley Energy Inc.	Double Eagle Energy Permian LLC; Double Eagle Development LLC; Apollo Global Management LLC	Acquired Midland Basin properties in W TX; includes about 71,000 net acres with 3.6 Mboe/d of net production.
2017	\$2,430	Diamondback Energy Inc.	Brigham Resources Operating LLC; Brigham Resources Midstream LLC; Warburg Pincus LLC	Purchased all leasehold interests and related assets; includes mostly operated interests on 76,319 net acres in the Delaware Basin in Pecos and Reeves counties, TX.
2017	\$2,400	RSP Permian Inc.	Silver Hill Energy Partners LLC; Silver Hill E&P II LLC; Kayne Anderson Capital Advisors LP; Ridgmont Equity Partners LP	Acquired Delaware Basin's Silver Hill, which controlled about 68,000 gross (41,000 net) acres and produced about 15 Mboe/d net in W TX. Silver Hill I was completed in Nov. 2016; Silver Hill II was completed in March 2017.
2017	\$1,100	Marathon Oil Corp.	BC Operating Inc.; Crump Energy Partners II LLC; Crown Oil Partners V LP	Acquired about 70,000 net surface acres in the Permian Basin; includes 51,000 acres in the N Delaware Basin of NM and production of about 5 net Mboe/d.
2017	\$775	WPX Energy Inc.; RKI Exploration & Production LLC	Panther Energy Co. II LLC; Carrier Energy Partners LLC	Acquired 18,100 net Delaware Basin acres in W TX with about 6.5 Mboe/d of production (55% oil); includes 920 gross undeveloped locations.
2017	\$684	QEP Resources Corp.	JM Cox Resources LP; Alpine Oil Co.	Purchased 13,000 net acres in the core of the Midland Basin in Martin and Howard counties, TX, nearly all HBP in the Wolfcamp or deeper; includes more than 730 potential horizontal drilling locations.
2017	\$648	Carrizo Oil & Gas Inc.	ExL Petroleum Management LLC; Quantum Energy Partners	To acquire Delaware Basin properties covering 23,656 gross (16,488 net) acres in Reeves and Ward counties, TX, and net production of about 8 Mboe/d (48% oil, 67% liquids); includes up to \$125 MM in contingency payments.

Year	Amount (\$MM)	Buyer	Seller	Comments
2017	\$633	Callon Petroleum Co.	American Resource Development LLC (Ameredev); American Resource Development Upstream LLC; American Resource Development Midstream LLC	Acquired about 16,700 net surface acres in S Delaware Basin in Ward County, TX; includes additional acreage in Pecos and Reeves counties, TX.
2017	\$607	Parsley Energy Inc.	Apache Corp.; Undisclosed	Acquired about 23,000 net leasehold acres with 2.3 Mboe/d net production in the Midland and S Delaware basins in W TX; includes \$43-MM purchase of royalty acreage in Pecos and Reeves counties, TX.
2017	\$600	Concho Resources Inc.	Undisclosed	Bought 12,400 net acres in the Midland Basin in Andrews and Martin counties, TX; includes average volumes of about 3,000 boe/d, 73% oil.
2017	\$600	Occidental Petroleum Corp.	Hess Corp.	Purchased Hess' interests in EOR assets in the Permian Basin in NM and TX.
2018	\$10,500	BP Plc; BP American Production Co.	BHP Billiton Ltd.; Petrohawk Energy Corp.	Bought 100% of the issued share capital of Petrohawk, which holds BHP's Eagle Ford, Haynesville and Permian/Delaware Basin shale assets in LA and TX; includes about 526,000 net acres which produced 58.8 MMboe in the 2018 financial year.
2018	\$9,500	Concho Resources Inc.	RSP Permian Inc.	To acquire Dallas-based RSP Permian in an all-stock transaction; includes roughly 92,000 net acres in the Permian and 55.5 Mboe/d of 4Q 2017 production.
2018	\$9,200	Diamondback Energy Inc.	Energen Corp.	Acquired Energen, which holds a 179,000-net-acre position across the Permian's Midland and Delaware basins; includes \$830 MM net debt.
2018	\$1,245	Diamondback Energy Inc.	Ajax Resources LLC; Kelso & Co.	Purchased Ajax in a cash-and-stock transaction; includes about 25,493 net leasehold acres in the Northern Midland Basin with more than 12,100 boe/d (88% oil) of production and 362 net identified potential horizontal drilling locations.
2018	\$946	Oasis Petroleum Inc.	Forge Energy LLC; EnCap Investments LP; Pine Brook Partners LLC	Bought about 20,300 net acres in the Delaware Basin across Loving, Ward, Winkler and Reeves counties, Texas; includes 3,500 boe/d production in November and locations targeting the Wolfcamp and Bone Spring.
2018	\$620	The Carlyle Group LP	Diamondback Energy Inc.	Formed JV to develop San Pedro area assets in Pecos County, TX, within the Southern Delaware Basin.
2018	\$570	Callon Petroleum Co.	Cimarex Energy Co.	To purchase oil and gas properties in the Delaware Basin covering about 28,657 net surface acres primarily in Ward County, TX; includes 6,831 boe/d (73% oil) of production mainly from the Bone Spring Formation and 18,925 net undeveloped Wolfcamp acreage.
2019	\$57,000	Occidental Petroleum Corp.	Anadarko Petroleum Corp.	To acquire The Woodlands, TX-based independent producer with a portfolio of international assets including 600,000 gross acres in the Permian's Delaware Basin; stock-and-cash transaction includes assumption of debt.
2019	\$1,600	Cimarex Energy Co.	Resolute Energy Corp.	Cimarex called the Resolute bolt-on "tailor-made," and it expanded its company's Reeves County, TX, footprint while adding 35,000 boe/d (45% oil).

1920 issue of Petroleum Magazine reported. Buyers included Gulf Production, Humble Oil and Refining, Monarch Oil and Refining and Simms.

The first Permian land grab had begun.

Foundations

In 1919, geologist Charles C. Coulter concluded in an Oil and Gas Journal article that Pecos County,

Texas, was destined to be a 30,000-square-mile "petroleum graveyard."

Though some took him to task, calling him a "geology prophet," the consensus was that across the vast West Texas area, there was no oil.

As with other parts of the Permian Basin, however, a decade of drilling then proved all Permian doubters wrong.

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WHY CHOOSE US?

- ✓ SAFETY AT THE FOREFRONT
- ✓ OPERATIONAL EXCELLENCE
- ✓ COMMITMENT TO INTEGRITY
- ✓ WINNING TEAM CULTURE

“After monetizing a large asset in the Eagle Ford shale in 2010, my company undertook an exhaustive process in search of its next asset. We kept returning to the Permian Basin for many of the same attributes investors covet today; a large geographic footprint with numerous, stacked oil pays. We acquired an asset about six miles northeast of Big Spring in Howard County. At the time, the play was the vertical Wolfberry—no horizontal wells had been drilled in the county, and everything east of the Lamesa Highway was considered ‘goat pasture.’ During our hold of the asset, the wells went from vertical to horizontal, the rig count rose dramatically, and what was once goat pasture was sold by Athlon to Encana for \$7.1 billion.

“We sold that asset in 2013 and have remained in the Permian ever since. A common theme within the basin has been the application of new technology where we know there is oil.

“There were challenges then as there are today. And one of the best assets the Permian has going for it is the grit, determination and ingenuity of the people living and working in the Basin.”



Matt Gentry
President & CEO
Monadnock Resources LLC

In 1926, the Mid-Kansas Oil and Gas Co. and Transcontinental Oil Co., drilled through 992 feet of the San Andres formation in the Yates Field owned by Ira G. Yates. Production started off at 450 barrels of oil per day.

Lured by riches or adventure, once nearly empty counties such as Pecos exploded in population. By 1930, the number of residents in Pecos had more than doubled as the Delaware Basin was, indeed, proved fruitful.

Within a decade, other Texas Permian counties such as Martin saw their population quadruple. Others experienced rapid growth, too, including Midland by 226%, Reagan by 703% and Winkler, which had 81 people in 1920 and grew to 6,784 people, according to U.S. Census records.

The deals of this era, starting in the early 1920s, would lay foundations for still larger deals that would amass enormous acreage positions in the Permian.

During random drilling in Winkler County, Westbrook and Co. found a discovery well in 1926. In February 1926, a company leasing agent sold more than 21,000 acres worth of leases near the well for 35 cents per acre, or roughly \$7,400.

By November, Southern Crude Oil Purchasing Co., a subsidiary of John D. Rockefeller’s Standard Oil Co. of Indiana, bought 1,440 acres and the discovery well from Westbrook for \$510,000. Other Westbrook leases sold to oil companies, including Marland Oil Co., Humble Oil and Refining, and several others.

Marland Oil, founded in 1917 and estimated by 1920 to control 10% of the world’s oil production, drilled Howard County in 1926.

Owner E.W. Marland seemed to exalt in wildcatting. “I have slept in the derrick of many a discovery well—gone for a week at a time without even taking my boots off, wet to the skin in freezing weather—meals out of a dinner pail—and loved it for the excitement it gave and the sense of satisfaction that came from tapping a treasure house of nature, filled with liquid gold,” he said, according to the Marland Estate, a museum that showcases his Oklahoma home.

By then, the nascent Permian was turning into a drill and flip story.

In May 1923, Texon Oil and Land Co. drilled the historic Santa Rita oil well in Reagan County, Texas. Texon followed in 1929 by drilling the University 1-B, then the world’s deepest well at 8,525 feet. The well’s daily production averaged about 3,000 barrels of oil.

In perhaps one of the first Permian mega-deals of the time, shortly after the University 1-B was announced, Texon agreed to sell its assets and about 85,100 acres to Marland for \$10 million.

Later that year, in June 1929, Marland merged with Continental Oil Co., to create Continental Oil Co., later known simply as Conoco.

Eye-popping deals

The early deals of the Permian Basin, as Ancestry.com might put it, fit into a “deeper family story.” But the genealogy of the Permian works in reverse, with corporate family lines dwindling over time into larger descendants.

Permian operators from the 1930s on are now owned by majors such as ExxonMobil Corp. and Chevron Corp. and large independents such as Devon Energy Corp. and Pioneer Natural Resources Co.

Consider Sid W. Richardson, a man who typified the oil wildcatter of the 1920s. He rode booms and busts, becoming a millionaire in 1920 a year after joining the oil world. A year later, the markets turned and Richardson’s fortunes fell.



Of the largest U.S. oil-producing companies in 1978, few survive today. Hess Corp. (then Amerada Hess) is more or less intact. Marathon Oil Corp., another piece of Standard Oil, merged in 1930 with Transcontinental Oil Co., which was among the leaseholders in the Delaware's Pecos County discovery well. Marathon bounced around a bit, was purchased by U.S. Steel in 1982, before settling into its current incarnation as an independent E&P in 2011.

In early 2019, Cimarex Energy Co. developed its Delaware Basin position by acquiring Resolute Energy Corp.
Photo by Tom Fox

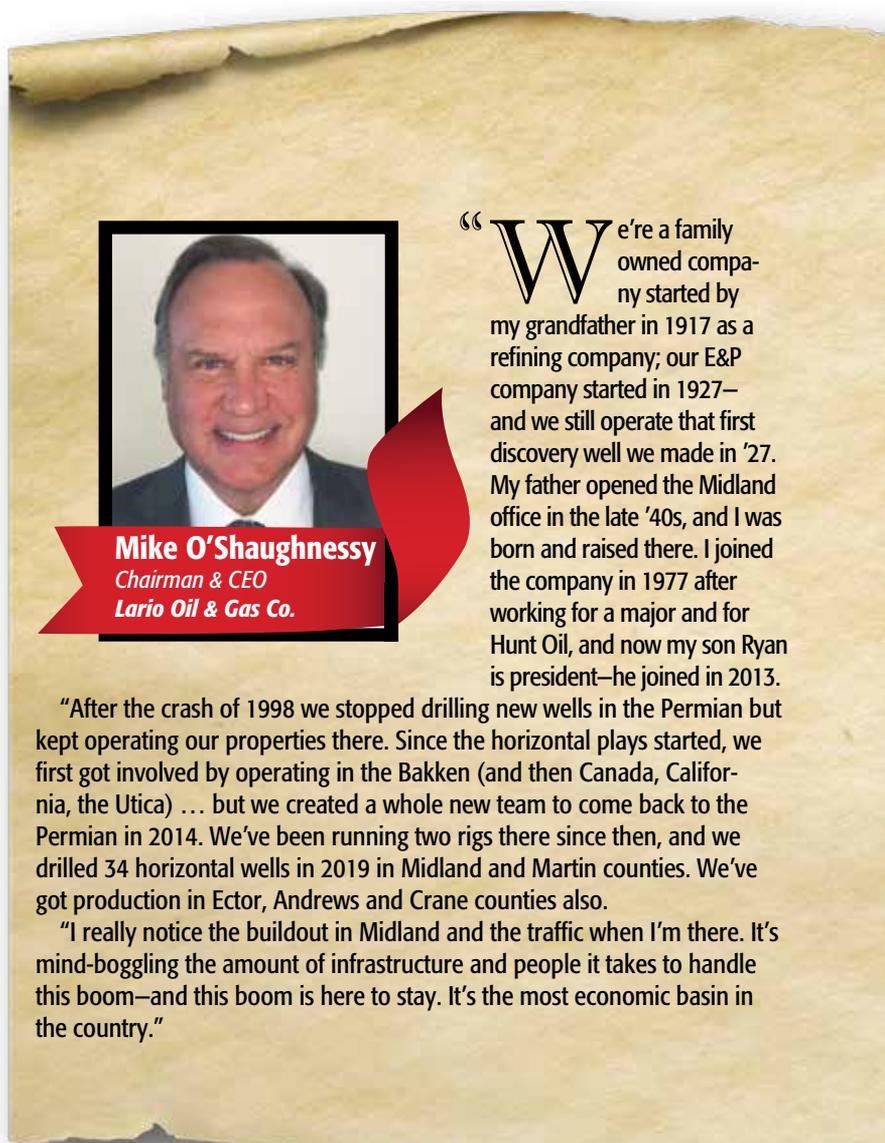
After gaining and losing fortunes a few more times and facing the Great Depression, Richardson finally established his reputation and fortune as an oil man in 1935, opening up the Permian's Keystone oil field in Winkler County, Texas.

At his death in 1959, part of his fortune went to his grandsons, Sid, Edward, Robert and Lee Bass, typically known as the Bass Family Enterprises.

Following World War II, high prices buoyed producers, but by 1949, production had overcome demand.

"The statement, we were 'swimming in oil' became typical," Federal Trade Commission (FTC) Commissioner John Carson said in testimony in May 1950.

Texas producers came under fire for a near-simultaneous raise in gasoline prices in February 1949, resulting in then Attorney General Price Daniel suing 10 major oil companies accused of collusion and conspiracy.



Mike O'Shaughnessy
Chairman & CEO
Lario Oil & Gas Co.

"We're a family owned company started by my grandfather in 1917 as a refining company; our E&P company started in 1927—and we still operate that first discovery well we made in '27. My father opened the Midland office in the late '40s, and I was born and raised there. I joined the company in 1977 after working for a major and for Hunt Oil, and now my son Ryan is president—he joined in 2013.

"After the crash of 1998 we stopped drilling new wells in the Permian but kept operating our properties there. Since the horizontal plays started, we first got involved by operating in the Bakken (and then Canada, California, the Utica) ... but we created a whole new team to come back to the Permian in 2014. We've been running two rigs there since then, and we drilled 34 horizontal wells in 2019 in Midland and Martin counties. We've got production in Ector, Andrews and Crane counties also.

"I really notice the buildout in Midland and the traffic when I'm there. It's mind-boggling the amount of infrastructure and people it takes to handle this boom—and this boom is here to stay. It's the most economic basin in the country."

Underwritten by



1983

The First National Bank of Midland, a pillar of the town for nearly a century and worth an estimated \$1.2 billion, was declared bankrupt.

1983

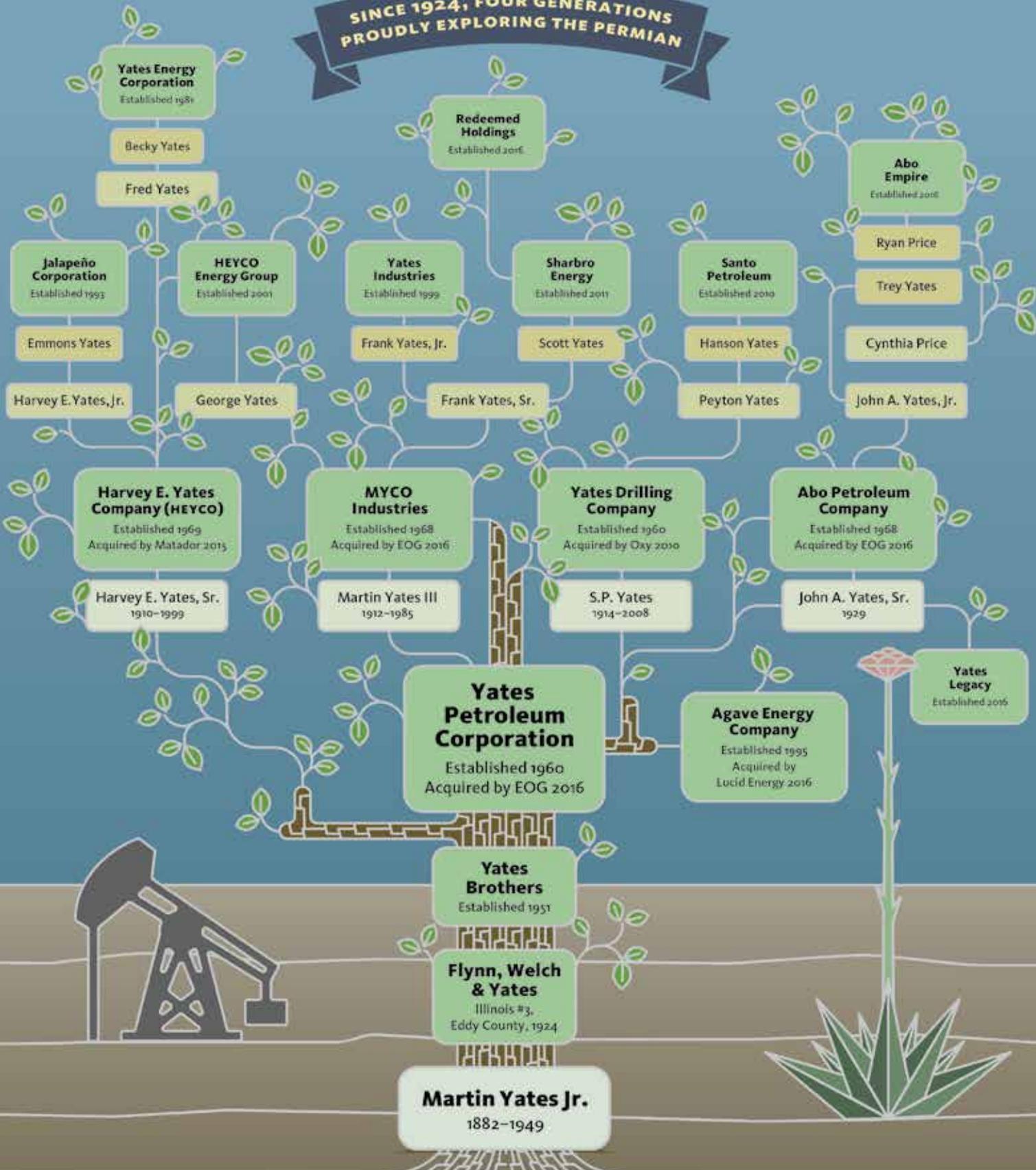
Crude oil futures started trading on Nymex for the first time.

1985

The Yates Field produced its 1 billionth barrel of oil and was operated by Marathon Oil Co.

the YATES FAMILY of NEW MEXICO

SINCE 1924, FOUR GENERATIONS PROUDLY EXPLORING THE PERMIAN





Since selling its Ward County acreage in 2017, Ameredev II now drills in Lea County, N.M. Photo courtesy Ameredev II LLC

By the 1980s, large petroleum companies were shedding the previous decade's conglomeration strategy. Early Permian driller Continental Oil, for instance, invested in uranium in the 1970s while in 1972 selling its plants food business to future pipeline behemoth The Williams Cos. for \$125.5 million.

By the end of the decade, a new focus emerged on energy-related assets, according to a 1989 study commissioned by the FTC.

From 1979 to 1984, large oil company acquisitions averaged more than \$3 billion per year compared to \$331 million from 1971 to 1978, according to the FTC report.

In 1984, six oil and gas acquisitions accounted for \$29.4 billion. Even unadjusted for inflation, the deals were eye-popping. Permian driller Gulf Oil Corp. agreed in 1984 to sell its company to Standard Oil of California (what became Chevron) for \$13.3 billion—then the largest corporate merger to date. Also that year, Getty Oil was purchased by Texaco, still standing 60 years after its well in Mitchell County, for \$10.2 billion.

By October 2000, Texaco itself was consumed by Chevron, which offered \$45 billion, then the largest deal, creating the second-largest oil company in the United States and the world's fourth-largest publicly traded oil company with a combined market value of approximate-

ly \$95 billion. The merged company was named ChevronTexaco.

As for Richardson's descendants, the Bass family had made prudent investments in oil as well as shares of Disney and other corporations. In December 2005, the family sold the Sid Richardson Energy Services Co., a network of pipelines, to Southern Union Co. for \$1.6 billion. Southern Union was itself purchased in 2011 for \$7.9 billion by Energy Transfer Partners.

And in 2017, the Bass family sold BOPCO LP, which held 250,000 net acres of Permian leasehold, to ExxonMobil for \$6.6 billion.

By the late 1990s, however, the Permian stage was being set for a revolution.

Modern times

A photographer taking pictures in Colorado City, Texas, in 1922, seemed to look dimly on the prospects of the city, the county seat of Mitchell County, birthplace of the Permian.

"The streets are all dirt roads," he wrote of the oil town.

He made note of power lines strung between buildings, an auto parts shop and two drug stores across from one another. The future West Texas, land of the Ford and the Chevy pickup truck, was then home to Studebakers and solemn men, their faces dark under the brim of their hats.

1986

With the 1980s oil glut at its peak, the price of oil dropped to \$9/bbl. Companies divested some Permian holdings and the U.S. rig count plummeted.

1986

The trade of crude oil options is approved on Nymex.

1988

Mobil Corp. drilled the first horizontal well targeting the Lower Spraberry. Future implications of this weren't evident at the time.

1989

Aubrey McClendon and Tom L. Ward co-founded Chesapeake Energy Corp. It would become one of the largest producers and most active drillers in the U.S., with substantial and prolific assets in the Permian Basin.

UNDERSTANDING OWNER SENTIMENT IS A COMPETITIVE ADVANTAGE

The partners at Paint Rock Royalty LLC have learned to be versatile while working with owners to get deals closed.

It's 6:15 p.m. on a Wednesday night. Partners Logan King and Chase Bechtel are going over check details and leases provided to them by an individual who owns significant holdings in Martin County, Texas. It turns out the owner had multiple offers on the table and gave the pair a "drop dead" date of Friday to get in the mix.

"We realized in order to be competitive in this space you had to excel at multiple and different disciplines."

Logan yells across the hall to Chase, "Is the acreage located in Block 36 leased at 3/16ths, or 25%?" Everyone who has waded into the mineral and royalty acquisition space has been in this situation. Chase responds, "That's the tract where the owner said everyone who has already made offers is assuming it's a 25% royalty burden, but it's actually leased at 3/16ths." These are the kinds of details that can either make or break a potential acquisition. Handling this problem is one of the many ways that Paint Rock Royalty LLC sets itself apart from the competition.

Before starting Paint Rock in 2016, Logan and Chase had taken different career paths. In 2011, Logan was wrapping up at the University of Texas at Austin and had no ambitions of being in the oil and gas business—until he began interning at a start-up mineral and royalty acquisition company in Fort Worth, Texas. Being the analytical type, he said, "One day I returned home, and my father was researching the depositional environment of the Woodbine A

Formation in Madison County, Texas. It was then and there I was hooked."

Meanwhile, Chase had begun a career in commercial real estate with Marcus & Millichap Inc. in 2009. "It was an extremely tough market in those days. We were in the midst of the financial crisis, and the real estate market had bottomed out. I had to get creative and figure out ways to help potential sellers navigate the waters of a highly volatile market. That time in my career made me realize how important it is to understand each individual owner's expectations and how they plan on executing their business model."

In 2012, Chase left commercial real estate after nearly four years to work at a mineral and royalty company in Fort Worth. It just so happens that it was the same company where Logan had interned almost two years earlier.

Forming a foundation

Fast forward to February 2016 when Chase and Logan launched Paint Rock Royalty LLC. Chase realized that they faced the same challenges with owners and investors as he did when he was in commercial real estate. WTI oil averaged \$30.32 at that time. "We not only weathered the storm, but grew the company. Nonetheless, it was a very difficult environment," said Logan.

The mineral business and the amount of capital being committed to the space was growing quickly. This is where Paint Rock saw an opportunity. "We realized in order to be competitive in this space you had to excel at multiple and different disciplines."

Logan and Chase had to identify each other's skill sets and how they would be used most efficiently. They also had to figure out what else was needed to build a company that would be competitive in an already competitive marketplace. In order to complete their roster, they decided to bring on Doug King, an exploration geologist with 35 years of experience, along with a knowledgeable and aggressive acquisitions team.

“While Logan is more focused on the analytics and land aspects of our day-to-day, my strengths lie on the financial and business development side. We also have the luxury of having a highly experienced geologist on our team,” said Chase.

This is Logan and Chase’s partnership in a nutshell. They know each other’s strengths and, equally important, their weaknesses.

Relationships are key

The most important aspect of their business is relationships, period—relationships with mineral owners, investors and capital partners, the first and primary focus being on the mineral owner. “This space is, and always will be, driven by the mineral owner. In the oil business, your reputation precedes you. In order to transact in any given area, first and foremost, you must have a solid relationship with the mineral owners,” Logan said.

Paint Rock high grades areas through a geological and financial lens. When evaluating a potential Area of Interest (AOI), several questions need to be answered: Does the rock check out? Is it a Tier 1 operator? Has the area been developed with modern technology? What is the land situation and owner sentiment? It’s imperative that Paint Rock check all the boxes in order to purchase minerals in a particular area.

Since its outset, the company has successfully integrated a strategy that is effective, efficient and repeatable. “Most, if not all of the areas that we have played are areas that are considered “core” today, i.e., Tier 1 rock, Tier 1 operators and a Tier 1 land situation,” Logan said.

Chase adds, “While any one potential acquisition may check all of these boxes from an evaluation standpoint and look good on paper, there is one other key component that a number of people either over-

look or don’t explore enough, and that is owner motivation. In our experience, no owner has sold their interests just to sell. They have a very specific reason for doing so, but most won’t come out and just say it. You have to dig to get the root reason why they are considering a sale in the first place. In my opinion, that might be the most difficult part of our business, but without it you’re just spinning your wheels.”

The pair works tirelessly on the front end with owners to make sure each owner’s current situation makes sense to truly consider a sale. They make sure, if all expectations are met, that the owner is prepared to move forward.

Reflecting on the last nine years he’s been in the industry, Logan said, “We would like to congratulate all the owners and operators who have been involved in making the Permian Basin not only the most productive basin in the country, but also one of the most productive in the world. From everyone here on the Paint Rock team, we look forward to working with you moving forward.”

By the way, in case you were wondering, they got that Martin County deal. And since inception, they have closed 176 transactions, totaling over 13,000 net royalty acres. ■



paintrockroyalty.com



“In the oil business your reputation precedes you. In order to transact in any given area, first and foremost, you must have a solid relationship with the mineral owners.”

—Logan B. King,
Partner, Paint Rock Royalty LLC.

Partners Chase Bechtel (left) and Logan King (right).

WPX Energy Inc.'s 2015 acquisition of RKI Exploration & Production LLC ushered sizable public companies into the Delaware Basin. *Photo by Tom Fox*



Mitchell, on the eastern fringe of the Permian, was marginalized by Pecos, Winkler, Crane, Reagan, Howard and Glasscock counties within a decade, according to a 1936 report by the U.S. Department of the Interior. It would take another 85 years for the Westbrook Field to shine again.

In the late 1990s and early 2000s, a new crop of independents was bent on making deals and finding their fortune in Permian's aging fields.

The present-day juggernauts of the Permian began to coalesce. In April 1997, T. Boone Pickens' Mesa Inc. agreed to merge with Parker & Parsley Petroleum Co. The company took on a new name: Pioneer Natural Resources Co.

At the head of the new, \$4.2 billion company was 44-year-old Scott Sheffield. At the time, it was the

third-largest independent oil and gas company in the U.S. In October 2019, Pioneer reported holding the largest share of Midland Basin acreage, about 680,000 net acres, while producing more than 200,000 barrels of oil per day. In 2018, the company was the second-largest oil producer in the state and was valued in later 2019 at nearly \$21 billion.

As the shale boom manifested, moving from the gas "shale gale" to oil, the Permian took on an out-sized role in deal flow in the 2010s. Between 2015 and 2017, roughly \$74 billion worth of deals were transacted in the Permian.

Early on, deals seemed to fall like dominoes, pushing one company after another into action.

For instance, in 2010, SandRidge Energy Inc. purchased the Arena Resources Inc.'s assets in the

Handling pipe on a Wolfcamp well for RSP Permian Inc. in Midland County. RSP was acquired in 2018 by Concho Resources. *Photo by Tom Fox*



Permian and other areas for \$1.6 billion, gaining prospects in West Texas and New Mexico as well as the Central Basin Platform. By late December 2010, Energen Resources Corp. announced it would pay \$110 million for 21,300 net acres in SandRidge's Third Bone Spring play in Loving, Reeves, Ward and Winkler counties.

In hindsight, the early Midland Basin deals were bought at thrift-store prices with companies banking on their geological knowledge rather than proved areas.

Diamondback Energy Inc. was among the earlier movers in the Midland, grabbing acreage at a relative pittance. Its early deals in 2014 included purchasing 11,150 acres in Martin and Dawson counties for \$165 million—or roughly \$9,000 per acre.

“Although northern Martin County and southern Dawson County have not been derisked horizontally, we applaud the acquisition ... [as] well below recent transactions in the basin,” a Simmons research director told Hart Energy in 2014.

In time, acreage prices soared in the Midland. In 2016, QEP Resources purchased 9,400 acres in Martin County for \$600 million. Some analysts pegged the deal at \$58,000 per acre.

As the Midland was more firmly established, companies began to look farther west, to the Delaware Basin.

RKI Exploration & Production LLC founder Ronnie Irani arrived in the Delaware around 2006 and later would describe simply: It was dead. He purchased acreage for as little as \$200 per acre. After cautiously keeping the company's drilling success quiet, Irani and WPX Energy Inc. CEO Rick Muncrief struck a deal.

In a \$2.75 billion merger, WPX became one of the first sizeable public companies to make a large-scale acquisition in the Delaware in 2015.

The area, known by WPX as its Stateline area, helped trigger a second wave of Permian activity, focused now in the Delaware. In 2018, Matador Resources Co. set a record price for acreage during a BLM auction near WPX, paying roughly \$95,000 per acre for a federal lease.

Beginning in June 2016, buyers went on a tear in the Delaware. For eight consecutive quarters ending in June 2018, the Delaware surpassed the Midland in deal values for assets in Texas and New Mexico.

The streak ended in August 2016 as Diamondback agreed to buy Energen Corp.'s assets in the Midland and Delaware for \$9.2 billion—as well as Ajax Resources' northern Midland position for \$1.25 billion.

As a footnote to Diamondback's deal, in 2005 Energen had purchased assets in the Permian for about \$168 million. Energen's acquisition included Mitchell County's North Westbrook Unit.



Mike Middlebrook
COO, Chisholm Energy Holdings

“We closed on our first acquisition in Lea and Eddy counties, New Mexico, in May 2017 and have since drilled and completed 60 wells across the northern Delaware Basin. We have more than doubled the size of our acreage position over the past two years to about 36,000 net acres, which is evenly split between Lea and Eddy counties. Our current plan is to run two rigs and one frack

crew throughout 2020 while growing our acreage position as needed to efficiently develop the acreage and grow production. Our net production is over 10,000 boe/d and is approximately 70% oil.

“With the rise and fall of commodity prices there have been and will continue to be opportunities to grow and expand our acreage position in more creative ways including drill to earn, farm outs and term assignments. Operators who are focused in certain areas of the Delaware Basin are often willing to participate in such deals in an effort to evaluate and bring forward value in other areas.

“One of the biggest challenges in the Permian over the past several years has been takeaway capacity for oil, gas and NGLs. As the industry has responded and pipelines have been and continue to be constructed, we expect to see improvement in basis differentials and volatility over the next couple years. Meanwhile we have been actively hedging our production to ensure we have the cash flow needed to continue growing and developing our acreage position.”

Nearly 90 years after Mitchell County first discovered oil, Energen rejuvenated the field, increasing production in nine years from 900 barrels of oil per day to 4,150 barrels of oil per day.

Energen's operations team spoke almost with reverence for the area.

“Many people think the first well was the Santa Rita well, but it really was the No. 1 Abrams, which is actually in the Westbrook Southeast Unit,” says Joe Niederhofer, Midland, Texas-based general manager of the Permian operation. “It is still producing today.

“It's kind of a monument out there, and we keep it painted and in good condition.” 100

Private Equity Likes The Permian

BY ELLEN CHANG,
CONTRIBUTING EDITOR

The boost in Permian Basin drilling and production during the past decade has prompted a surge in interest from private equity firms that saw opportunities in the region. It's been said that as many as 200 to 300 companies working in the Permian are backed by private equity.

Some of the largest Permian M&A deals closed in the past three years have involved private-equity-backed E&Ps being sold for huge returns. For example, Silverback Exploration I, active in Reeves County, sold to Centennial Resource Development for \$855 million in 2016 and promptly formed Silverback II. Both times it was backed by EnCap Investments.

In February 2019, EnCap funded Pegasus Resources LLC again, a Fort Worth mineral and royalty company, with an additional \$300 million of equity, following a first commitment of \$300 million in November 2017. Pegasus focuses on the Delaware and Midland basins. Publicly held Kimbell Royalty Partners LP acquired oil and gas royalty assets from EnCap for \$151.3 million in a 100% equity transaction that same month, and these assets included production from the Permian Basin as well as other basins.

Riverstone Holdings LLC committed to invest up to \$500 million in Three Rivers Operating IV in February. It's common for PE firms to re-up with successful Permian entrepreneurs. Three Rivers III was sold in 2018 for \$205 million in gross proceeds, including assets in Culberson and Reeves counties.

Since 2009, Three Rivers CEO Mike Wichterich has built three Permian companies via 15 acquisitions, aggregated over 380,000 net acres, drilled over 300 wells, and operated over 1,000 wells. "Over the course of Three Rivers I, II, and III, our team has generated total sales proceeds of more than \$3 billion," he said.

The Permian Basin has also attracted private equity from RedBird Capital Partners, said Hunter Carpenter, partner. "Ten to 15 years ago, the view of the Permian was that of an aging oil field with a relatively flat production profile," he said. "Today people think of it as an endless resource whose production profile has increased to greater than four times what it was 10 years ago. Technology has unlocked the resource; what remains to be seen is can the pace of productivity continue."

RedBird's most recent investment was in May 2019, backing FireBird Energy LLC, which operates in the Midland Basin. FireBird is comprised of former RSP Permian team members and other industry veterans. RSP was sold for \$9.5 billion to

Concho Resources Inc. in 2018. This kind of recycling of private equity dollars has been very common in the Permian Basin.

While economic conditions heading into 2020 remained murky, RedBird planned to deal with any uncertainties by working with its partners on a "very aggressive" hedging program and always analyzing commodity prices, execution and its pacing of capital, Carpenter said.

Private equity deals aplenty

Apollo Global Management LLC has invested in the natural resources industry for many years. One of its latest deals was to fund DoublePoint Energy in 2018 by merging Double Eagle Energy Holdings III and FourPoint Energy with the backing of other private equity firms, GSO Capital Partners, Magnetar Capital and Quantum Energy Partners. DoublePoint owns 70,000 acres in six Texas counties.

In addition to funding E&P and midstream startups, some private equity funds have started to fund activity for well-established public companies as well. For example, in 2018 the Carlyle Group and Diamondback Energy Inc. said they would invest \$620 million to develop assets in the San Pedro area of Pecos County, Texas, in the southern Delaware Basin. Carlyle will fund 85% of the development costs over five years.

Yorktown Partners, the New York firm that has invested nearly \$8 billion in more than 90 onshore companies, also likes the Permian. Its investments include Vaquero Midstream, which offers midstream services in the Permian, and Momentum Midstream, which has over 2,000 miles of gathering pipeline, 12 processing facilities, three NGL-fractionation facilities and more than 1 million barrels of storage.

In 2016, Blackstone Energy Partners committed up to \$1 billion to Jetta Permian, a partnership with an affiliate of Jetta Operating Co., based in Fort Worth. Jetta Permian targets assets and leasehold in the Delaware Basin, as well as in other basins.

NGP

Dallas-based NGP has made \$20 billion of cumulative equity commitments since 1988. The firm has backed seven companies in the Permian Basin currently.

"We do like the Permian," said Bob Edwards, a partner at NGP. "We have not even scratched the surface there [in terms of total potential of reserves as calculated by the USGS]."

The highest concentration of companies within NGP's portfolio is in the Permian. It supports these very active companies in the Delaware Basin: Tap Rock Resources, Luxe Energy LLC, Colgate Energy LLC and Titus Oil & Gas. In the Central Basin Platform and Midland Basin, it sponsors: Black Beard Operating, Steward Energy II and Hibernia Resources.

In addition, NGP backs Wing Resources III, a minerals company that is active in the Permian. A prior edition of Wing sold some mineral assets to Alliance Resource Partners for \$145 million the same month.

NGP has sponsored a number of these Permian companies more than once, as second, third and fourth generation companies; Luxe, Hibernia and Wing are but a few examples.

Edwards said the Permian has the potential for additional output and investment opportunities.

“From an industry perspective, even though the core-of-the-core in the Permian has narrowed over the last few years, there will still be material production growth in absolute terms, and still the need for capital and a role for private equity as the basin matures,” he said.

Both private equity firms and major public oil companies can work together and unlock value in the basin, he said.

“Creating value in the upstream is not a zero sum game between the majors and private equity in which one wins and

one loses. There has been and will be a synergistic business ecosystem where both the majors and private companies can succeed by leveraging their unique capabilities, oftentimes side by side.”

There are benefits to having both types of companies drilling in the region. Majors can take larger financial risks while smaller private-equity-backed E&Ps can use various forms of technology. “The majors can create value in very large-scale, complex developments such as large pad developments that have risk that the smaller firms are not comfortable taking,” Edwards said.

“But at the same time, smaller, more focused private-equity-backed companies can create value by applying specialized technology or specific land expertise to unlock reserves and to optimize later-life production.” ■

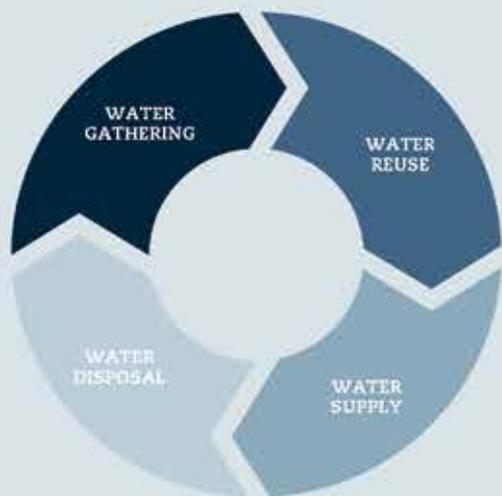
Select Permian Private Equity Sales

Announced Date	Target Company	PE Sponsor	Bidder Company	Deal Value (\$MM)
1/16/17	Clayton Williams Energy	Ares Management	Noble Energy	3,242
7/2/17	Double Eagle Energy Permian	Apollo; Post Oak	Parsley Energy	2,800
7/14/15	RKI Exploration & Production	First Reserve	WPX Energy	2,750
12/14/16	Brigham Resources	Warburg Pincus; Yorktown Partners; Pine Brook Road Partners	Diamondback Energy	2,550
8/8/18	Ajax Resources	Kelso & Company	Diamondback Energy	1,245
10/13/16	Silver Hill Energy Partners I and II	Kayne Anderson; Ridgmont	RSP Permian	1,231
5/17/19	BC Operating	Quantum Energy, Post Oak, Wells Fargo	Marathon Oil	1,100
12/11/17	Forge Energy	EnCap Investments; Pine Brook Road Partners	Oasis Petroleum	946
6/20/16	Payrock Energy	EnCap Investments	Marathon Oil Corporation	904
8/23/16	Arris Petroleum Corporation	Kimmeridge Energy Management GP	PDC Energy	868
11/28/16	Silverback Exploration	EnCap	Centennial Resource Production	855
1/12/17	Panther Exploration/ Carrier Energy Partners	Kayne Anderson; Riverstone	WPX Energy	775
3/21/17	Black Mountain Oil & Gas	NGP	Marathon Oil	700
12/13/16	American Resource Development	EnCap	Callon Petroleum Company	633
4/19/16	Big Star Oil and Gas	Highbridge	Callon Petroleum Company	220
9/12/19	Santa Elena Minerals	EnCap	Viper Energy Partners	150
6/23/19	Wing Resources	NGP	Alliance Resource Partners	145
10/4/16	FireWheel Energy	EnCap	Resolute Energy	135
4/18/17	Forge Energy	Pine Brook; EnCap	Lime Rock Resources	119
4/18/19	Trail Ridge Energy Partners II	Trilantic; Riverstone	Lario Oil & Gas Company	ND
11/5/18	Roxo Energy	Vortus	Murchison Oil & Gas	ND
2/17/18	Three Rivers Operating Company III	Riverstone Holdings	Admiral Permian Resources	ND

Source: Acuris



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STEVAN

CHAPTER 7 | INFRASTRUCTURE TAKEAWAY

BIGGER, FASTER: MIDSTREAM RAMPS UP

BY FRANK NIETO,
CONTRIBUTING EDITOR

*The surge of Permian Basin
output has sparked a flurry of new
midstream projects to replace legacy
assets and foster exports.*

Vaquero Midstream's Caymus natural gas processing facility in the southern Delaware Basin includes two processing plants with a total current capacity of 400MMcf/d. Photo courtesy Vaquero Midstream LLC

America loves a comeback story, whether it's Rocky, Tiger Woods at the 2019 Masters, or Elvis in 1968. America also loves money-makers. Combine the two, and you wind up with the Permian Basin.

It's been 100 years since the Permian's first commercial well was brought online. This well sparked a nearly 50-year run of prosperity. However, the basin began to experience production declines in the 1970s, until the advent of better hydraulic fracturing techniques in shales helped the region's operators find their fastball again.

This led oil and gas production out of the Permian to surge to the point where it took on a whole second life far larger than the first. Between 2011 and today, oil production quadrupled and is now more than 4 million bbl/d. Gas output has also



surged and could reach 15 Bcf/d by 2023, according to IHS Markit.

Unlike other booming shale plays, the Permian also has the advantage of existing infrastructure that has helped kickstart the region's ability to get production to market.

Yet this legacy infrastructure was quickly outmatched by production, which resulted in crude oil bottlenecks and negative natural gas prices in the region. "The problem was it bounced back so much that it just overwhelmed existing infrastructure," Peter Fasullo, principal at En*Vantage Inc., said.

Unlike when similar situations occurred in other shales, there wasn't the economic discretion to back off gas production to improve prices, since all the gas being produced in the Permian was associated gas from rapidly rising crude production.

According to Fasullo, the biggest challenge associated with the Permian Basin has involved developing end markets rather than midstream infrastructure. "Once there was this realization that new natural gas infrastructure was needed, gas pipelines were built across the Rio Grande to export volumes to Mexico. The problem is that Mexico hasn't really executed on its plans to convert to gas-fired power generation from petroleum-derived fuels. Their economy also hasn't grown as fast, and the only reason why we're exporting gas to Mexico really now is because Mexico's gas production is in steep decline," he said.

Pipelines for moving crude, liquids and gas are the infrastructure components most needed in the Permian, and their buildout is underway. "There's been a lot of money spent on infrastructure in the last several years to try to catch up with production, and I think that by the first part of 2020, for the most part we'll be caught up," said Karl Pfluger, president of Oryx Midstream Services, Midland. Oryx, the largest private midstream company in the Delaware Basin with at least 1 million acres dedicated to its system, will have transportation capacity exceeding 900,000 bbl/d.

Catching up—for now

Midstream capacity additions are lumpy, always not enough or too much, too soon or too late, as pipeline companies chase after producers and their activity. At one time in 2019, seven proposals for new Permian pipelines were on the table. The ones that have been greenlighted so far are expected to transport an additional 4 MMbbl/d of oil to the Gulf Coast by year-end 2022. More than 2 MMbbl/d of this new capacity will go to Corpus Christi for export, according to Wood Mackenzie.

That's the good news. However, consulting firm East Daley Capital has said that by 2021, crude oil pipeline capacity out of the Permian could surpass the basin's production by more than 3 MM bbl/d, "creating perhaps the largest midstream overbuild the word has seen." This may be a temporary phenomenon.



Permian producers have no choice but to have flow assurance, said Peter Fasullo, principal, En*Vantage Inc.





Permian production will once again exceed infrastructure, according to Karl Pfluger, president, Oryx Midstream Services LLC.

According to Enverus, the pace of Permian production growth is at risk of slowing down considerably if commodity prices remain flat. In order to support an increase in prices, long-haul pipelines to markets are necessary. Despite this, it's likely that production will again exceed infrastructure in the region because of the sheer size of the Permian resource opportunity.

"There's always been a cycle where production outpaces infrastructure, but it's an efficient market and you've got a lot of midstream teams chasing opportunities by trying to get ahead of the production curve and build more infrastructure. Our expectation is that this field is way north of 4 million barrels a day of production and at some point production will again exceed the infrastructure. We just don't know when that will be," Pfluger said.

Infrastructure development is so important that for many projects, multiple partners are needed. Producers and midstream operators have joined to ensure systems are close to the wellhead. Some E&Ps are taking equity positions in pipeline projects.

One such project is EPIC Midstream LLC's 700-mile EPIC NGL Pipeline. It had the capacity to transport 400,000 bbl/d of crude oil out of the Delaware and Midland basins, but the company's 590,000 bbl/d EPIC Crude Pipeline came online in January 2020. One of the partners in EPIC is Ares Management LP, which is a publicly traded global alternative asset manager that invests in upstream and midstream projects.

Large publicly traded midstream companies are also a driving force behind many projects, including Plains All American LP's \$1.1-billion, 575-mile Cactus II Pipeline that transports up to 670,000 bbl/d of crude out of the Permian. Both Cactus II and EPIC NGL pipelines began interim service in October 2019.

In addition, Energy Transfer LP and ExxonMobil's Permian Express IV pipeline expansion added 120,000 bbl/d of capacity to the system when it came online in the third quarter of 2019, and Phillips 66 Partners intended to bring its 900,00 bbl/d Gray Oak Pipeline online in late 2019.

"The Permian is such a big play that producers have to have flow assurance; they have to make sure



those hydrocarbons—whether crude, gas or liquids—flow. They have no choice,” Fasullo said.

Transporting these huge volumes to the Gulf Coast for export overwhelmed the market and depressed prices in 2019. Fasullo believes that sustained price depression may result in majors becoming further involved in the midstream.

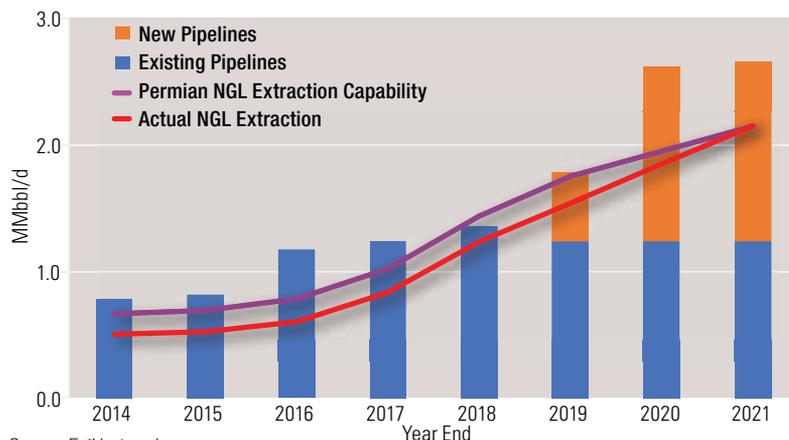
“Independent producers in the Permian are not well capitalized, and they are being pressured by investors to cut spending and focus on maximizing cash flows from volumes being produced. Larger major players like ExxonMobil and Chevron that have been in the Permian a long time will replace the independents as the future drivers of production growth. They have the staying power and the capital to continue to expand even with lower commodity prices,” he said.

Fasullo noted that the interest these majors take in the midstream is not necessarily full ownership or operation of assets, but they are gaining interest in various projects and assets in the region, because of the large volumes they have at stake and the critical need for flow assurance.



An early Delaware Basin midstream player, Vaquero's operations, such as the Caymus facility shown here, are now well-established. Photo courtesy Vaquero Midstream LLC

PERMIAN NGL EXTRACTION VS NGL PIPELINE TAKEAWAY CAPACITY



Source: EnVantage Inc.

“Permian producers have been anticipating the end of takeaway constraints and preparing to ramp up their production in the Midland and Delaware basins—assuming prices for the region’s benchmark West Texas Intermediate (WTI) stay at reasonable levels, by working with midstream companies to develop new gathering lines, storage capacity and shuttle pipelines to transport increasing volumes of crude oil from the lease,” RBN Energy said in a research note.

This infrastructure will connect to multiple West Texas hubs, including Orla, Wink, Crane and Midland. “By offering this optionality—and with it, the ability to access destination markets in Cushing, Corpus [Christi], Houston and elsewhere—midstreamers with well-thought-out gathering systems enable those they serve to secure the highest-possible prices for their crude,” RBN said.

Big play Permian

Gary Conway, president and CEO of Vaquero Midstream LLC and proud Aggie, told Hart Energy that he was aware of the Permian because of high school football and the iconic pumpjacks in some highlights of Friday night games. “I grew up in East Texas, but I was definitely aware of Permian High and Midland Lee growing up.”

The Permian has been a consistent part of Conway’s professional life since then, starting with early career consulting in sour gas fields around Pyote, Wink, Coynosa and Fort Stockton in West Texas. The Permian was always a place of interest as an area that kept rediscovering itself over and over again. Conway was a contributor in TEAK Midstream LLC. Though this company was largely focused on the Eagle Ford Shale, Conway said that he and his partners were looking at projects in other plays, including the Midland Basin.

After selling TEAK Midstream to Atlas Pipeline Partners LP in 2013, Conway and Bryant Patton,



Gary Conway, president and CEO of Vaquero Midstream LLC, has experienced the difficulties and successes of private midstream operations in the Permian.



Tanner Alexander
VP of Business Development
Brazos Midstream

“**F**ormed in early 2015, Brazos Midstream made its entrance into the Permian, specifically the Delaware Basin, through the acquisition of a small gathering system in Ward and Reeves counties. Over time, we have built upon that initial footprint to become one of the largest privately held midstream companies in the region.

“After recapitalizing in 2018, we are well prepared

for the next wave of midstream infrastructure that will be needed as technologies improve and production continues to increase. This type of growth will include the expansion of existing infrastructure and potentially M&A or some combination of both.

“The Permian Basin has proved to be a major contributor to our country’s energy independence, and we see this continuing. We believe in the longevity of the play and are excited about the additional midstream opportunities that will come as producers continue to advance their drilling programs. Staying ahead of production demands and customers’ needs is critical to any midstream company’s success and we look forward to continuing to provide the best customer service in the industry.”

one of his fellow partners at TEAK, teamed up to form Vaquero. They considered projects in the Midland, but realized they may have been a bit late to the party. Their story illustrates how private midstream players approach big Permian production growth.

“We realized it was going to be tough to build an asset that we had in mind in the Midland Basin. We were always looking to build a much larger scalable asset, but the Midland side was a bit crowded, so we went further west to the Delaware Basin. We felt we could get into the area and build something of size and scale in that area, which was sort of like the new West,” Conway said.

When Vaquero entered the Delaware, drilling was just starting to ramp up. Future production was going to require plenty of additional infrastructure, especially takeaway capacity.

One of the ways Vaquero seeks to differentiate itself in the face of fierce competition from other midstream operators is to focus on service. “Those of us on the private side, we’ll often face a bit of a struggle with some producers who favor public companies, because they’re afraid the private equity-backed companies will sell at some point and they don’t know who will then own the midstream asset. Fortunately, this wasn’t as big of a deal when we started Vaquero,” he said.



Oryx Midstream Services is expanding its 800 Mbbbl crude oil storage capacity in Crane, Texas, by 360 Mbbbl. *Photo courtesy Oryx Midstream Services LLC*



1989
 The Exxon Valdez oil supertanker ran aground on Bligh Reef in Prince William Sound, Alaska, after almost 12 years of daily oil tanker passages through the area. The accident resulted in a massive oil spill.

1990
 The first natural gas futures traded on Nymex, with the delivery at Henry Hub.

1990
 The Santa Rita No. 1 was taken out of service and plugged after 67 years of service.

A SEA CHANGE IN THE WATER MANAGEMENT SPACE

A new partnership ushers in the next stage of evolution in the Permian Basin's water business, creating new growth opportunities in the basin's core areas.

Oilfield Water Logistics LLC (OWL) has been a pioneer in the water infrastructure and management space for nearly a decade with a focus on the Permian Basin. "We were the first [water] company working in the core of the northern Delaware Basin," said Chris Cooper, CEO. But now, thanks to a recent partnership with InstarAGF Asset Management Inc., a leading essential infrastructure investor, OWL is ready to launch its next chapter—and possibly the next evolutionary stage of the Permian's water business as a whole.

"It's been interesting to watch the evolution of this business to midstream," Cooper said. "At first, it was all about trucking and disposal, then pipeline gathering and mostly disposal, and now, complex hydraulics with gathering, re-use and recycling."

OWL has proved its reputation for customer service and safety in what Cooper called "a tough business with high barriers to entry."

"Through the downturn of 2016, OWL was building infrastructure and taking water and proving our mettle," he said.

But with millions of barrels of produced water coming out of the ground each day, OWL recognizes the opportunity for further development, in terms of both infrastructure and investment, in the sector.

That's where InstarAGF comes in. "To be recapitalized and re-energized with an infrastructure partner of Instar's caliber is exciting and bodes well for our company's next chapter—and for the Permian," Cooper said. "I think that infrastructure funding coming into this space is a threshold event for the whole industry."

"Instar has a longer term vision for the Permian that aligns perfectly with that of our customers," he continued.

"[With Instar's support,] we can engage in long-term projects with our customers with a 20-year trajectory."

Sarah Borg-Olivier, senior vice president at InstarAGF, confirmed this approach. "Infrastructure is stable and predictable due to the essential nature of the service it delivers. The outlook of a partner like Instar is very different from other investors. We look for high quality businesses to grow long term where we can work with management to create new value for customers and other stakeholders."

The Permian has moved from exploration to production and E&Ps to a long term focus, the idea of a more farsighted water space is promising and, with infrastructure funding, hardly a distant reality.

The ability to make water commitments on a 10- or 20-year basis is critical. It alleviates the reluctance of some producers that, prior to signing a contract, worry about whether the same management team will be handling their water in a few years, Cooper explained.

Ultimately, "that's what this is all about—serving our customers," Cooper said. OWL supports "a broad set of blue-chip operators," and "it was key to bring in a large capital partner to be able to fulfill our customers' evolving needs." ■



OILFIELD WATER LOGISTICS



oilfieldwaterlogistics.com

"To be recapitalized and re-energized with an infrastructure partner of Instar's caliber is exciting and bodes well for our company's next chapter—and for the Permian."

—Chris Cooper,
CEO, Oilfield Water Logistics LLC





GOODNIGHT

MIDSTREAM

99%

UPTIME FOR
CUSTOMERS

58

SALTWATER
DISPOSAL WELLS

500

MILES OF
PIPELINE

**BUILDING AND OPERATING
PRODUCED WATER INFRASTRUCTURE**

Part of this confidence was due to the size of Vaquero's Caymus natural gas processing system in Pecos County. Two processing plants have total capacity of 400 million cubic feet per day (MMcf/d). The system was originally designed to provide up to 1 billion cubic feet per day (Bcf/d) rich gas header capacity to the cryogenic facility. Conway also noted that Vaquero was purposefully set up to look like a long-term, MLP-style company in order to make producers more comfortable.

Caymus was designed with optionality in mind, with six residue connections and four NGL connects. This allows producers to make their own downstream arrangements should they choose rather than thinking Vaquero is pushing them in a certain direction.

Vaquero decided to build its processing facility as close to the Waha gas hub as possible because that allowed for the flexibility of quickly connecting to multiple downstream infrastructure, interstates and intrastate pipelines on both residue gas and NGL products. Multiple access points ensure that producers can get the best price for their product or have a place to offload it if prices are not as strong.

The company has a third 200 MMcf/d plant in inventory that it is gearing up to construct once a final decision is made to move forward. "You don't build 400 MMcf/d right away. You build 200 MMcf/d [first] because it takes a while to grow it," Conway said.

To bring the third Caymus plant online, Conway said the company is reading the tea leaves. "We're watching our producers' growth rates and crude prices, even though we're dealing with associated gas. This is a crude oil basin. It's very important to them because they manage inside their cash flow just like we do, but we'll be ready when they are," he said.

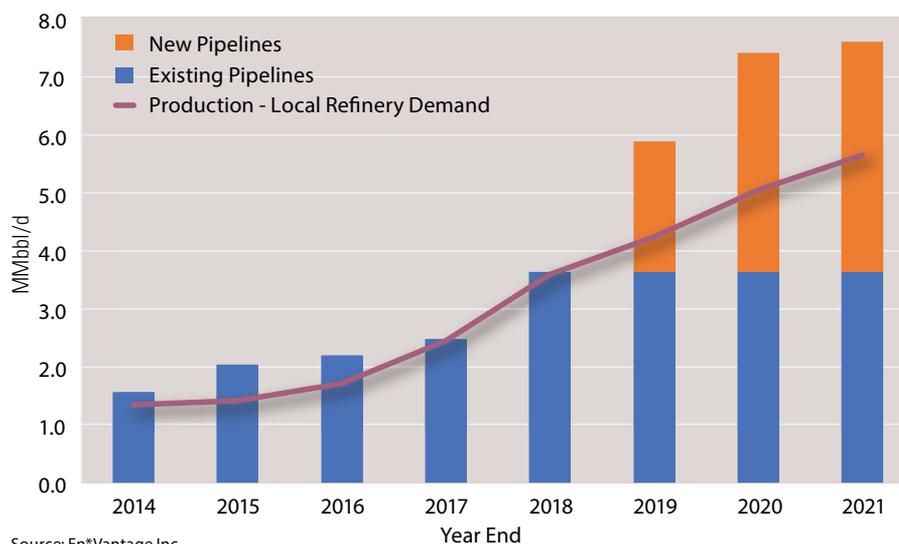
The long-term goal for Caymus? It will be a 1 Bcf/d system with five 200-MMcf/d processing plants, although Conway said the company has room for more than five plants on the system's 309 acres. Though the Permian is a crude oil play, a massive amount of associated natural gas is coming out of the wellhead, and reliable service will be paramount for producers.

"Our solution was to go in with large assets because the gas needs processing, and it's very difficult in our mind, to be able to go in with smaller plants and pipelines," Conway said.

Legacy issues

One challenge midstream operators face in the Permian is the region's history. Some operators used legacy midstream assets at first for expedi-

PERMIAN OIL SUPPLIES VS. PIPELINE TAKEAWAY CAPACITY



Source: En*Vantage Inc.

ency, but that created issues because those assets weren't designed for the products or specifications inherent in today's surging oil and gas production.

"That legacy infrastructure served as a good bridge to new infrastructure, but the problem is that it was really built to service vertical activity, and it has been overwhelmed by horizontal production. We've had to basically recreate any infrastructure that did exist and then fill in the gaps for places that didn't have infrastructure," Pfluger explained.

Another issue has been the sheer volume of legacy infrastructure in place in the region, which can make it difficult to build new infrastructure. In Vaquero's case, Conway said the company crossed more than 100 pipelines in the first three miles of the Waha area with its 30-inch Lariat header pipeline.

"The challenge has been more on the right-of-way side of things, maintaining safe distances and depths," he said, adding that Vaquero and some other midstream operators have placed extra importance on being environmentally sound.

As the Permian boom really took off, the midstream lagged behind production to a great extent, but it has been catching up. "We as an industry almost always overbuild, though sometimes it's not been in the right place. I think we all try to build in the right places, but inherently producers are pushed to the edges of plays needing services," Conway said.

"Producers will go out into a geologic area and press the edge to see where the boundary is. Everybody first started out in relatively the same area and then started spreading out and we in the midstream will follow to serve the guys the furthest away," Conway said.

Vaquero has chosen to build laterals off its large rich gas header into these areas rather than build a



Finite labor resources, said Brett Wiggs, CEO of Oryx, lead to a very interactive construction process in the Permian.



Drew Ward
Partner & Chief Commercial
Pinnacle Midstream II LLC

“My first experience in the Permian was five to six years ago when I first met with Clayton Williams and he told me that Reeves County was going to be the center of the universe before anyone else recognized it. He was proven right when they sold to Noble Energy Inc. “Pinnacle [Midstream] I was a success due to the risk that the management took

on an unknown ‘fringe’ area in Culberson County that turned out to be some of the best acreage in the Delaware Basin.

“When starting Pinnacle [Midstream] II, it was impossible to not begin looking for opportunities within the Permian as it still has a lot of chapters to write in its development cycle.

“The Permian Basin is a national treasure in that it was thought to be depleted just a few years ago and has since gone through a revival. There isn’t any other place on earth that has the proven stacked pay and other potential horizons that the Permian does.

“The Permian directly and indirectly influences every Texan whether they know it or not through revenue taxes, royalties to the UT Land system and the incredible amount of jobs that have been created through the development of the resource.”

plant further away from takeaway, power and other needed infrastructure.

Despite its existing assets, the Permian has required significant investment in other areas outside of the typical midstream purview as production has grown in the past decade. Conway noted that the sudden development of the basin created a huge need for more electrical power, better highway infrastructure and lots of workers. On the worker front, this has required not only skilled industry workers, but also healthcare, educational, and service workers to help deal with the influx of industry personnel.

Brett Wiggs, CEO of Oryx Midstream Services, said that the finite resource pool for skilled workers in the region has translated into higher construction costs and longer lead times to execute projects.

A midstream project may seem like any other construction project on paper with lead times for funding, planning and development. During this phase, midstream operators work very closely with producers, similar to how real estate developers meet regularly with clients. However, operators and producers may actually meet more often once the facility or pipeline system is online.

“Developing a pipeline gathering system that meets producers’ needs is a very interactive process, so regular interaction with the customer is extremely important,” Wiggs said. We always have a minimum of biweekly meetings to update our process, communicate and coordinate with those producers. As we get closer to in-service, that often goes to kind of a weekly coordination meeting.”

He added that this kind of project management extends to working with other operators, especially on the downstream side, to ensure that connecting projects remain on track throughout the value chain.

Rapid growth, more capacity

Private equity-backed midstream teams have found a nice foothold in the Permian since they’re able to move quicker and are more focused than some companies that operate in multiple plays, according to Pfluger.

“Larger public companies can offer more services in-house that we use third parties for, but we believe that we’re more nimble and able to act quicker than many of those companies. We’re also 100% focused on one asset: our system in the Permian Basin,” Pfluger said.

When Wiggs, Pfluger and their partners created Oryx Midstream, they wanted their system to stand out for safely being used 50 years in the future. This system is built of 100% steel with a larger diameter pipeline than required. It also features world class control systems such as SCADA, leak detection, continuous monitoring and a 24-hour operation and control center.

Oryx Midstream’s pipeline system is also the only purpose-built, batchable system in the Permian. The company can transport crude at various API ranges and then segregate them at central terminals, then batch that through its regional transport line for delivery to different market centers.

The rapid growth of the Permian is evident in the Oryx pipeline system being designed to transport about 200,000 bbl/d of crude. Company officials assumed that would be enough for about five years—but after 18 months, they had to expand due to high demand from producers. Oryx more than doubled the line’s capacity to achieve an average transportation capacity of about 425,000 bbl/d. The company anticipates capacity to reach about 1 million bbl/d in the next few years.

In early October 2019, Oryx announced a \$355-million joint acquisition with Rattler Midstream LP of Reliance Gathering LLC. This deal included more than 230 miles of crude gathering and regional transportation pipelines and about



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According to a Rystad Energy analysis, gas flaring and venting in Texas and New Mexico reached an all-time high in third-quarter 2019, averaging more than 750 MMcf/d.

200,000 bbl of crude oil storage in Midland, Martin, Andrews and Ector counties. Oryx will operate this system.

“We’re really excited about the acquisition and working with Rattler and their parent, Diamond-back Energy. It’s our first expansion to the Midland Basin; it gives us a good growth platform to expand the services that we have on the Delaware side of the Permian into the Midland Basin, and to capitalize on infrastructure that we already have in place relative to connections and deliverability,” Wiggs said.

Bottlenecks abound

In some ways the biggest concern from a midstream perspective in the Permian is related to natural gas production. Producers have been focused on crude and liquids and more relaxed when it comes to developing new natural gas pipelines and LNG export terminals in certain hubs.

Since natural gas is a byproduct of crude production, producers haven’t been as focused on this less economic commodity. The result is that midstream operators are following producers’ focal points to develop crude and NGL infrastructure first.

“E&P companies have become so efficient that they’ve been able to produce at much higher rates, and it overruns the existing infrastructure. That’s why you’ve seen so many bottlenecks occur,” Fasullo said, noting there has been significant flaring of gas in the region. According to a Rystad Energy analysis, gas flaring and venting in Texas and New Mexico reached an all-time high in third-quarter 2019, averaging more than 750 MMcf/d.

The LPG export terminal area of choice for Permian production will be the Upper Texas Gulf Coast from Freeport to Nederland, Texas. While Corpus Christi is closer and has fewer potential bottlenecks than Mont Belvieu and the Houston Ship Channel, there is far less NGL storage and LPG export capacity in the greater Corpus Christi area.

“There’s not enough NGL market down in Corpus to absorb that much liquid. Just isn’t. If you go up the coast at Belvieu, you’ve got a huge market with much more optionality,” Fasullo said.

Indeed, it’s likely that once takeaway capacity

meets production levels, the next challenge will be storage, along with market distribution to domestic and international customers.

Although producers have gotten extremely efficient at drilling and the midstream companies have been quick to develop new pipelines and natural gas processing plants, developing and constructing world-scale ethane crackers, refineries and export terminals takes longer. Many large integrated midstream players such as Enterprise Products Partners LP, Targa Resources and Energy Transfer Partners are meeting these challenges by expanding their downstream infrastructure, particularly their LPG export capacities.

Indeed, as of mid-year 2019, there were as many as eight offshore export terminal projects proposed, requiring billions of capital investment. Among other objectives, these projects recognize the need to better accommodate very large crude carriers (VLCCs), which, in order to be loaded efficiently, require either deeper channels or offshore terminals.

Admittedly, some projects have generated concern. Trafigura Trading LLC’s proposed Corpus Christi offshore terminal has faced opposition from the Port of Corpus Christi, due to the terminal’s purported environmental risks. Others, however, have received stamps of approval, such as the Phillips 66 subsidiary Bluewater Texas project, which would link to two pipelines and receive VLCCs to carry Permian crude.

Even so, the results from new links between the pipeline buildout and export terminals already show. According to the companies’ August 2019 press release, Trafigura and Buckeye Partners LP’s terminal at Corpus Christi received its first delivery of Permian crude oil from Plain’s All American’s Cactus II pipeline, ahead of the line’s full operation, foreshadowing increased activity in the export hub.

This will be needed, given the quick rise of Permian crude production, which according to the U.S. Energy Information Administration has increased from about 849,000 bbl/d in 2007 to 4.2 million bbl/d at present.

That’s a huge increase, and it’s not likely to slow down anytime soon. It’s likely the midstream buildout won’t be slowing down anytime either. 



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PERMIAN

CHAPTER 8 | PERMIAN LEGENDS



Photo by Tom Fox

PERMIAN BASIN

PERMIAN LEGENDS

GEORGE T. ABELL

It's hard to talk about the history of the petroleum industry without including George T. Abell. Based in Midland and starting as an independent during the Great Depression, Abell's instincts translated into tremendous success. But the capstone of his career was to translate his dream for the Permian Basin Petroleum Museum, Library and Hall of Fame into brick and mortar.

Born in Kansas, Abell graduated from Colorado A&M College with degrees in civil and mechanical engineering. He joined Midwest Refining Co. in Wyoming, where he was assigned to the company's geological department. After spending time in Utah, Colorado, New Mexico, Oklahoma and, finally, West Texas, Abell joined Rector Oil in 1927 and moved to Midland.

Not long afterward, Abell headed out as an independent oil operator. He took farmouts from major companies, including Shell and Humble Oil, in Ward and Pecos counties and drilled shallow wells in Shipley Field. In a 1976 newspaper interview, he said, "But the price of crude was low, being sold for as little as 17 cents a barrel. Some of the oil was sold to school districts for heating purposes."

Abell raised funds for drilling by mortgaging his home and automobile and borrowing money at a high rate of repayment: a 50% bonus on the production of oil. Through this time, Abell lived in a shack in the field and obtained enough second-hand equipment to continue his business.

His greatest achievement came from his subsurface geological work, which located a promising area for oil and gas northeast of Imperial in Pecos County. He worked up the geology and leased

about 13,000 acres. After promoting several test wells, one finally was completed in 1940 for a potential of 939 barrels of oil per day from the McKee sand. This served as the opening for the Abell Field. He continued an active exploration and development program until there were 44 fields named Abell. By 1976, these fields had produced more than 32 million barrels of oil.



George T. Abell

In 1956, Abell built a gasoline plant to serve the Abell area. Working with associates in 1962 and 1963, he drilled the Gomez Field discovery well near Fort Stockton, which went down 21,624 feet in the Ellenburger and had an adjusted open flow potential of 68 million cubic feet of gas per day. At that time, this was the deepest producing well in the world.

Abell was involved in drilling between 250 and 300 wells and did the majority of the land and

geological work and much of the engineering and production.

A history lover, Abell saw pieces of the oilpatch disappearing with the advent of new technology and wanted to do something to save its history. He and several friends began gathering old equipment and storing it in warehouses. With Abell spearheading the idea, they began to plan for a museum that would tell the story of the petroleum industry, covering its every aspect, from how petroleum was created to the geology, the technology and the people who were part of the story. The result was the Permian Basin Petroleum Museum, Library and Hall of Fame. From idea, to raising money, to concept and design, Abell was the guiding force. His dream opened its doors in 1975, dedicated by President Gerald Ford. ■

From day one, the successes, setbacks and surprises of the Permian Basin have been marked by the daring and doggedness of the players, whether they were exploration geologists, big-time producers, drilling and frack crews, or bankers and investors. While we cannot possibly profile them all, we do acknowledge all of them. Here, enjoy reading about some of them.

We'd like to acknowledge these sources for their valuable information and photographs: The Midland Petroleum Museum Archive Center, "The Greatest Gamblers," El Paso Herald Post, Midland Reporter-Telegram, FocusNM.com, The Odessa American, and Henry Resources.

—BIOGRAPHIES BY
LANA COOPER



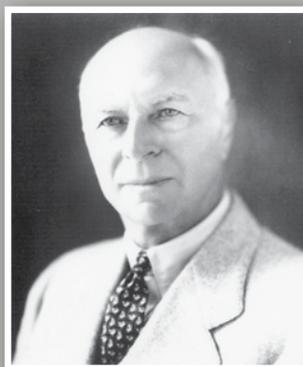
MICHAEL L. BENEDUM & JOSEPH C. TREES

One of the greatest wildcatting teams in history came out of West Virginia in the 1890s. Michael L. Benedum and Joseph C. Trees met in Pennsylvania. Trees was the operating man, an engineer and an expert in drilling. Benedum was the finance guy and assessed the risks. They worked together as Benedum-Trees Oil Co. and also branched out alone on various deals.

In 1905, they made their big discovery in Illinois. They searched the country and overseas for oil. The breakthrough in the Permian Basin, though, came with the discovery of the Yates Field in southeastern Pecos County. Wells had been drilled in numerous places, but the prevailing thought was that the Pecos River marked the western limits of petroleum deposits in Texas.

Ira G. Yates had recently bought a ranch in the area and didn't have enough money to pay the mortgage and taxes. On a hunch, he invited Transcontinental Oil Co. to drill on his land. Transcontinental was working with Ohio Oil, and wells drilled in another area of Pecos County were dry. Getting a rig moved 60 miles to the Yates Ranch was not an easy proposition.

But one of Benedum's employees said he had promised Yates when he leased the ranch that a well would be drilled there. Benedum reportedly said, "If you gave your word we'd drill, you know I'll back you up." Ohio Oil agreed to drill that one well. They reached oil at 1,000 feet, and the well blew in with tremendous pressure.



Michael L. Benedum



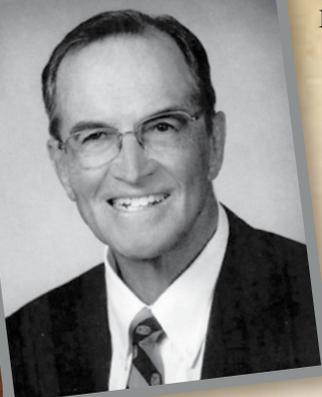
Joseph C. Trees

The Yates Field was significant to the basin because of its size, potential and the fact that exploration now was feasible west of the Pecos. The Yates Field has produced more than 1 billion barrels of oil.

Working alone, Benedum continued wildcatting and discovered the deep sands of the Ellenberger. In 1947, the Alford No. 1, located about 50 miles southeast of Midland, started a boom that swept West Texas.

Benedum and Trees are credited with finding more new oil in more new places than anyone could imagine and are placed in the top ranks of history's wildcatters. ■

ROBERT C. BLEDSOE



Robert C. Bledsoe

First, he wanted to be a cowboy and then a trial lawyer, but Robert C. Bledsoe was assigned to oil and gas law wherever he went. He used that knowledge to change the Texas Supreme Court's ruling on title opinions, which greatly impacted the petroleum industry, simplifying oil and gas title work.

Bledsoe was born in 1930 in El Paso, Texas, and grew up in Marfa. He attended the New Mexico Military Institute and then the University of Texas at

Austin. After graduating in 1955 with his law degree, Bledsoe moved to Houston for a job with Baker Botts practicing oil and gas law. But two years in the Houston heat, humidity and traffic sent Bledsoe north to Roswell, N.M., for a job with Hervey, Dow & Hinkle and another assignment in oil and gas law.

Two years later, Bledsoe was offered a job with the Midland firm of Stubbeman, McRae, and he thought he would finally get into litigation. He didn't.

In 1974, Bledsoe's experience in oil and gas law caught the attention of British Petroleum, and he was asked to

help write the Prudhoe Bay Agreement and Unit Operating Agreements for the company's Alaska operations. He spent numerous weeks out of town working on the legal papers.

That same year, Bledsoe and five other attorneys started their own law firm, even though they had no money and no clients. However, time was on their side. The Arab Oil Embargo hit in 1973, and the petroleum industry boomed. The expanding firm—known as Cotton Bledsoe Tighe & Dawson—moved into new offices in 1984 and then watched the price of oil drop to \$10/barrel. In the ensuing years, the firm developed into one of the state's most highly regarded oil and gas law specialists.

In 1984, the Texas Supreme Court ruled in *Alford vs. Krum* that no matter what a deed said, the granting clause was the final determination. This put thousands of former title opinions at risk. Attorneys throughout Texas voted this as one of the 10 worst oil and gas decisions by the court. In 1991, Bledsoe took the *Luckel vs. White* case before the Texas Supreme Court, which essentially challenged the 1984 decision. The Court reversed its previous decision and ruled that attorneys could look to the four corners of a document to decide the parties' intentions.

For his more than 50 years as an attorney, Bledsoe has been regarded as one of the most knowledgeable oil and gas lawyers in the state. ■

JACK E. BROWN & CYRIL WAGNER

Jack E. Brown and Cyril Wagner formed a partnership in 1962 with no money. Possessing a passion and drive to find oil and gas, their company, Wagner & Brown Ltd., built a reputation for success.

Cy Wagner was born in 1934 in Tulsa, OK, and graduated in 1956 from the University of Oklahoma with a degree in geology. He started as a scout and geologist for Amerada Hess in Midland and later joined J.E. Jones Drilling.

Jack E. Brown was born in 1925 in Brownsville, Texas, and, after serving in World War II, graduated in 1950 with degrees in petroleum and mechanical engineering. He worked as an engineer first in Alice, Texas, and then in Venezuela, before joining J.E. Jones Drilling in Midland.

By 1961, both Wagner and Brown could discern their future at the drilling company was dim.

They started talking about a partnership. They pooled their resources, which amounted to \$0, and opened the firm on April 1, 1962. The first major expenditure was getting a loan for \$20,000 to build a rig. Despite Brown's hesitancy, that "popcorn" rig helped pay the bills. Using tubing and a diamond drill bit, the men deepened wells in the Clearfork, going down to the Spraberry Formation.

Their break came in the Bagley field outside Tatum, N.M. A major company had lost interest because of the excessive amounts of water produced with the oil. Brown engineered the Burro Pipeline to dispose

of the water, and the two men began drilling quickly. Wagner prepared the geology for the next well and Brown set the pipe. They averaged two wells a month; most paid out in about eight months. By the time they finished in the Bagley, Wagner and Brown had completed more than 60 wells that provided significant cash flow.

In 1975, the team began its largest drilling program ever on 30,000 acres of the Conger Field in Sterling and Glasscock counties, Texas. By 2000, Wagner & Brown operated more than 600 wells to produce more than 11 million barrels of oil and 265 billion cubic feet of gas.

The company branched out into natural gas gathering and marketing, crude oil purchasing and reselling, pipeline development, and construction and operation.

Through their determination, Cy Wagner and Jack Brown earned the distinction as oilmen entrepreneurs. ■



Jack E. Brown



Cyril Wagner

THOMAS C. BROWN & JOE ROPER

A fast-talking salesman paired with the ultimate roughneck to develop Tom Brown Drilling into one of the most successful independent oil companies in the nation and one of the largest drilling companies in Texas. Later, it became the first Midland oil company to go public.

Thomas C. Brown studied engineering in college before deciding it was time to find a job. He started in 1949 as a salesman with Goodyear Tire and Rubber Co. at Wichita Falls, an area impacted by a booming oil industry. After two years, during which time he successfully wooed back the Halliburton account, Brown opened Oilfield Specialties.

With Smith bits as one of his products, Brown sought drillers willing to try them. He found a candidate in Joe Roper, who worked for Jack Grace Drilling Co., in 1953, when Brown met Roper on a rig at midnight with a new Smith tricone bit.

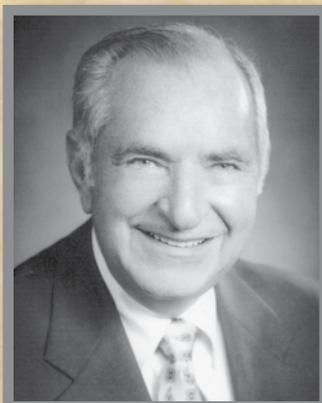
Roper, the 12th of 13 children, attended college for one semester and left to support the family after his father died. Roper thought if Brown was crazy enough to show up at midnight, then he would try the new bit. "He made the most fantastic run with the bit, and we ended up selling a ton of them," Brown recalled.

Brown bought a rig and entered the world of independent oil operators. Roper worked as a driller and then as supervisor for Brown. In 1959, Brown's fleet had grown to four rigs and he owed money on all of them. He called in Roper, asked for \$2,500 and made Roper part-owner.

"I turned him loose to do his work. I made the deals and negotiated the contracts," said Brown, who often showed up at the rigs at midnight to discuss business.

The combination of sales with skills boosted the company. In 1969, the firm was publicly traded, and the name was

changed to Tom Brown Drilling Co. It changed again in 1971 to Tom Brown Inc. when it added E&P. The company expanded during the 1970s, opening extensive Spraberry production in Martin County and also moved into Wyoming and North Dakota. In 1979, the company started Oncor, a tool manufacturing firm.



Thomas C. Brown



Joe Roper

Both men, admittedly, were workaholics. Roper called for drilling reports until the day he died in 2001. Brown, who passed in 2006, said of himself: "I will always be a wildcatter at heart."

Then the economic bust hit. In 1981, the company made \$75 million and Exxon was begging for more rigs to add to its 11. The following year, it lost everything. Assets were sold to pay off debts, which was accomplished at 100 cents on the dollar.

The company was restructured, but at its peak, the various companies employed more than 2,000 people. The drilling operation spun off as TMBR Sharp Drilling Co. with Roper as CEO. Brown took over Tom Brown Inc., an E&P company. It later was sold for \$2.2 billion.

Both men, admittedly, were workaholics. Roper called for drilling reports until the day he died in 2001. Brown, who passed in 2006, said of himself: "I will always be a wildcatter at heart." ■

1999

Following an agreement signed the previous year, Exxon and Mobil joined to form ExxonMobil Corp. in an \$81 billion merger, thereby forming the largest non-state-owned oil and gas company in the world.

2001

The Chevron-Texaco merger was approved by the FTC, allowing Chevron Corp. to proceed with the \$39 billion acquisition of Texaco Inc. to create the 2nd largest U.S. oil and gas company.

2003

Kinder Morgan took over operation of the Yates Field in Pecos County from Marathon Oil Co. The field had surpassed 1.5 billion bbl.

2004

Encana agreed to buy Midland E&P Tom Brown Inc. for \$2.7 billion.



George H.W. Bush, left, and George W. Bush, right, in Midland.

GEORGE H.W. BUSH & GEORGE W. BUSH

A different kind of life. Something challenging. Outside the mold. Those thoughts pulled a young man from his Connecticut roots to the West Texas plains in the late 1940s. Those same thoughts pulled his son back to Midland where he had spent his young childhood years.

George H.W. Bush and his son, George W. each pursued a career, first in the energy industry and, later, in the White House. They both learned that West Texas produces a different type of energy—one comprised of individualism, community, family and faith.

After serving in the Navy during World War II, George H.W. Bush returned home to his wife Barbara and son George to finish his degree at Yale University. Graduating in 1948, he looked for a job that he said was different. Advised to go to West Texas, Bush started as an oilfield equipment salesman for Ideco, a subsidiary of Dresser Industries. In Midland, he and friend John Overbey founded Bush-Overbey Oil Development Co., which bought and sold oil drilling royalty rights. In 1953, they merged with friends Bill and Hugh Liedtke to start Zapata Petroleum. By the end of 1954, they had 71 wells producing an average of 1,250 bbl/d. The company added offshore drilling operations, and in 1959, the offshore segment became a separate company, with Bush as its president.

Bush picked up his family and moved to Houston, where his company prospered—as did his political aspirations.

In a 1979 interview, Bush noted the oil field doesn't get credit "for the fiber of its people. ... But the way they devoted their lives to their work, their fierce loyalty, competitiveness and spirit were an inspiration. It made a lasting impression on me."

After settling into the offshore business, Bush turned his

eyes to politics. In 1966, he won the race for U.S. Congress from Houston's Seventh District. The following years brought political ups and downs: a 1970 senatorial defeat, an ambassadorship to the United Nations, two years as chairman of the Republican National Committee and director of the CIA in 1976 and 1977. In 1980, Bush was elected vice president with Ronald Reagan as president. In 1988, Bush was elected to the top spot, where he served four years.

Son George W. never forgot his early years in Midland or his close friends. After graduating from Yale with a bachelor's degree in history, he enlisted with the Texas Air National Guard. From there, he went on to Harvard for his MBA.

And then he did what his father had done—moved to Midland to start a career in the energy industry.

"I didn't want to work for a corporation," he said. "I wanted to strike out on my own in business." Veteran landmen showed Bush what to do, and then he started trading minerals and royalties. Eventually, he founded Arbusto Energy. He proved to be an excellent salesman and fundraiser, but the young business major faced dry holes and barrels of disappointment.

"The largest lesson I learned in Midland still guides me. Everyone, from immigrant to entrepreneur, has an equal claim on this country's promise."

—George W. Bush

His longtime friend Joe O'Neill introduced Bush to another Midlander—Laura Welch. They were married in 1977, and Bush already was campaigning for the U.S. congressional seat on the Republican ticket. After losing the election, he and Laura remained in Midland until 1986, when they moved to Dallas. Bush returned to his first love—baseball. He found some partners, and the group bought the Texas Rangers.

But politics hadn't left his blood. In 1994, he won the Texas gubernatorial race and was re-elected in 1998. Two years later, Bush entered the presidential race and, before the year ended, he had won the hard-fought race against Al Gore.

When terrorists attacked the U.S. on September 11, 2001, Bush relied on the principles he learned in West Texas. "I learned in Midland you have to stand for what you believe and to defend it. Midland has a spirit of individualism that says 'stick to your guns and don't sell your soul.'"

He told a reporter, "I come from a different place and it has made me a different leader. There was a restless energy, a basic conviction that with hard work, anybody could succeed and everybody deserved a chance. The largest lesson I learned in Midland still guides me. Everyone, from immigrant to entrepreneur, has an equal claim on this country's promise." ■

RUFE S. BYNUM

Rufe S. Bynum, aka Mr. Core Lab, set the standards in West Texas for analyzing cores for various clients and for maintaining confidentiality.

As a teenager, he became the sole wage earner for his San Antonio family when his father lost their ranches during the Depression. Bynum worked his way through Texas A&M University and graduated with a degree in petroleum engineering in 1938. Core Laboratories Inc. hired Bynum and sent him to Centralia, Illinois, and then to Shreveport, LA, where he opened several offices for the company. After serving in World War II, Bynum returned to Core Lab, which sent him to Midland in 1949 to open the Midcontinent Division office.

Numerous associates from those years noted Bynum's attention to detail, his leadership skills and his focus on innovation, which led to Core Lab's worldwide reputation. One associate referred to Bynum as the "Einstein" of the industry.

In the early 1950s, core analysis was 90% art and 10% science as the industry utilized homemade equipment and variable procedures. West Texas reservoirs offered extreme challenges with producing formations



Rufe S. Bynum

that were extremely heterogeneous from well to well. Bynum and his staff spent countless hours designing equipment and procedures so these rock formations could be evaluated properly for their fluid saturations and physical properties. Among the innovations were core gamma and whole core analysis. His new methods shortened the data turnaround time to the operator from weeks to hours.

He listened to his clients' needs and designed equipment and procedures to answer their requirements. Above all, Bynum was known for his confidentiality. In short, Bynum helped his clients find millions of barrels of oil and gas.

Under Bynum's leadership, Core Lab initiated industry seminars in 1959, starting with a course in the fundamentals of core analysis. The program grew, and in one year, 1,700 people attended the various schools at Core Lab.

Bynum also helped found the Midland Energy Library, a non-profit geological library preserving valuable historic geological information being disposed of by merging E&P companies.

His honesty, drive, innovation and devotion to core analysis defined Mr. Core Lab, Rufe S. Bynum. ■

MACK CHASE & JOHN R. (JOHNNY) GRAY

Mack C. Chase and John R. (Johnny) Gray each developed a reputation for their knowledge of the petroleum industry in southeast New Mexico. In 1974, they joined forces and merged their personalities and talents to form the Marbob Energy Corp. in Artesia. These men discovered the productive capacity of the Yeso Trend and were pioneers of the field that would become the largest oil producer in New Mexico.

Mack Chase grew up in Loco Hills, N.M., and attended Artesia schools. After serving two years in the military, Chase returned to Artesia and started Chase Well Service with his brother George. By 1968, he had established his own business, Mack Chase Inc., and was operating 18 to 21 rigs.

Johnny Gray grew up in Artesia and learned the basics of both the oil field and house-moving businesses from his father. After military service, he also returned to Artesia and found work with C.H. Mahres as a tool dresser. He advanced to drilling superintendent and then joined National Drilling as a pumper. When Kewanee bought out National, Gray left to start his own business: Gray Pumping Service. With his old pickup and used tools, Gray grew the company to 35 employees, pumping and servicing wells in Eddy, Chaves and Lea counties.

The year 1974 brought the two men to a crossroads, and they decided to merge their talents into one company, Marbob. Gray had an opportunity to buy some wells, but he didn't have the money. Nor did Chase, who had heard about the wells. But Chase's philosophy was, "If it's a good

deal, go for it." Chase told Gray they could get the money in six months and to tell the seller they would take the wells.

The merger proved successful. Chase was known for his boisterous personality and full-speed-ahead business decisions. Gray tempered him with a conservative, analytical sense that kept the duo from jumping into a venture too quickly.

After the Yeso Trend discovery, the men purchased properties from Sun Oil Co. and Tenneco that kept them going at a time when other companies failed. They developed innovations in completion techniques that helped them to acquire, drill and produce extensive amounts of oil and gas in southeast New Mexico.

In 1992, the two men went their separate ways. Gray kept his share of the assets and continued operating as Marbob. Chase put his assets into a new company, Mack Energy Corp. Before two years had passed, each owner had built his company back up to where production exceeded 20,000 barrels per day.

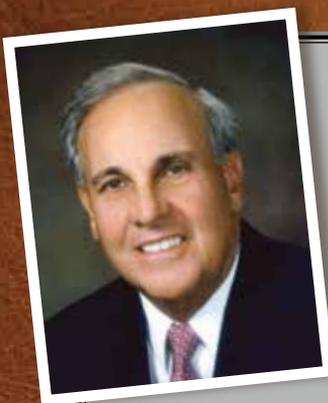
Marbob was purchased by Concho Resources in 2010 for \$1.65 billion; Chase also sold a large property to the Midland-based firm. Chase and Gray are still remembered for their integrity, hard work, entrepreneurial spirit and generosity to their employees and community. Their partnership became legendary in southeast New Mexico. ■



Mack Chase



John R. (Johnny) Gray



Ted Collins

TED COLLINS & HERB WARE

C.O. (Ted) Collins Jr. was a people person who loved making deals. Herbert E. Ware Jr. preferred the quiet side of the business and in-depth assessments. This duo formed Collins & Ware Inc., developing a reputation as “Wildcatters Extraordinaire.”

Collins and Ware both attended the University of Oklahoma. Collins graduated with a B.S. in geological engineering;

Ware earned a B.S. and M.S. in geology.

Collins was hired by Pan American Oil Co. and worked in Odessa and Andrews before moving to Midland in 1963. It wasn't long before he left to buy leases in the Delaware Basin.

Ware first worked for Arkansas Fuel and then Richardson & Bass/Bass Production Co., which brought him to Midland in 1963.

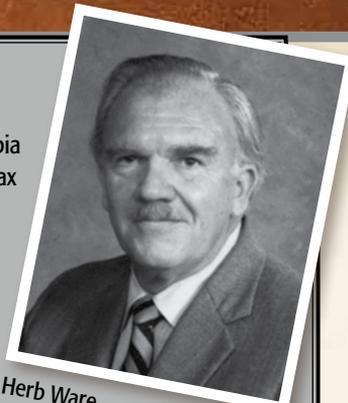
In 1969, the two joined to form American Quasar Petroleum Co. Collins handled the deals and Ware was vice president of exploration. Collins said of Ware: “His geology was solid. He was very good at visualizing and it didn't take him all day to look at a deal.”

The duo opened up the Overthrust Belt in Wyoming and Utah with the discovery of the Pineview Field. They developed numerous deep Delaware fields including Mi Vida and other discoveries in the Permian Basin including Munn and the Davidson Ranch. From 1970 to 1982, American Quasar was the largest publicly traded drilling fund in the U.S.,

and it drilled wildcats from British Columbia to the Gulf of Mexico. In 1982, when the tax laws changed, the men exited the drilling fund business. Collins left for HNG Oil Co. in Houston while Ware stayed in Midland to handle the partners' interests.

In 1988, Collins returned to Midland to merge his talents with Ware's in the firm Collins & Ware Inc. In 12 years, the company grew from no assets to over 1 Tcf of proven reserves, more than 100 employees and assets of over \$500 million. They operated over 500 wells in the Permian Basin, South Texas and Rocky Mountains. Collins & Ware was one of the first companies to use 3-D seismic as an exploration tool and participated in more than 1,000 square miles of 3-D seismic.

The two men, with their opposite personalities, complemented each other. Collins was the out-front person known as “Ten Percent Ted” for all the deals he was in. He never forgot a name, a new play or a trade, and was always willing to share his insight. Ware was reserved and more comfortable working with maps. Both men loved the excitement of the deal. When looking at a deal, if Ware didn't like it he tugged at his left ear. A tug on the right ear meant “Make the Deal.” Collins and Ware, with their spirit of optimism, courage and risk-taking, exemplified the idea of true wildcatters. ■



Herb Ware

L. DECKER DAWSON

With the country easing out of the Great Depression, L. Decker Dawson was lucky to have found a job after graduating with a civil engineering degree from Oklahoma State University in 1941. Magnolia Petroleum Co. assigned Dawson to the seismograph crew, and there he discovered a love for “doodlebugging.”

Dawson's first assignment for Magnolia Oil Co. (which became ExxonMobil) was “lugging jugs,” or laying electrical devices that recorded sound waves generated by explosive charges. “I was an instant doodlebugger,” he said.

After serving in World War II, he returned for a position with Republic Exploration Co. He worked his way up to party chief, which put him in charge of the field crew that drilled holes and shot dynamite. He moved constantly with the crew, going from Louisiana to Mississippi, Oklahoma and then Texas.

In 1952, he launched his own company based in Midland: Dawson Geophysical. A lucky break came to his firm when Republic Exploration told Forrest Oil that they couldn't send a seismograph crew to a location.

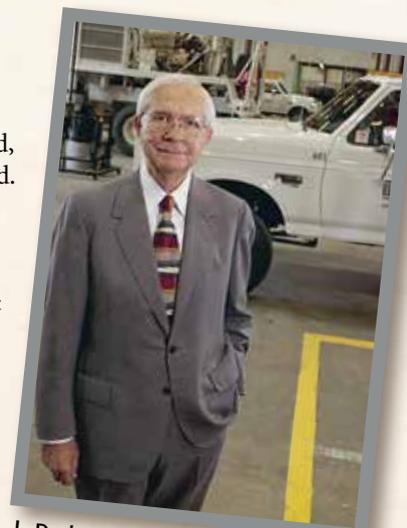
Dawson stepped in with his fledgling company. Seven years

later, he had crews working from coast to coast.

As drilling technology changed, so too did the seismograph world. Dawson Geophysical continued to upgrade its equipment; it was one of the first companies to use three-dimensional (3-D) seismic technology.

Dawson also noted that wherever a crew goes, a location experiences a mini-boom to feed and house the employees.

After six decades, the company still thrives. With crews in every major basin in the U.S., the company offers a channel count that is one of the largest in the continent. “There is so much riding on what we do,” Dawson said in an interview. “We're trying to help the industry find oil and gas.” ■



L. Decker Dawson

2004

Concho Equity Holdings Corp. was formed by Timothy A. Leach and his business partners.

2006-07

Following a 2006 acquisition from Chase Oil, Concho Equity Holdings becomes Concho Resources Inc. The next year, the company goes public.

2008

Attributable to several factors, the price of U.S. crude went over \$147/bbl. As a result, a gallon of gasoline averaged around \$4. This in turn led to a global economic recession.

2008

T. Boone Pickens launched his grassroots campaign for U.S. energy independence, the “Pickens Plan.” He also published his book of late-in-life reflections, “The First Billion is the Hardest.”

DON EVANS

Financial engineering and problem solving mark the various careers of Donald L. Evans. He moved to Midland in 1975 for a roustabout job, moved up to CEO, then to U.S. Commerce Secretary, and returned to Midland for more problem solving.

The Houston native received a bachelor's degree in mechanical engineering and an MBA from the University of Texas at Austin before making the move to West Texas. Tom Brown sent Evans to work on rigs for three months before bringing him into the office of Tom Brown Inc. The firm grew to a \$2.5 billion market cap company with consolidated operating revenues of over \$100 million annually, along with 1,200 employees.

Evans became CEO in 1985. Six months after he became an executive, the price of oil dropped to \$10/barrel and Evans was engaged in financial engineering, designing ways to restructure the company so it could survive.

Parts of the company were sold, and it restarted with 50 employees, \$4 million in revenue and substantial debt. In the following years, Evans narrowed the company's focus to natural gas production in the Rockies and accumulated vast amounts of natural gas reserves and acreage. Evans developed a new vision and strategy for Tom Brown Inc. while recruiting people with integrity and ability. One investor remarked, "Tom Brown is the only stock I know that trades



Don Evans, left, with Tom Brown, right.

on a spiritual basis—a belief in Don Evans."

By the time Evans resigned in 2000 to assume the role of U.S. Commerce Secretary in George W. Bush's cabinet, Tom Brown Inc. had grown into a \$2 billion company. In his new position, Evans traveled the world promoting business and job growth policies.

After four years, Evans returned to Midland and the world of business. In mid-2019 he was tapped to serve as the Permian Strategic Partnership's chairman. With a focus on improving schools, infrastructure, healthcare, affordable housing and workforce development, the PSP puts Evans back into the problem-solving arena. ■

DR. SAM G. GIBBS

Sam Gibbs really wanted to play golf with his buddies at Texas A&M one warm afternoon, but he dutifully went to his course on the numerical solution of differential equations. His professor made a comment about wave equations that opened his eyes to a whole new dimension. Gibbs took that remark and used mathematical formulas to get the maximum value out of producing wells. With his numerous inventions, Dr. Gibbs became the world's premier authority in rod pumping artificial lift technology.

Born in Lufkin, Texas, Gibbs wanted to become a champion calf roper, but his father suggested that Sam study mechanical engineering at Texas A&M. He graduated in 1954 with a degree in mechanical engineering, began a job with Shell and then answered the military draft call. After his service, he returned to Shell and was assigned to Midland as a unit engineer.

In 1958, Gibbs returned to A&M for a master's degree in mathematics, and that's when a professor's words triggered the idea for designing rod pumping installations. He returned to Shell and then earned a doctorate in mathematics at Rice University. In 1971, Gibbs and associate Ken Nolan founded Nabla Corp. and moved



Dr. Sam G. Gibbs

to Midland. They were the first to install a computer in a vehicle to make wellsite computations and determine bottomhole pump operations in real time on location.

"We were the first of our kind using mathematics, physics, engineering and computers to solve oilfield problems," Gibbs said.

For the next 26 years, Nabla offered the latest artificial lift technology to the oil industry worldwide. The company developed digital dynamometers, pump-off controls and fluid level instruments. This work enabled operators and producers to pump more oil deeper and cheaper through his pump design and software.

Nabla was sold to Lufkin Industries in 1997, but Gibbs never stopped experimenting with ideas. He authored and presented numerous professional papers. He received several patents and wrote a textbook on rod pumping for university classes. He also spoke before professional groups in Asia, Europe and North and South America.

Gibbs' decision to postpone work on his golf swing became a turning point in his life and for the petroleum industry. ■

OLIVER C. (KIP) HARPER



Oliver C. (Kip) Harper

When Oliver C. (Kip) Harper came to the Permian Basin in 1922 with Gulf Production Co., knowledge of the basin's subsurface was limited—where to drill a well was a guessing game. After much geological work, Harper gave the industry a map that opened the huge area to successful drilling.

Harper, a native of Chicago, studied geology at the University of Chicago before joining the U.S. Air Corps during World War I.

In 1919, Harper was employed by Empire Gas and Fuel Co. (which later became Cities Service) as a geologist in Kansas and Oklahoma, before joining Gulf.

He and Gulf supervisor Ernest Closuit took information from some Gulf dry holes, along with the Santa Rita No. 1 and Westbrook wells, and began to solve the Permian's geologic mysteries.

In 1924, Harper put the finishing touches on one of the

most significant pieces of geological evaluation ever seen in the United States—the recognition and delineation of the Central Basin Platform. The map showed structural features from the southeast corner of New Mexico to Terrell County, Texas. It included areas ranging from Yates Field in Pecos County to prolific pools in Winkler County. The discovery of many oil fields, with a total yield in the hundreds of millions of barrels, resulted from this map.

It also guided Gulf's early West Texas exploration, and oilmen credit Harper's early regional evaluations as the basis for the vast region's development.

Harper left Gulf in 1927 to strike out on his own, wanting to learn more about the earth and to test his theories. He joined R.L. York in a partnership that drilled numerous exploratory wells. Among the fields he discovered are the Harper, Foster, Water Valley, Rafter-Cross and Vel-Rex. After buying out York, Harper drilled more discoveries, including Weger Field and Northwest Ozona Field. He played a major role in interesting Amon Carter to invest in drilling the Wasson Field discovery.

Harper's work unlocked the mysteries of the Permian's subsurface and gave a blueprint for drillers to successfully develop the basin. ■

JAMES C. HENRY

From a two-person office, James C. Henry grew Henry Petroleum into a 100-person exploration, drilling and production company, before selling it at the height of the boom in 2008. That didn't mean retirement for Henry, who immediately opened Henry Resources, which is approaching record highs in capital budget, net production rate and net reserves.

Henry was born in 1934 to American parents working in Colombia, eventually settling in Oklahoma City. He graduated with a bachelor's degree in 1957 and followed that in 1958 with a master's in petroleum engineering from the University of Oklahoma. He then accepted a job at Humble Oil and Refining Co. in McCamey, Texas. After serving in the military, Henry returned to Humble Oil in Monahans and Houston before transitioning to Midland. In 1964, Henry moved to Tulsa to work for Skelly Oil. He returned to Midland five years later to work for a small independent. When the company closed its doors, Henry and geologist Bob Landenberger formed their own company in 1969 after writing a three-point business plan on a half sheet of paper.

With no money and no investors, H&L Consultants experienced a slow start. In less than two years, the men became independent operators, changed the name to Henry & Landenberger Inc. and drilled the first well in August 1971. They focused on the Midland Basin and the Spraberry Formation.

In 1977, Henry bought out Landenberger and changed the name to Henry Petroleum Corp. By 1983, the company listed 24 employees and 34 successful wells. However, the price of oil plummeted. Though Henry had tried to prepare for the downturn by selling assets and eliminating debt, three years later he still had to lay off half his staff.

Through a series of creative asset optimization deals with many of the majors and independent companies active in the Permian, Henry and his team found ways to profit through the difficult '80s and '90s.

In the early 2000s, Henry and his team quietly began using hydraulic fracturing techniques in an area dubbed the Wolfberry. They used the slick-water frack, involving a more-refined gel and water pumped at higher pressure. This technique unleashed oil previously considered uneconomical to capture. Henry Petroleum's early wells in 2003 are credited with establishing the scope and potential of this play. Once the team saw the fracking technique was going to work, the company leased about 330,000 acres in the Midland Basin to drill.

When oil rose to \$140/barrel in 2008, Henry sold the company and the acreage to Concho Resources, with the stipulation that all his employees would be retained. He regrouped as Henry Resources, still focusing on the Wolfberry. The company has transitioned into a horizontal operator, developing assets in the Midland and Delaware basins.

The amazing part of this story, Henry said in 2014, is about the small independent, the Midland dream of making a lot of money and the advance of technology. ■



James C. Henry

BILL KLEINE

Building relationships with clients allowed William D. (Bill) Kleine to turn a small crude oil trucking firm based in Midland into the largest crude oil purchasing company in the world.

Born in Slater, Missouri, Kleine's 6-foot-10-inch frame guided him as a star football and basketball player at Missouri Valley College. Graduating in 1949 with a business degree, Kleine turned his back on offers from professional basketball teams to work with Phillips Petroleum. After playing basketball for the Phillips '66ers, he was sent to the company's Midland office and its crude oil support division.

In 1956, Kleine joined The Western Oil Transportation Co., and from there he launched The Permian Corp. Kleine pioneered a new concept with this crude oil marketing company. For many years, independent operators in the Permian Basin had marketed their own production, but without a market, there was no reason for independents to drill. The majors were buying only their



Bill Kleine

own production and squeezing the independents out of the market.

Starting with 22 trucks, Kleine developed relationships by purchasing oil in the field and building contacts in the oil refineries. One man noted he sold his oil to The Permian Corp. because of Bill Kleine and he knew he would always have a market. His leadership and ability to maximize profit margins for oil producers played a major role in the growth and financial stability of the industry.

In 1963, The Permian Corp. became the first Midland company to be traded on the New York Stock Exchange. After that, substantial expansion began. By the time Kleine retired in 1989, The Permian Corp. transported almost 500,000 barrels of oil a day in 600 trucks or in 6,000 miles of pipeline, and in barges from 33,000 leases in 17 states.

Annual revenues hit \$5 billion. Kleine transformed a small firm into a mammoth company while providing a new and much needed service to independents. ■

FRANCIS H. (MAC) McGUIGAN

Francis H. (Mac) McGuigan spent a decade trying to convince his employer, Lion Oil Co., that oil was present under the Diamond-M Ranch in Scurry County. A well completed in 1949 opened the Diamond-M Field, which has since produced more than 220 million barrels of oil.

McGuigan graduated from the University of Oklahoma with a petroleum geology degree. First hired by Roxana and assigned to San Angelo, he moved in 1937 to Midland for a job with Lion Oil. He was named district geologist in 1941. His territory spanned from west of Fort Worth through New Mexico.

The Diamond-M Ranch was considered a dry hole by most geologists. Nonetheless, McGuigan saw the probable presence of a large Pennsylvania-age limestone reef, and results from gravimetric surveys supported that theory. Lion Oil had purchased a lease on the



Francis H. (Mac) McGuigan

A well completed in 1949 opened the Diamond-M Field, which has since produced more than 220 million barrels of oil.

ranch several years earlier, based on the geologist's advice. The company tested McGuigan's theory; the No. 2 J.T. McLaughlin well was completed on January 6, 1949, and opened the prolific field.

McGuigan later planned and supervised a study of the geology and reservoir characteristics of the area and its contained fluids. That work led the Texas Railroad Commission to approve a water injection program in the field. ■

2010

The Deepwater Horizon oil spill occurred when a BP-operated drilling rig exploded and sank in the Gulf of Mexico. The spill is the largest marine oil spill in oil and gas history.

2011

When Libya broke into civil war, its 1.5 million bbl/d production halted. Pres. Obama announced the release of 30 million bbls of oil over 30 days from the U.S. Strategic Petroleum Reserve to offset this loss.

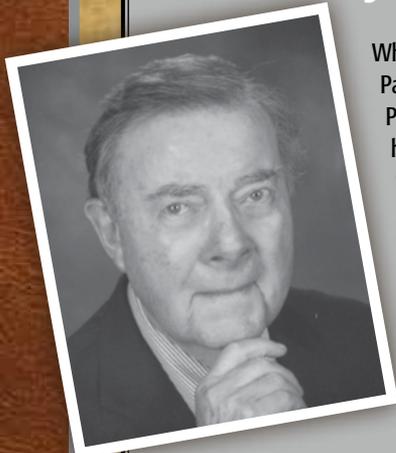
2012

The "zipper fracking" technique, whereby operators drill two wells side by side and then frack them simultaneously, was developed by professors at Texas Tech University.

2012

Chesapeake Energy Corp. announced multiple agreements to sell the vast majority of its Permian properties for approximately \$6.9 billion, in a historic exit from the region.

JOE PARSLEY & HOWARD W. PARKER



Joe Parsley

When Joe Mac Parsley and Howard Winn Parker opened the doors to Parker & Parsley Petroleum Co., they were unemployed and hadn't had a salary for two months, but they eventually turned a few leases into a multi-million dollar company. Focusing on the Spraberry Trend, these men set the stage for today's explosion in Permian Basin drilling.

Parker was born in Oklahoma, and his father and grandfather worked in the oil business. After serving in World War II, he graduated from the University of Texas at Austin (UT) with a bachelor's degree in geology. Midland was his destination as he found a job with Gulf Oil Co. in the geology department.

“They created the foundation for developing the largest field in the United States. They decided to go into the Spraberry, the most uneconomical field in the world, and focus on 100% success in low-risk drilling.”

—Scott Sheffield

Parsley was born in Texas and graduated in 1951 from UT with a petroleum engineering degree. He worked for Marathon Oil Corp. and eventually was transferred to the Midland office where he served as district reservoir engineer.

Parsley opted to open a Midland office for a Houston independent, and he asked Parker to join him as the geologist. Their skills and personalities merged as they enjoyed each other's sense of humor and business acumen. But the office-owner went bankrupt after two years, and that left Parker and Parsley deciding their next move.

They formed a partnership (the name was decided on a coin toss) and opened an office in the Gulf Building. It was 1962, and



Howard W. Parker

the pair acquired some overriding royalty interests. The Spraberry Trend, they knew, was the best place for them “because you couldn't drill any dry holes,” Parsley said. Their techniques for producing oil from troublesome formations set industry standards. Parker focused on finding places to drill and on obtaining money from investors. Parsley was responsible for drilling and completions.

During the 1960s and 1970s, the partners accumulated 150 Spraberry Trend wells that they drilled with joint venture partners. In 1979, they began to hire a few employees, including a young engineer named Scott Sheffield, who came to play a major role in the company's expansion.

In 1983, the Parker & Parsley Drilling Fund brought in over \$83 million for exploration and production expansion from diverse investors. Two years later, Southmark made an offer the partners couldn't resist, so Parsley and Parker sold their company for \$32 million. Sheffield was named president, and the two founders retired. Later, the company became independent again.

Sheffield said, “They created the foundation for developing the largest field in the United States. They decided to go into the Spraberry, the most uneconomical field in the world, and focus on 100% success in low-risk drilling.” ■



2012

Diamondback Energy Inc. completed its IPO of 12.5 million shares at \$17.50 per share, receiving net proceeds of an estimated \$204.6 million.

2012

After its completed IPO, Matador Resources Co. received approximately \$127.6 million from the sale of 11,666,667 shares at \$12 per share.

2013

Pioneer Natural Resources Co. announced the first successful horizontal Wolfcamp A on the west side of the Midland Basin, at 1,712 boe/d.

2014

Encana Corp. bolstered its Permian assets in a big splash by acquiring Athlon Energy Inc. for \$7.1 billion, a Permian pure-play. Encana CEO Doug Suttles grew up in Midland.

FRANK T. PICKRELL

Nothing but sand dunes, cactus and mesquite clothed the tract of land in West Texas he had targeted, but Frank T. Pickrell was confident that he could find oil there. Investors saw no reason to back Pickrell's efforts to drill an oil well near Big Lake. However, an extraordinary set of circumstances converged to set off an explosion with repercussions rumbling almost a century later. Pickrell's Santa Rita No. 1 started the petroleum exploration boom in the Permian Basin.

Orphaned at 15, Pickrell moved to El Paso, where he worked for an uncle in a candy store, and then for a bank. He bought part of his uncle's store and invested the profits in mining stocks, which made him wealthy at 23. He served in World War I then came home to lose all his money in the stock market. Pickrell sold his share of the candy store and hopped on a train headed east.

Then the coincidences began. He ran into El Paso businessman Haymon Krupp on the train, and the two met in Fort Worth with Pickrell's former commanding officer, Rupert Ricker. He had title to 431,360 acres of oil leases on University of Texas lands in Reagan, Crockett, Upton and Irion counties. Ricker was unable to make



Frank T. Pickrell

a lease rental payment of \$43,136 and sold his assignments to Pickrell, Krupp and their associates, who organized as Texon Oil & Land Co.

Then came the task of finding investors so that Pickrell and his partners could drill before an 18-month deadline expired on the lease. In a 1972 issue of the El Paso Herald-Post, Pickrell said he "spent a lot of time in New York educating the eastern promoters about oil," even though he knew very little about it himself. He eventually secured investors, including some Catholic nuns. He was asked to christen the well to invoke the aid of St. Rita, the Saint of the Impossible.

The Santa Rita No. 1 was spudded north of the railroad tracks, 14 miles from Big Lake. This well was a shot in the dark, Pickrell said afterward.

On May 27, 1923, the tool came up from a depth of about 3,000 feet with a showing of oil. The well was shut down and boarded up that night. But the next day, on May 28, the well "blew." Oil and mud shot into the air, proving that a large quantity of oil could be found in West Texas.

The rest is history, as the Permian Basin has given up billions of barrels of oil and the Texas University Lands Permanent Fund grows every year with royalties from its acreage. ■

WALLACE E. PRATT

"Geology is a way of life," said Wallace E. Pratt, a geologist who guided Humble Oil Co. to become a leading player in the Permian Basin.

A Kansas native who earned a master's degree in geology from the University of Kansas, Pratt first worked for the U.S. Bureau of Mines in the Philippines for seven years. He then returned to the U.S. to work for the Texas Co., before joining Humble as its chief and only geologist in 1918. He did the original geologic work that led to the Bronte Field. Humble geologists under Pratt's interest and encouragement attacked the reef problem in the Guadalupe Mountains of West Texas.

"It has been said that Pratt raised the profession of petroleum geologist to an eminence and a dignity which it would not otherwise have attained."

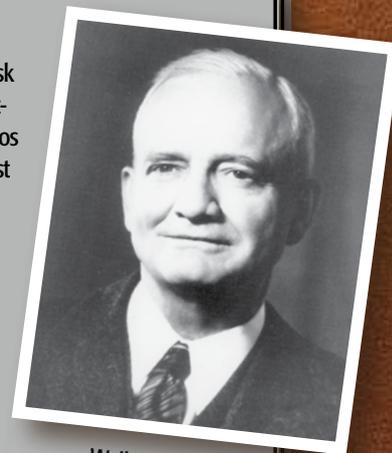
"It has been said that Pratt raised the profession of petroleum geologist to an eminence and a dignity which it would not otherwise have attained," said Everett Lee DeGolyer when he presented Pratt with the first Sidney Powers Memorial medal in 1945.

Pratt told the story of arriving in Pecos at dusk in 1919 to meet with Col. Bell, who was promoting an irrigation project at Dixieland on the Pecos River. "He had a geological report by a geologist from Iowa and a map that showed a pronounced anticline," Pratt said. "To my surprise, clearly displayed in the sharp tilt of the sandstones and shales through which the irrigation canal had been cut was the anticline."

Under Pratt's guidance, Humble acquired large holdings in Texas and New Mexico, including the Mexia-Powell and Talco fields, lease ownership of the King Ranch, the Bronte Field and leases in Crane, Andrews and Ector counties. Humble constructed the first pipeline from the Permian Basin to the Gulf Coast based on Pratt's advice.

Geology was always a way of life for Pratt. In his later years, he and his wife built a house on the Capital Reef front near the mouth of McKittrick Canyon in Culbertson County. They commuted daily in a two-seat plane to his office in Carlsbad, New Mexico.

When being honored for his work toward the end of his life, Pratt remarked, "For more than a half-century, I have been absorbed in playing a magnificent game. The name of the game is 'Find the Oil.'" And he did. ■



Wallace E. Pratt

SCOTT D. SHEFFIELD

Scott D. Sheffield spent one summer in Midland as an intern during college. He hated it and vowed to never return. But his first job after college sent him to West Texas, and he learned how this hot, dry and dusty plain holds a treasure of petroleum. Now as CEO and president of Pioneer Natural Resources Co., he relies on West Texas for his company's success.

Born in Dallas, Sheffield lived in Houston and then Tehran, where he graduated from

high school. He went to the University of Texas at Austin and majored in petroleum engineering, graduating in 1975. His first employer, Amoco Production Co., sent him to Odessa for two years. Another job offer in 1979 changed the direction of his life. A small independent in Midland, Parker & Parsley Petroleum, offered Sheffield a job as its only engineer. He just couldn't keep Midland in his rear-view mirror.

Within five years, the company had grown to \$32 million; in 1985 Sheffield was named president and CEO. The company began accumulating an enviable position in the Spraberry Trend by buying acreage from major oil companies that considered the area too expensive to drill. The independent could handle the job for much less money. In

1991, Sheffield was named chairman. The company went public and began trading on the New York Stock Exchange.

Under his leadership, Parker & Parsley merged with MESA Petroleum Co. in 1997 to form Pioneer Natural Resources. He became the company's founding CEO and assumed the role of chairman of the board in August 1999. When Pioneer Natural Resources was created, it was valued at \$1.5 billion and was reported to be the largest independent in the United States.

As the petroleum industry changed, so did Sheffield. He is credited with the ability to adapt and lead within a constantly changing landscape in terms of commodity prices, technological changes and the dynamics of international geopolitics. Pioneer expanded into several other countries before pulling back to focus on Texas.

In a 2016 interview, Sheffield said, "We've got the best rocks in the business—in other words, the best geology here around Midland."

Pioneer Natural Resources opened a new office building in north Midland in 2014, cementing its future in the place where Sheffield got his start.

"Over the last several years, our industry has changed significantly, and we have become a pure-play Permian company," he said.

As a young intern, Sheffield thought happiness was Midland in his rear-view mirror. Instead, he has discovered that it has been the key to his company's success. ■



Scott D. Sheffield

CLAYTON W. WILLIAMS JR.

An innovative marketing technique combined with an outgoing personality launched Clayton W. Williams Jr. onto a road of successful wildcatting and starting many companies while building a reputation as a "scrapper."

Born in 1931 in Fort Stockton, Texas, Williams grew up working on a ranch and running a sharecropper's farm. With a plan to become a rancher, he went to Texas A&M for a bachelor's degree in animal husbandry and graduated in 1954. After serving in the military, Williams sold insurance before entering the oil industry.

He partnered with John May of Fort Stockton in 1957, and the two tried to sell leases to major oil companies. They had no takers for a year, so Williams finally dreamed up a marketing technique: copying and mailing their Fall Clearance Sale on leases. At 5 p.m. a few days later, the phone started ringing. Within hours they had made \$1,200.

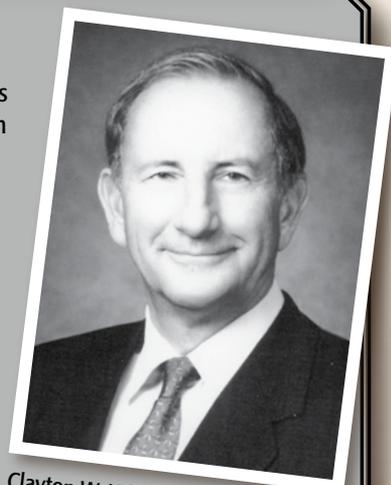
Tenacious and driven, Williams continued wildcatting. In 1959, he successfully drilled an oil well at Cuyanosa. From that well, Williams started a natural gas company, which led to Clajon Gas Co. in 1961. It became the largest individually-owned gas company in the state. In the mid-1970s, Williams made his biggest strike, the Gataga No. 2, one of the largest wells in the Permian Basin, producing 32 million cubic feet of gas per day.

In the 1960s and 1970s, Williams was one of the top natural gas wildcatters in Texas. In the 1980s and 1990s, he was known as the top oil producer in the Austin Chalk Trend. He is recognized for developing much of the first ultra-deep, high-dollar gas in the Trans-Pecos area of West Texas.

In May 1993, Williams took his oil and gas company, Clayton Williams Energy, public on the Nasdaq stock exchange. In the late 1990s, the company was noted for drilling record-breaking laterals.

Williams' other ventures included founding ClayDesta National Bank, Maverick Mud Company, Wil Gas Co., NGL Service Co. and Warrior Gas Co. In 2017, Clayton Williams Energy Inc. was sold to Noble Energy Inc. for \$3.2 billion.

His career was a series of ups and downs, but that never bothered Williams, who said, "It's not how many times you get knocked down. It's how many times you get back up. I'm a scrapper." ■



Clayton W. Williams Jr.

THE YATES FAMILY

A move to southeast New Mexico from Missouri looked to have been a bad decision for Martin Yates Jr. until he let his wife decide the next step. Her site selection for drilling the next well opened the biggest field in the state and gave Yates the title, "Father of the New Mexico Oil Business."

He grew up in Missouri and was editing a newspaper when he felt the urge to "go west." He stopped at Artesia, New Mexico, and opened a real estate business with William Dooley called Yates and Dooley. The oil bug bit the two men; the sign on their business became: "Pioneer Real Estate and Oil Men." They sold oil and gas leases, sometimes in exchange for groceries, and invested in some wells. They were part of the Illinois Producers investors, who had drilled the Illinois No. 1, which was unsuccessful, and Illinois No. 2, which produced gas. But Yates wouldn't quit, and the company geologist didn't know where to drill next.

Reportedly, Martin and his wife, Mary, went on a drive one day in 1924 to choose a drilling site. Mary had an uncanny intuition and was tasked with choosing the site. They hit oil at a location almost 300 miles west of the closest successful well. This became the first commercially successful oil well in the area and ignited an oil boom. Investors and drillers began to move to Artesia to be part of the new industry.

As time went on, Yates and his partners continued to drill wells, built a pipeline and refinery, and found new fields.

Reportedly, Martin and his wife, Mary, went on a drive one day in 1924 to choose a drilling site. Mary had an uncanny intuition and was tasked with choosing the site. They hit oil at a location almost 300 miles west of the closest successful well. This became the first commercially successful oil well in the area and ignited an oil boom.

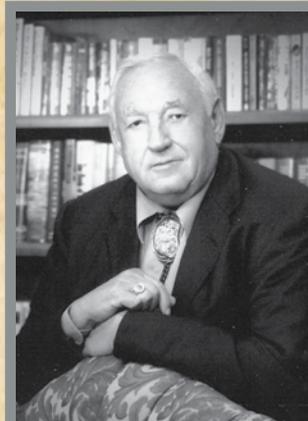
Eventually, Yates was joined by his four sons: Harvey, Martin III, S.P. (Peyton) and John. They pioneered their own oil ventures, including wildcatters and risk-taking enterprises while working for the collective interest of the parent company, Yates Petroleum Co. Their major discoveries included the Grayburg-Jackson Field, Loco Hills, Dagger Draw, Empire Abo, Eagle Creek, Penasco Draw, Pecos Slope Abo and



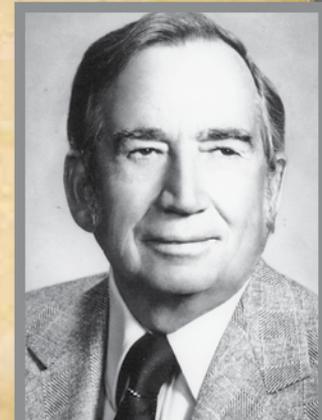
Martin Yates Jr.



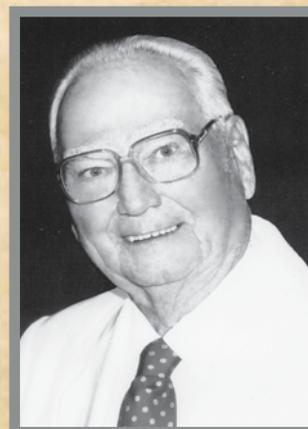
Martin Yates III



John A. Yates



S.P. Yates (St. Clair Peyton)



Harvey E. Yates

dozens of Morrow gas fields. During the 1970s Arab Oil Embargo, they kept the oil and gas industry growing to match the country's need for petroleum.

Martin III drilled 100 wells during a slow time and kept rig hands working. S.P. Peyton and John pioneered a new process to handle overproduction of water and earned awards for their water-control development. In 2016, EOG Resources Inc. acquired Yates Petroleum for \$2.4 billion, including the company's 186,000 net acres in the Delaware Basin. ■



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- 33,000 indirect jobs across Texas
- \$40 million in local tax revenue
- \$16 million to local school districts

What we do makes a difference, and we look forward to the next 100 years of giving back!

THE

CHAPTER 9 | THE PERMIAN GIVES BACK



PERMIAN PHILANTHROPY

BY PAUL WISEMAN,
CONTRIBUTING EDITOR

Individuals, foundations and companies have donated in outsized ways to uplift Permian Basin citizens and communities.

From October 14-16, 1987, the eyes of the world were glued to images coming from a backyard water well shaft in Midland. Playmates had dropped 18-month-old Jessica McClure into that well, not realizing that they were creating a worldwide event.

As a city accustomed to drilling holes, there may not have been a better place for this to have happened. The oil community banded together—from oil giants like wildcatter Clayton Williams to service companies like Permian Reamer, Robinson Rathole, Caisson Drilling and HyperDrill among many others, to individuals ready to spend 54 hours rescuing Baby Jessica.



Permian communities, such as Pecos, Texas, grow in tandem with oil and gas operations. *Photo by Tom Fox*





Permian communities are supported by the highest levels of government. President Gerald Ford dedicated Midland's Petroleum Museum in 1975. Photo courtesy Permian Basin Petroleum Museum

Park, the company has led initiatives to protect both the McDonald Observatory and Balmorhea's historic spring-fed pool. The company's Dark Skies Initiative is designed to keep the lighting at Apache's own facilities in compliance with the Observatory's needs and to educate others on avoiding or mitigating light pollution. Fortunately, focusing oilfield light sources toward the ground, where they're needed, actually reduces costs.

Apache also gave \$1 million and mobilized others to donate a matching amount, to repair the Balmorhea pool—and pledged to avoid drilling in the area. The firm donated large amounts to researching

the karst system underlying the park and other areas, to make sure oil and gas activities do not disturb these underground systems. It also donated to establish an endowment that will ensure the park is maintained well into the future.

A broader reach

While many companies rightfully focus on their own community or specific area where they are drilling, in November 2018, 19 companies banded together to reach beyond that, to affect every county in the basin. The Permian Strategic Partnership was formed by Apache, BP Energy, Chevron, Cimarex, Concho, ConocoPhillips, Devon Energy, Diamondback Energy, EnCana (now known as Ovintiv), Endeavor Energy Resources, EOG Resources, XTO Energy, Halliburton, Occidental, Parsley Petroleum, Pioneer Natural Resources, Plains All American Pipeline, Schlumberger and Shell with a goal of raising \$100 million to fund infrastructure improvements over a five-year span—a time frame that could be expanded if needed.

PSP's president and CEO, Tracee Bentley, said research had identified five main areas that the partnership needs to focus on to improve quality of life: "Education, health care, housing, roads and workforce."

Participating companies contributed about 110 employees to canvas local leaders to learn each town's needs during first-quarter 2019. The first project funded was to bring IDEA charter schools to Midland and Odessa, in which Bentley said many other organizations and businesses also contribut-

With less drama but with wider opportunity, that spirit of cooperation continues today, as donors seek to address community issues of health, education, safety and the challenges of explosive growth.

In the summer of 2019, the Permian Basin became the world's most prolific oil field. As money and people flow in, opportunities to help abound—and over the last 100 years, area individuals have opened their hearts and wallets to many in need, whether there is a dramatic TV rescue or the chance to fund a quiet opportunity for someone to get a meal, take a class or find shelter for the night.

Oil-based philanthropy extends deep into the area's past, with money flowing into theatres, schools, museums, hospitals, higher education and much more. Jody Sneed, a Midland-based nonprofit consultant, notes that cities he's lived in outside the Permian Basin have fewer charitable foundations. "Here, we're a sector of the economy. The first lesson I learned when I came here, in 1985 to work with the Boy Scouts, was that the national pastime of Midland was raising money for your favorite charity."

Throughout the basin, oil companies encourage or even assign employee involvement in charities such as Habitat for Humanity and others. Apache Corp., for example, encourages employees to get involved in things like Keep Midland Beautiful, Petroleum Museum summer programs, packing boxes to be sent to the USO and more. Chevron, Saulsbury Industries and many others have done the same.

Because Apache's Alpine High Field stretches across vast areas of the southwestern Permian Basin near the Davis Mountains and Balmorhea State



Tracee Bentley, president and CEO of the Permian Strategic Partnership, has identified five key areas to improve quality of life in the Permian.

UNIVERSITY LANDS PUTS REVENUE TO USE FOR TEXANS' BENEFIT

From the first Santa Rita royalty check to those generated by modern wells, University Lands has led the oil and gas industry in shaping the state's higher education potential.

The year was 1923, when Warner Brothers launched its film studio and the first baseball was pitched at Yankee Stadium. Halfway across the country, one of the first commercial oil discoveries in the Permian Basin took place on Permanent University Fund (PUF) lands at the Santa Rita No. 1 well.

These oil-rich lands have since proven to be a tremendous gift to the state of Texas, West Texas communities, and the 350,000 students of the state's two largest university systems, the University of Texas and Texas A&M.

The story began in 1839 when the congress of the Republic of Texas set aside land to establish and endow what it hoped would become a world-class university.

Today, University Lands manages surface and mineral interests on more than 2.1 million acres in 19 counties, to the benefit of the PUF endowment, now the country's largest public university endowment, valued at \$22 billion.

More than 250 companies operate the 9,000 producing wells across University Lands' 4,000 oil and gas leases. Some of the larger producers include Royal Dutch Shell PLC, Sequitur Energy Resources LLC, Diamondback Energy, and Pioneer Natural Resources Co.

Giving back

In the past decade alone, \$8.3 billion of mineral royalties have been deposited into the PUF, used to fund dozens of capital projects that support life-changing research and discoveries. University of Texas and A&M schools that benefit from these dollars span the state, from Tyler to El Paso and from Dallas to the Rio Grande Valley.

"The revenue really touches all Texans," said Mark Houser, the group's CEO. "We are creating revenue that builds facilities that cancer patients go to for treatment; it builds classrooms and laboratories that university students go to. That's really a source of pride for us."

There is also a substantial economic impact to the state and communities. The Perryman Group estimates that each year commercial activity on the lands generates \$3.5 billion in gross product, 33,000 jobs, \$176 million in state tax revenue and \$40 million in local tax revenue.

Oil and much more

Near-record revenue of \$1.135 billion was reported last year, and production reached peak volume of 300,000



"The revenue really touches all Texans. That's a source of pride for us."

—Mark Houser,
CEO, University Lands

gross barrels of oil equivalent per day. "The Permian is one of the more viable oil and gas plays in the world," Houser said. "The data suggests oil and gas is going to play a predominant role in the energy mix for the next 20, 30, 40 years."

University Lands' work also goes far beyond hydrocarbons. The lands are home to extensive ranching and grazing and could soon be home to 100,000 acres of solar panels and wind turbines. Being a leader in environmental stewardship and protecting the natural resources of West Texas is a critical component of the mission.

Long-term outlook

"At University Lands, we have a really long-term view," Houser said. "We're not like a lot of private, or even public, companies where you're thinking about the next year or two. We're trying to think about decades ahead since our revenue goes into an endowment."

University Lands' prudent management of commercial activities is essential to the past, present and future of higher education in Texas. For Houser and the staff at University Lands, "It will always be our mission to protect these lands to ensure they continue to benefit Texas for generations to come." ■



UNIVERSITY LANDS

utlands.utsystem.edu



Local entrepreneurs feel a need to give back, said Aaron Bedell, COO, the Permian Basin Area Foundation.

ed funding. IDEA plans to build seven schools that will educate about 10,000 students, to relieve some school crowding.

Second, the PSP approached apartment management company Weidner Homes about the company offering a 10% housing subsidy to Midland/Odessa teachers in their first two years in either city. PSP added another 10% for a total of 20% rent reduction. Approximately 200 slots were available beginning fall 2019.

PSP also works closely with the Permian Road Safety Coalition and the MOTRAN Alliance to focus attention on road and highway overcrowding and safety issues. Basin residents in January 2019 began hearing that the Permian hosts 2% of Texas' population but an alarming 10% of the traffic fatalities. They have MOTRAN, PRSC and PSP to thank for publicizing that information.

On the New Mexico side, the PSP's New Mexico Grant Initiative is a sort of self-help program. "What we found in some of the more rural areas of the Permian Basin, is that they qualify for a lot of federal grant money, but it takes resources to get

resources. Some of these tiny, tiny communities don't have people who have the time to dedicate toward grant writing, or maybe they've never written a grant," Bentley said.

The Grant Initiative's purpose is to fund grant writers for Lea and Eddy counties to help them apply for what PSP believes is about \$80 million in grants that could be available. PSP has also joined with other philanthropists to fund a career technical education high school in Hobbs, New Mexico. Though the bricks and mortar will be in Hobbs, the program will benefit the entire Permian, Bentley said.

Another clearinghouse between givers and receivers is the Permian Basin Area Foundation, which provides money for 200 to 300 distinct organizations over two-year giving cycles, according to COO Aaron Bedell. About half of the PBAF's money comes directly from oil companies, with the rest originating with individuals, many of whom are in the oil and gas industry. Over its 30-year existence, PBAF has surpassed \$100 million in grants and scholarships serving 22 basin counties.

Bedell noted that the area is blessed with many entrepreneurs and their families, "who understand that they wouldn't have gotten there without the support, the help and the encouragement of this community, and therefore they feel almost an obligation to give back."

Among the oldest and most prominent organizations in the area is the Abell-Hanger Foundation, founded in 1954, which has given out approximately \$245 million by issuing more than 10,000 grants. Oilman George T. Abell came to Midland in 1927, shortly after the basin's first discoveries and about the time of the Santa Rita No. 1 well, which triggered the area's first oil boom.

Abell was the driving force behind the founding of the Petroleum Museum, which opened in 1975. Almost all the original funding came from local people and entities.

The foundation may be best known for the Abell-Hanger Scholarship, founded in 1986 to provide Midland College scholarships for area high school graduates. Since renamed the Legacy Scholarship, its funding also comes from the Helen Greathouse Charitable Trust, Harvey and Harriet Herd, through the Chaparral Foundation and the Scharbauer Foundation.



Throughout the oil patch, charity golf tournaments have been a staple for many years. Photo courtesy Oil Patch Kids.

Underwritten by



UNIVERSITY LANDS

2014

The RSP Permian Inc. IPO was completed after the sale of 20 million shares at \$19.50 each. The company received an estimated \$390 million.

2014

Parsley Energy Inc.'s shares rose by 21.5% after its \$925 million IPO, the result of the Permian pure-play selling 50 million shares at \$18.5 per share.

2016

The U.S. active rig count fell to 404, the lowest ever recorded by Baker Hughes since it started gathering data in 1940.



In recent years, executive director Mark Palmer has seen a rise in requests for capital expenditures, as other charities update or outgrow their facilities. He credited Priority Midland and the Permian Strategic Partnership with publicizing infrastructure needs in the area.

The foundation relies solely on assets provided by Abell and his wife, Gladys Hanger, through an investment management firm.

Kim Evans, Career and Technology Education director for Midland Independent School District, lists Occidental, Concho, XTO, Anadarko, SM Energy and Chevron among that program's donors. CTE offers dozens of career pathways along with three areas of particular focus: the Petroleum Academy, the Health Sciences Academy and the Business, Management and Technology Academy.

Here is a partial list of other longtime contributors to the area:

- The Henry Foundation
- Rosalind Redfern Grover (Led the passage of a \$110 million bond issue for Midland Memorial Hospital and solicited \$60 million in private donations for the hospital)
- The Davidson Foundation
- Fasken Foundation
- Phyllis and Bob Cowan Performing Arts Series at Midland College

And while the aforementioned organizations benefit the whole area, Odessa has its own list of corporate and individual benefactors with wide reach. Saulsbury Industries, which celebrated 50 years in business in 2017, encourages employees to

Oilfield workers are a fixture of Permian communities, and many establishments, such as The Oil Can sports bar and grill in Barnhart, Texas, respect their work. *Photo by Ricardo Merendoni*

2015-16

Congress voted to end the 40-year-old oil export ban in the U.S. on Dec. 18, 2015. In January 2016, shipments of crude oil left the U.S. for foreign markets for the first time since 1975.

2016

Aubrey McLendon, "America's Most Reckless Billionaire," died in an early morning car crash, a day after he was indicted for violating antitrust laws.

2016

EOG Resources purchased the Yates Petroleum Corp. for \$2.5 billion.

2017

Wasson Field had produced a cumulative 2 billion bbls from the San Andres Formation.

A SINGULAR COMMUNITY, SUSTAINED BY OIL AND GAS

Artesia, New Mexico, has produced giants of oil and gas. Many still call it home, and they have helped create a city focused on entrepreneurship and the common good.

For years, it was common knowledge, as evidenced by the town's namesake, that any land west of the Pecos River contained excessive amounts of artesian water and therefore was not suitable for oil drilling. In 1922, however, Van Welch and Tom Flynn, Oklahoma natives, joined forces with Martin Yates Jr. in Artesia to instead drill east of the Pecos River—and that changed the game.

The partners' first endeavor, the Illinois No. 1, produced 38 barrels of oil and was shut in as a gasser. Not to be deterred, they drilled the No. 2, which provided plenty of gas to drill a third well, the Illinois Producers No. 3. This well's location was selected by Martin's wife Mary in 1924, based on her intuition. Its success told the world that an oil field was now open in the Pecos Valley.

Nearly a century later, Artesia is a vibrant and active entrepreneurial community with ample amenities more common to larger cities. Much of Artesia's current success can be attributed to several large-scale, homegrown independent E&P companies, as well as numerous smaller midstream and oilfield service companies.

Yates Petroleum and related entities

Yates and his partners continued finding new fields. Eventually, Yates' four children joined him in the oil business, and together with their heirs, went on to build what became Yates Petroleum and its related entities.

In the years since, the family has invested much of its earnings back into the community, creating non-profit foundations that have funded everything from a performing arts center and public library, to an auditorium and even a scholarship program for aspiring doctors.

In 2010 Yates Drilling Co. sold to Occidental Petroleum Corp., and in 2016 Yates Petroleum, ABO Petroleum, MYCO and eight other related Yates-family owned entities sold to EOG Resources Inc. for \$2.5 billion. Many members of the Yates family still reside in Artesia and actively support it with their finances and efforts, while others have moved away but will always call Artesia home.

Marbob Energy

In 1974, nearly 50 years after the Artesia Field was established, Artesians John R. Gray and Mack Chase formed Marbob Energy Corp. Initially, Marbob purchased wells or leases with marginal production and reworked these,

PRIVATELY-FUNDED GIFTS:

- Ocotillo Performing Arts Center
- Chase Foundation Scholarships
- History in Bronze: (6 bronze statues depicting the community's heritage)

PUBLIC-PRIVATE PARTNERSHIPS:

- Artesia's state-of-the-art public library
- Artesia Aquatic Center
- Estelle Yates Auditorium
- Mack Chase Athletic Complex
- Bulldog Bowl press box and Astro turf
- Artesia High School Welding Facility

but as the company grew, it began its own drilling and development. Marbob is credited with being first to discover the productive capacity of the Yeso Trend in southeast New Mexico. Thanks in large part to their innovations in completion techniques, Gray and Chase are considered pioneers of the Yeso Trend, which would become the largest producer of oil in New Mexico.

By the early 1990s, Marbob properties were producing about 3,000 barrels of oil per day. While still at Marbob, Chase established Mack Energy Corp. in February 1990. Chase and Gray decided on an amicable split, with each family having new visions for their companies. In 1992, Chase put his assets into Mack Energy Corp., while Gray retained his assets with Marbob.

Gray's son, Johnny C. Gray, maintained the family business until 2010, when Concho Resources Inc. acquired Marbob and its affiliates for an estimated \$1.65 billion.

Mack Energy

Chase expanded his company and affiliates to include drilling, farming, ranching, real estate, insurance and aviation. In 2006 Mack Energy sold a large property and interests to Concho but remains one of its largest shareholders. Today, Mack Energy and affiliates employ more than 900 people in various areas and locations. Mack Chase still is active in day-to-day operations and serves as vice president of Chase Oil.

In 2006, Mack and his wife, Marilyn, established The Chase Foundation to serve Artesia and nonprofit organizations within southeastern New Mexico. They have contributed millions of dollars to a local scholarship program and funds to countless other groups in the region. The Foundation is defined by the values of its founders, including a strong connection to public schools, colleges, youth and a passion to improve the quality of life for all families.

Other key contributors

Artesia is fortunate that three generous oil families call the community home, but it is important to note that other E&P, oilfield service, and midstream companies with local ownership have also contributed much. Mayor Raye Miller, who joined Mack Chase and Johnny Gray in 1980 before venturing out on his own, said the entrepreneurial spirit is alive and well in Artesia.

"I've seen some interesting things over the years," he said. He cited an insurance salesman he met who assembled a group of investors to purchase some oil and gas wells, eventually seeing enough success that he left the insurance industry altogether. The salesman's son left a thriving dental practice in Texas to join his mother in running the oil business after the father passed away. Another example was the man whose humble beginnings did not deter him from opening and successfully running an oilfield supply store that he has since handed over to his son.

Countless other humble, determined people have, through hard work and determination, created businesses that have lasted generations. "You don't see a lot of them, not like you do the Chases and Yates, but they are a great part of our community," Miller said. "They have employed folks, provided benefits, and family-friendly work environments for their employees. These family-type businesses have been a cornerstone of the Artesia oil and gas industry."

A positive outlook

Oil companies have long been powerful supporters of Artesia, providing personnel and dollars to the school system, medical facilities, churches and the police and fire departments. Artesia's entrepreneurial spirit, community pride and culture of generosity create a unique environment with significant privately-funded gifts to the community, as well as multiple successful large-scale public-private partnerships.

From the state-of-the-art public library, complete with an original Peter Hurd mural, to nine bronze sculptures depicting the town's History in Bronze exhibit, the private sector has donated millions of dollars to the beauty and betterment of the community. "There are folks, such as the Chase family and others, that took risks and were highly levered to build large oil and gas

companies," Miller said. "Fortunately, they have been very kind in giving back into the community."

Artesia is known for its public and private sectors joining forces to help create a lifestyle for its citizens that is typically uncommon in small towns. The most recent partnership saw the City of Artesia, the Artesia Public School District, and private donors build the Artesia Aquatic Center, an indoor/outdoor water park and swimming pool that gets visitors from all over the region. In addition to the arts, education is a top priority, which is why other public-private partnerships have included renovations to the high school auditorium, a new welding facility at the high school, and most notably, a scholarship program that is unrivaled by any other in the nation.

Miller said the outlook for Artesia and the Permian Basin is "extremely good," thanks in large part to the numerous pay zones. "There will be other horizons that will be derived over time," he said. "That's been the case for the past 100 years for Artesia and will continue to be the case for the future as long as our world demands oil and gas."

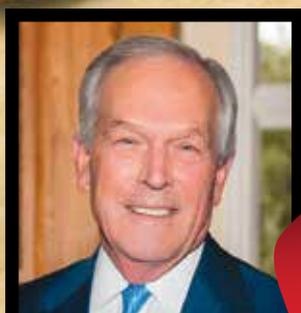
With its strong leadership and generous donors committed to improving the quality of life for Artesia and its youth, the community is sure to continue reaping the rewards of the oil and gas industry. ■



artesianm.gov



Mary Yates selected the site for the Illinois Producers No. 3 well. She is memorialized with her husband, Martin, in this Artesia statue.



Don Evans
Chairman
Permian Strategic Partnership

“The Permian is becoming one of the world’s most secure and strategically important sources of the oil and gas we all rely on to power our daily lives. All Permian residents benefit from the tremendous economic opportunity that comes with developing these vast resources, while maintaining the quality of life that attracted so many people, including me, to live and raise our families here.”

“The Permian Strategic Partnership (PSP) is an unprecedented coalition of 19 energy companies that have come together to address current and future challenges surrounding the responsible development of the vast oil and natural gas resources of the Permian Basin. The PSP is working in collaboration with elected officials, local leaders, community organizations and citizens from West Texas and Southeast New Mexico to develop solutions that strengthen local communities.

“The PSP will provide business expertise to help plan for and address future needs, convene conversations with stakeholders, and advocate with federal, state and local officials. In addition to individual company projects, the PSP has committed to providing more than \$100 million as seed money to spur additional private sector investments.”

give time and money to entities like the United Way, Meals on Wheels, West Texas Food Bank and more.

The company’s corporate contributions committee meets quarterly to choose recipients, mostly in the categories of community, STEM education and social services. More than one building at Odessa College bears the Saulsbury name, and UTPB’s STEM education has also benefited from numerous company grants.

International giant Halliburton celebrated its 100th birthday in 2019 by giving \$10,000 to 10 communities, and Odessa received one of those grants to help victims of the serial shooting that occurred over the Labor Day Weekend, said Odessa Chamber of Commerce president and CEO Renee’ H. Earls. Pioneer Natural Resources Co. also contributed to the fund.

The Odessa College automation department displays a \$500,000 check it received from Chevron, which greatly contributed to the founding of that program in the last decade. Earls also cited Chevron’s contributions to the Ector County Independent School District. A number of oil companies participate in committees that analyze and provide funding for equipment needs at OC and UTPB, especially in STEM education.

Earls added XTO, Occidental Petroleum and FMC Technip as corporate donors.

The Wood Family Foundation, founded by Clay and Louise Wood, has given millions of dollars to UTPB, Odessa College, Texas Tech, retirement centers and other health and educational entities.

Giving money to schools and other educational programs is the focus of the Dan and Hermine Hemphill Foundation, founded in 2000.

Odessa’s Citizen of the Year, honored in February 2019, was Kirk Edwards. Edwards is president of Latigo Petroleum, and has been president of the Permian Basin International Oil Show. He was on the UTPB Development Board that brought Division II football to the school. He has also been chairman of the Permian Basin Petroleum Association, the Odessa Chamber of Commerce and has served in a long list of other capacities.

Opportunities and challenges

Earls pointed out that the tremendous population growth of the entire area since 2010 has created wide-ranging challenges common to every community. “Obviously, we all want growth, but there’s a price to pay. We didn’t find ourselves like this overnight. It’s been years in the making. It’s a lack of imagining that we would ever get to this point,” which is now requiring massive influxes of money from taxing entities as well as philanthropic organizations to catch up. “I don’t think anyone saw it coming.”

A Priority Midland-funded report issued by economist Ray Perryman assesses the benefits to the entire Permian Basin if infrastructure issues had been better anticipated, as Earls suggested. Meeting those needs five years ago, says the report, the basin’s real gross product would have increased by \$37.4 million or 12.4%, and the job count would be higher by 80,000, up 7.9%.

The report foresees further losses if infrastructure is not expanded in the next few years.

Large influxes of money are stuffing government coffers also, and funding some road improvements. Odessa’s share of the state sales tax shot up by more than 40% in 2018 from the previous year—to \$69.5 million from \$49.4 million in 2017. In September, the city of Midland reported year-to-date 2019 collection numbers of just over \$60 million, up 17% from the previous year. Both cities’ collections are millions of dollars in excess of budgeted numbers.

Property tax assessments are also rising, as the demand for housing outstrips supply, forcing prices up. Apartment rents in these areas have been among the highest in Texas over the last two years. Rates in Pecos, Monahans and elsewhere are also high though, due to their size, those cities are not listed.

To help with the homelessness that results from ever-escalating housing prices, John-Mark Echols and his wife, Briana, started The Field's Edge in 2017. With funding from the Mabee Foundation and other area firms, they plan to break ground on a tiny-house community in June 2020, on 23 acres of donated land southwest of Midland. A movie, *Finding Home in Boomtown*, documents the Echols's journey. Backers of the movie include Wellworx, Parkhill, Smith and Cooper and others.

New Mexico's oil-fueled giving

New Mexico's Lea and Eddy counties are two of the most prolific producers in the area, and that gives rise to a significant amount of oil-fueled giving. Education is the theme of a program funded by the New Mexico Oil and Gas Association (NMOGA) and the American Petroleum Institute (API) in association with the Albuquerque Community Foundation. Begun in September 2019, the Brighter Future fund will award grants to non-profit and educational organizations, focusing on STEM education, increasing economic opportunity and alleviating childhood hunger. With total funding of \$1 million, it plans to distribute \$200,000 annually.

Ryan Flynn, executive director of NMOGA, explains that his organization's participation in the Brighter Future Foundation and other philanthropic efforts is part of a larger view of the community, and that the \$1 million figure is just the beginning. "We look at that as the floor. Success begets success, so if the fund that we've established is building momentum, and really making an impact, and really helping cement the relationship between oil and gas and throughout the entire state, I think it's just the beginning and will continue to grow.

"The big thing that's unique is that we invest in our philanthropy typically targeted toward the communities where we're operating. But we realize that we're part of New Mexico and that means that we really need to make sure that the entire state fully appreciates what this industry does."

Teacher help in Hobbs Municipal Public Schools comes through the Veteto Foundation, founded by Burton and Mark Veteto of Me-Tex Oil and Gas. It awards yearly cash bonuses to five outstanding teachers in Hobbs.

An annual golf tournament hosted by Concho Resources raises funding

for organizations like the Carlsbad Battered Families Shelter, Boys and Girls Club of Carlsbad and Habitat for Humanity, Artesia.

Devon, Concho and Logos Resources II also participate in community giving. Recipients of private gifts in Artesia include the city's state-of-the-art public library, the Ocotillo Performing Arts Center, Chase Foundation scholarships, and public art in the form of a series of statues titled "History in Bronze," among many other projects.

There are public-private partnerships as well, such as the Artesia Aquatic Center, Estelle Yates Auditorium, Mack Chase Athletic Complex, Bulldog Bowl press box and the stadium's artificial turf surface, and the welding facility at Artesia High School.

Throughout the basin, golf tournaments are a popular fundraising option, and many cities take advantage of the area's sunny skies to tee off. In Midland/Odessa, the Oil Patch Kids organization hosts annual tourneys that have raised more than \$1.6 million for at-risk children. The Patrick Wayne Memorial Golf Tournament funds a scholarship also, named after the late Marine Corps second lieutenant. The scholarship is distributed by the Permian Basin Area Foundation.

In November 2019, Oilfield Helping Hands held its first annual charity golf tournament. The agency helps families of oilfield workers who have been laid off. 



Ryan Flynn, executive director of NMOGA, sees great potential for industry-led philanthropy in New Mexico.



Halliburton CEO, chairman, and president Jeff Miller raised \$4.5 million for High Sky Children's Ranch in West Texas, from a golf tournament the company hosted in November 2019. The Ranch has assisted children and their families since 1963. *Photo courtesy Halliburton Co.*

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Photo by Tom Fox

CHAPTER 10 | THE FUTURE

THE FUTURE



Photo by Troy Fields

PERMIAN STAYING POWER

BY LESLIE HAINES,
HART ENERGY

The Permian Basin could deliver much more oil and gas in the future.

Was Yogi Berra born in Midland? After all, the baseball legend famously said, “It’s tough to make predictions, especially about the future.”

Pundits have weighed in on the future of the Permian Basin for 100 years, and they usually have been wrong, underestimating its potential. In a basin 250 miles wide by 300 miles long, with several hundred companies drilling its numerous stacked pays, anything can happen.

By year-end 2019, Permian output was approaching 4.4 million barrels a day (MMbbl/d), and the Texas Railroad Commission reported that about 400 companies were active as operators of record.

The debate today revolves around how long the torrid pace of production growth can continue. Several E&P companies have announced extraordinary growth plans to reach 1 MMbbl/d of output from their Permian holdings, but most others are stepping on the brakes to match their outlays with cash flows and improve return on capital.

Pioneer Natural Resources Co. president and CEO Scott Sheffield, who once declared the company would reach that goal of 1 million barrels daily, recently has changed his message to investors and the media. Pioneer, and the industry, must now adopt what he called a “more measured” pace, he told Hart Energy’s Executive Oil conference in November. “I don’t think OPEC has to worry that much more about U.S. shale growth long term,” Sheffield told media outlets. “The Permian is going to slow down significantly over the next several years.”

Still, if West Texas Intermediate is at least \$50/bbl, Pioneer has about 25 years of inventory ahead of it.

Based on the significant locations that companies have identified, and the very good rock quality, growth can continue, but it won’t maintain the fast pace seen in the past two or three years. Several groups have estimated different, yet slower, levels of future growth. In the past, U.S. production grew by almost 2 MMbbl/d, an all-time global high, but today, all agree that we are entering a period of moderation and caution. An IHS Markit study in November predicted U.S. shale oil growth would slow in 2020 to only 440,000 bbl/d and plateau in 2021, with some modest growth thereafter.

Drillers are cutting back their spending, unless oil prices rise significantly. Then too, in many shale plays it appears that tech improvements have reached the point of diminishing returns. That will happen in the Permian. Meanwhile, total U.S. production was approaching 13 MMbbl/d at yearend 2019, even as the total rig count had fallen by about 25% year-over-year.

With success come many challenges. Permian producers must spend enough to deal with annual production declines and keep production flat. Increasingly, they must contend with proper well spacing to avoid parent-child well interference. They must reduce natural gas venting and flaring, employ better methane leak detection practices, and secure enough power to supplement the grid in far west Texas with solar and wind to keep operations running smoothly.

How much potential?

Early on, most oilmen believed there was no oil to be found west of the Pecos River. That has certainly been proven wrong. Today drilling activity is rising faster in the Delaware Basin side of the Permian than it is in the Midland Basin.

People claimed the Spraberry Trend, discovered in 1949, was the most uneconomic oil field in the world. Indeed, in 1951 more than 650 geologists and engineers met at Midland High School to dis-



“Occidental is proud to be the largest producer and acreage holder in the Permian Basin. Starting with the Cities Service acquisition in 1982, Occidental has recognized the potential of the prolific Permian. While others were exiting, we persistently grew our position: first with conventional reservoirs and EOR, and more recently through industry-leading unconventional resource development.

“Looking ahead, we expect the Permian to play a key role as our industry prepares for the energy transformation. Our Oxy Low Carbon Ventures subsidiary is pioneering the use of new technology that could lead to carbon-neutral oil production. We believe the last barrel of oil will come from a field using enhanced oil recovery, and that it will be produced in the Permian.”



Vicki Hollub
President & CEO
Occidental Petroleum Corp.

cuss the way forward: One key thing they couldn't figure out is the complex, multilayered geology of the basin. They could not even agree if the Spraberry was a sandstone or a siltstone, according to the 2018 book “Pioneering Independent,” a history of Pioneer Natural Resources Co.—now one of the Permian's biggest producers, with 680,000 net acres and an estimated 25-30 years of drilling inventory in hand.

Today, the Spraberry is one of the largest oil fields in the world, and some companies can make it economic even if oil stays below \$50/bbl. Drilling and completion costs have steadily declined while production keeps rising and efficiency improvements become the norm.

Even as predictions of the basin's slow demise recurred, activity has always snapped back, usually due to higher oil prices and plentiful capital. This led to new fields coming online.

Today, the future is going to be defined by better technology that allows for much higher oil recoveries—and by global oil demand trends.

Permian production first peaked in the early 1970s, followed by a long, slow decline until the mid-2000s. But since the unconventional boom caused by horizontal drilling and enhanced well

stimulations came to the Permian around 2010-2011, it's been a different story.

“More than any other basin, increased use of preferred management practices in the Permian Basin oil fields will have a substantial impact on domestic production,” said a report from the Energy Information Administration.

As far back as 1989, some claimed the Permian held 30 billion bbl of mobile oil and 45 billion of residual oil—ripe for exploitation with improved technology. Shell Oil's general manager for the Permian, Amir Gerges, has said there may be 40 billion bbl recoverable in the Permian. More recently, IHS Markit said there remains 60- to 70 billion barrels of recoverable oil. This was not always so.

Hiking expectations

Whenever experts think they have the answer, it soon becomes modified. The U.S. Geological Survey (USGS) noted in a 2012 report that estimates of recoverable oil reserves in the basin's 18 largest fields frequently were revised upward. These 18 fields, each discovered between 1923 and 1950 during the basin's first heyday, were originally thought to hold 430 million barrels of oil.

However, most of them showed significant reserve additions from 1982 to 2006, the USGS said, and that was *before* the widespread application of modern horizontal drilling and fracturing, pad drilling and tank development now happening in the basin.

“Between 1979 and 2004, estimates of the volume of recoverable oil in these 18 fields increased by 4.7 billion barrels of oil,” the USGS said.

In September 2019, the Bureau of Economic Geology (BEG) at the University of Texas at Austin estimated far, far more in a new report.

“The largest conventional fields in the basin are on the Central Basin Platform and the Northwestern and Eastern shelves,” it said. “These conventional systems hold some 45 billion barrels of oil and over 20 trillion cubic feet of natural gas reserves, of which about half has been produced. In fact, recent common belief was that the [basin] was fated for a long, slow production decline.”

The BEG indicated there are 2,700 billion barrels of oil in place (BBOIP) in the Wolfcamp and Spraberry formations of the Midland Basin, and about 570 BBOIP in the Wolfcamp and Bone Spring formations of the Delaware Basin.

“That's 3.2 trillion barrels!” said Dr. Scott Tinker, state geologist of Texas, director of the BEG, and a professor in the Jackson School of Geosciences at UT.

“Even if only 5% is ultimately produced, that represents 160 billion barrels. At 5 million barrels a day (which is approximately 5% of total current global



Given their long-term view of the Permian, several E&Ps have built new offices. Here, Mewbourne Oil Co.'s \$6-million regional headquarters in Hobbs, N.M., dedicated in June 2017. Photo courtesy Mewbourne Oil Co.

oil production), that amounts to nearly 90 years of production," he told Hart Energy.

Whatever turns out to be the reality these stunning figures, coupled with new technology, ensure the Permian Basin's staying power. It is drawing renewed interest from the major oil companies, IOCs such as Ecopetrol, and other big players. They will write the future. It will be big, it will last a long time, and it is just a matter of timing, underpinned by oil and gas prices. Scale has become increasingly important, which will drive more consolidation among companies.

Scenarios to 2025

An April 2019 study commissioned by the Independent Petroleum Association of America, which was conducted by IHS Markit, lays out a U.S. scenario to 2025, with the Permian playing a major role.

"Ten states currently contribute 95% of total U.S. oil production. Texas, which currently has 42% of the oil production, will continue to lead all states in 2025, with 46% of all oil production, due largely to massive increases in the Permian Basin, where production is projected to be over 6 MMbbl/d, or about 42% of all U.S. oil production. This will also affect New Mexico, where the oil production will double," said IHS Markit.

"Ten states currently contribute 92% of the U.S. dry natural gas production. Texas (including Texas Permian), which currently has 25% of the dry natural gas production, will continue to lead all states in 2025 with 27% of all natural gas production, driven solely by massive increases of associated natural gas in the Permian Basin, where natural gas production is projected to be over 11.7 Bcf/d by 2025.

"Ten states currently contribute 91% of the total U.S. new well counts and 84% of the total capex. Texas, which currently has 45% of the new wells, will continue to lead all states in 2025 with 51% of

all new wells. Likewise, Texas, which currently has 46% of the capex, will also continue to lead all states in 2025 with 53% of all capex. The largest increase through 2025 will be seen in the Permian Basin, where new wells will grow by 23% and capex will grow by 59.3% due to the complexity of the new wells that will be drilled there."

Looking at the near term in another way, the Permian land grab and acquisition boom of 2016 and 2017 cost buyers some \$29 billion, according to Enverus Drillinginfo. Those companies need to start fulfilling the promise implied in their acreage additions by drilling.

One leading Permian pure-play, Diamondback Energy Inc., acquired two area E&Ps in August 2018



Jeff Gustavson
Vice President, **Chevron**
Mid-Continent Business Unit

"Chevron's commitment to this region over the past 100 years has resulted in a leading position in the Permian. Our story here is a product of hard, smart work and disciplined investment decisions, combined with efficient, competitive performance. We're proud of our position as well as the role we play in supporting the region's energy resurgence. The resources of the Permian

will bring affordable, reliable energy for years to come."

Going forward, oil companies will increasingly employ environmentally friendly power. Source: Shutterstock.com



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2017

Noble Energy Inc. acquired longtime Midland independent Clayton Williams Energy Inc. for \$3.2 billion. The purchase included 2,400 gross drilling locations in the southern Delaware Basin.

2018

Matador Resources Co. purchases a slight 8,400 net acres in Lea and Eddy counties for a record-high price of \$95,001 per acre, at a BLM auction.

2018

The U.S. exported more crude oil and finished products than it imported for the first time on record, with net exports of 211,000 bbl/d for the week through Nov. 30.

for total consideration of \$10.45 billion. Critical mass for driving capital efficiencies is turning the basin into a manufacturing business as companies consolidate. Diamondback CEO Travis Stice said the company will spend as much as \$3 billion in 2020 and operate 20 horizontal rigs; it could complete as many as 300 gross wells. More important for the long term, it estimates having 7,600 net horizontal locations in inventory following these acquisitions. It's assuming 20 wells per section in the Delaware Basin and 28 in the Midland.

A temporary downshift

Many of the large E&Ps working these basins report similarly large inventories, ensuring long-term drilling activity lies ahead. But IHS Markit recently said it expects modest growth or flat production in the near term. "The scope of further productivity gains is limited," it said, noting however that there is an ample inventory of high quality wells to be drilled. The pace of continued development will depend more on oil prices than any other factor.

Last fall, IHS forecast U.S. capex would fall 10% in 2019, 12% in 2020 and another 8% in 2021—a nearly \$20 billion decline in three years. This will affect the Permian. Although cautious producers are cutting back on spending in 2020 to drill within cash flow, the future still looks bright.

"This is not going to grow at the same clip it's been doing in the last two years, but production will grow," assured Ken Medlock, senior director at the Center for Energy Studies at the Baker Institute, Rice University.

The true potential of the region has always been a moving target as technologies evolve that can improve recovery. The industry still cannot recover a high percentage of the oil in place, although the amount inches up over time.

Light at the end of the tunnel

The Permian is the most prolific, but most congested, of U.S. oil basins due to its sheer size and unprecedented production growth. IHS Markit has forecast that from 2018 to 2023, just five years (a blip in the life of a super-basin), some 41,000 new wells could be drilled, at a cost of \$308 billion.

Many people are working overtime to alleviate the infrastructure problems that will result.

The Permian's Promise

BY STEPHEN BECK,
STRATAS ADVISORS

The beginning of the Permian's second century presents both opportunities and challenges. The opportunity is obvious. At its core, the Permian holds vast quantities of crude oil, most of which is found in the Wolfcamp formation stretching across both the Midland and Delaware sub-basins. Industry's ability to tap into shale economically fundamentally transformed the balance of crude supplies globally. Single well economics are competitive and are likely to improve further if history is an indicator. Recent concerns over weaker than expected well performance likely overshadow the fact that the basin has years of attractive drilling inventory remaining.

Still, this is not the time for industry pros to take it easy. New technologies will be needed for the industry to be successful at lifting capital efficiency. Being able to extract more crude for each dollar expended is the holy grail for the Permian's future. Cube designs are still in their infancy, and significant improvements in "cube" performance will only come with enhanced understandings. In addition, infrastructure will remain a treadmill requiring ongoing investments just to keep pace.

Importantly, the adoption of manufacturing models could leave smaller operators behind due to increasing demands for captive capital. The current model of first drilling all wells in the proximal area, followed by completion operations at some later time, dictates the need for better capitalized operators. This trend will only increase in the years ahead.

The promise of the Permian will drive the future. Stratas Advisors projects growing production from the Permian through the mid-2020s peaking above 7 million barrels per day, followed by a relatively slow decline into the 2030s. Said another way, the Permian is here for the long-game. ■

2018-19

Energy development on state lands was a primary driver in a more than \$1 billion contribution to the State of New Mexico in 2019, the most the state has earned in a single year.

2019

Rattler Midstream LP completed the year's largest, at the time, midstream IPO, selling 38 million shares to the tune of \$665 million in proceeds.

2019

The U.S. exported more crude and finished products than Saudi Arabia, shipping nearly 9 million bbl/d to markets across the globe, in June.

2019

Anadarko Petroleum Corp. shareholders approved the \$38 billion merger with Occidental Petroleum Corp. (Oxy). The merger, the fourth largest in the history of North American upstream, substantially strengthened Oxy's Permian position.

“The Permian is the major source of oil production growth in the U.S., so it really comes down to a cost and technology question. Scale efficiencies will become even more important. People said it would plateau at 4.5 million bbl/d, but I think we’re going to blow right through that—if we start pushing toward 6 million a day, that could be the plateau. But it’s a moving target.”



Ken Medlock
Senior Director, Center for Energy Studies, Rice University

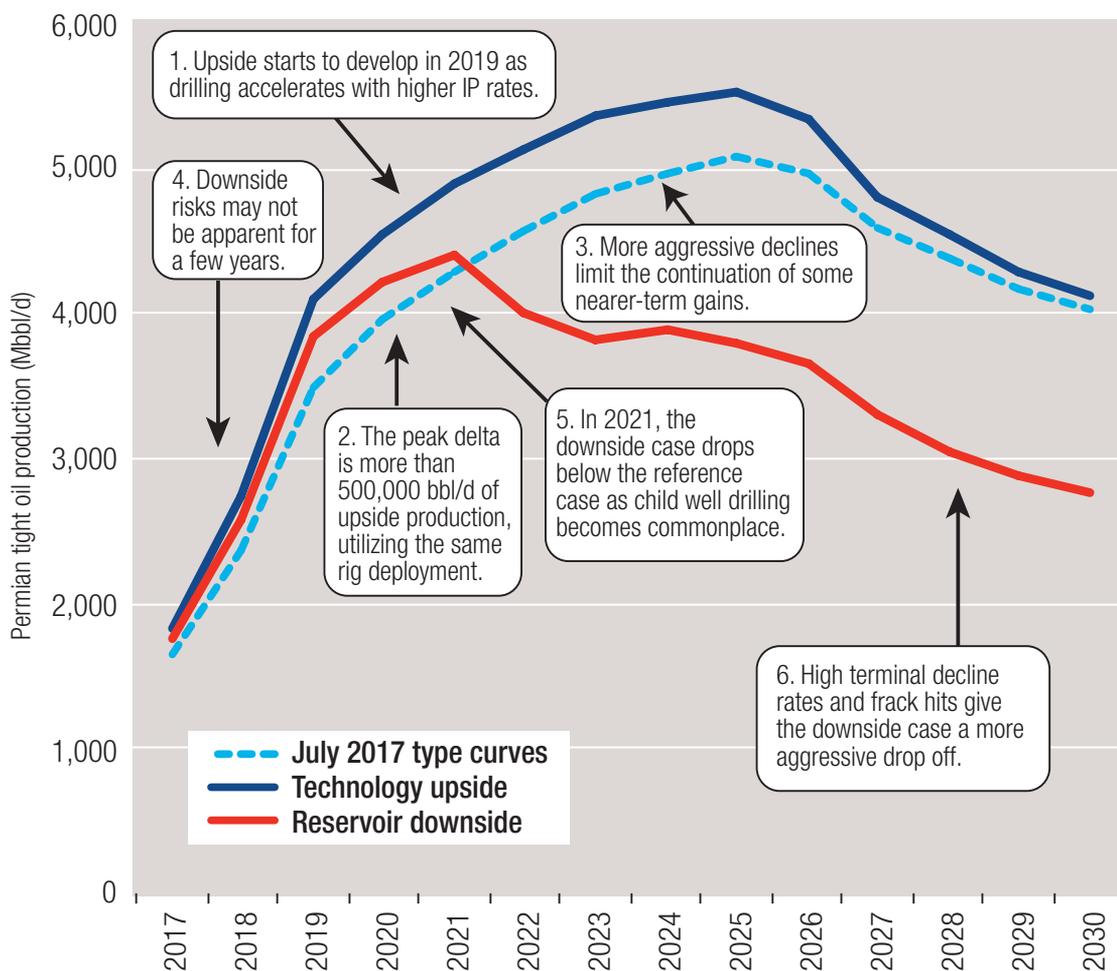
If one combines the projected Permian production from just four companies—ExxonMobil’s XTO Energy unit, Chevron, BP and Occidental—then by 2024 that’s an additional 4 million barrels a day coming from the Permian, not counting those produced by the independents.

Shell has approximately 600 employees in the basin managing over 1,000 wells. It is pushing the technology envelope by drilled wells using artificial intelligence (AI). It anticipated as much as 35% production growth in 2020 over 2019 numbers.

Global consulting firm ICF issued a report last September concluding New Mexico’s production could rise 300% to 2030. At year-end 2019, it was nearing more than 900,000 bbl/d, up about 35% from 2018, which itself set a record.

Every one of these incremental barrels will have to be exported and, for every million new barrels, you can count on another 2.6 Bcf of dry gas production and 460,000 bbl of NGLs as well, according to Bernstein Research analyst Jean Ann Salisbury.

Permian Bull-Bear Growth Story



Source: Wood Mackenzie

Depending on technology, oil price and reservoir exhaustion, some bulls think Permian output may even double to 8 MMbbl/d by 2025.

IN A TOUGH MARKET, TRADE FOR CERTAINTY IN CASH

The Permian holds many new risks for E&Ps and mineral owners, but Noble Royalties Inc. is providing trusted options in uncertain times.

The nature of the Permian Basin is changing from historically profitable wells, predictable revenue and the low-decline production that anchored the mindset in legacy mineral owners, who stated “Daddy always said never sell your Minerals,” and J. Paul Getty’s infamous “The meek shall inherit the earth, but not its mineral rights.”

Today, the Permian experience is much different. It includes many new risks, which in turn result in wildly variable results for our industry and its mineral owners.

Geopolitical risks are no longer concentrated in the Middle East. The war on fossil fuel is organized here at home and achieving material wins that are reducing the current and future value of many E&P companies and associated mineral estates. Funding remains tough for E&P and private equity as the trend to be politically correct and divest in fossil fuels continues.

Proven financial results are now mandatory, not optional. Capital markets are punishing public companies that are struggling to prove they can provide attractive returns in many basins, including the Permian. Wall Street demands to drill out of your “cash-flow,” and this challenges executives that historically acquired large acreage positions, took on debt and drilled enough wells to sell or merge. We expect consolidation to continue for the next three to five years throughout the Permian in an effort to build profitable operators in the shales.

Production results from a new stimulated well (fracking) now carry a 70% to 92% decline in the well’s first year of production, and “Boom to Bust” can now take place in years, not decades. Companies now measure results in real-time, and development plans are swiftly re-prioritized. The result can be a long waiting period for many mineral owners.

In summary, the political and financial risks combined with high-decline production present landowners with the risk and results normally only faced by E&P companies. Thus, we are seeing historical magnitudes of mineral owners divesting in their positions. Going forward, receiving a competitive offer for your minerals today should be a difficult decision for both

“Going forward, receiving a competitive offer for your minerals today should be a difficult decision for both the buyer and seller, given the uncertainties in today’s environment.”

the buyer and seller, given the uncertainties in today’s environment.

The Permian will still be the preferred place to be for the next 15 years, but many will struggle to grow in volume shortly and shift to reserve replacement by developing its multiple formations and re-fracks on the older wells.

Since its founding in 1997 by Scott Noble, Noble Royalties Inc. has given families, private royalty owners, E&P companies and even overriding royalty interest owners security and certainty regarding their Permian mineral interests as a trusted option for liquidity. Today, Noble owns interest in 36,680 wells in the Permian Basin and has a total of \$1.45 billion in assets under management across the U.S.

Noble provides a discreet and professional service that allows a mineral owner to rebalance their own risk thresholds at home and trade for the certainty in cash rather than being concentrated in the aforementioned uncertainties. ■



NOBLE ROYALTIES, INC.

nobleroyalties.com

Frack fleets proved to be a step-change for Permian production, and further refinement of the technology will lead the basin into its future. *Photo by Tom Fox*



She estimated current pipe, truck and rail capacity out of the Permian to be about 4.2 MMbbl/d, with announced new-builds and expansions taking that total up to 8.2 MMbbl/d by first-half 2021. No company would make that level of commitments without full confidence that Permian Basin producers can and will deliver.

“Finally, we look at gas pipelines, which have had a different path. As of 2019, there is 10 Bcf/d of dry gas produced and 1 Bcf/d flared. There is FID to 17 Bcf/d of takeaway, enough to cover production

until 2022, although with some intermittent flaring required. We need four more pipelines FID’ed to meet 2025 projections—one per year starting 2020—to avoid flaring significant volumes in the future,” she said.

People not in the oil and gas business cannot begin to understand what has occurred in Texas and New Mexico and how it has changed the global oil picture. “There has been a technical revolution. We never anticipated these advances in horizontal drilling,” said Curtis Mewbourne, who founded Mewbourne Oil Co. in 1965 in a one-room rented office. Today the company is the largest private oil producer in the U.S., and it is purely focused on the Permian.

“We have learned so much about how hydraulic fracturing could make these tight shales and carbonates economic. All this new engineering technology has made this a new business.”

Geopolitical realities

The political risk premium often afforded to the price of a barrel of oil seems to have disappeared. Historically, a sudden “black swan” event like the drone attack on a Saudi oil facility in 2019 would have strongly disrupted global markets and hiked the price of oil for some time. It did not. “The market basically shrugged. Shale oil has really alleviated those fears,” Medlock told Hart Energy. “The general impression is that U.S. oil production is a relatively secure supply to the global market, and that’s really good. The implications are far-reaching.”

Hastings Equity Partners wrote a white paper with the University of Houston’s energy team last year, whose key message was that as every incremental barrel flows out of the Permian it will have

“**W**hen we combine the vast wind resource being developed in West Texas, and the growing potential for geothermal and solar energy, the region is poised to lead the world in energy development. For that vision to come to fruition, the community, state and nation must converge around the long view.

“The time has come to shift perspective from one of boom and bust to one of global leadership in sustainable energy development. I believe West Texas will rise to the opportunity.”



Scott W. Tinker
 Director, Bureau of Economic Geology, UT

to be consumed somewhere else. “We ultimately concluded that if the flow is gradual, Corpus Christi can handle the influx for exports,” said Hastings managing partner Ted Patton.

He cited the majors that have forecast a lot more oil production by 2025. “If you combine all that they are saying, that’s another 3- or 4 MMbbl/d on top of what the independents say they will do, so the U.S. can only absorb so much.”

Traders like Vitol, Trafigura and Shell will be the ones to find new buyers. Leverage to oil prices will accrue to these shippers, not producers, he said. “Since the majors can essentially sell crude to themselves, what are the independents going to do? The obvious choice is to consolidate or form a consortium of some kind to retain some pricing power (but that has legal implications) and compete with Russia and Saudi, or will they throw up their hands and cede to the shippers?”

He said Permian production could peak at 7- or 8 MMbbl/d, reaching a point where the world cannot absorb that many incremental barrels unless demand increases.

The way forward

The future of the Permian will be marked by more modest growth, enhanced by technical advances and fine-tuning on well spacing. Environmental mitigation measures will increase.

Occidental, ExxonMobil and Shell Oil Co. each use wind and solar power in the Permian, as well as natural gas, to support their operations. Occidental has recently signed a long-term agreement with Core Solar LLC for 109 MW of power starting in 2021. ExxonMobil has a similar deal with Orsted, which will supply 500 MW of wind power in the Permian. The latter’s new windfarm is supposed to come online in 2020 and a solar project will follow in 2021.

Enhanced oil recovery will continue to unlock even more riches in the years ahead, with Occidental a leader in this regard. The company already injects 2.6 Bcf/d of CO₂ in the Permian for EOR, but it will begin in 2021 to build a new facility to capture carbon emissions from the atmosphere and recycle that into oil and gas fields, or store it underground. A pilot project will be ready by 2023.

Most observers agree that an oil price consistently at or above \$60/bbl would sustain much more drilling throughout the basin, leading to production increases if that price threshold were to stabilize. The EIA has cautioned that well productivity gains were waning. Drilling in the Permian, the most prolific of the shale basins, fell by 11% in the nine months to August 2019, according to the EIA.

But optimism about the Permian’s long-term prospects will carry the day. In November 2018, 17



Jim Wicklund
Managing Director, Energy
Banking, Stephens Inc.

“In the late ‘70s, I was a juggy with Western Geophysical, planting geophones. We’d stay in these little podunk towns east of Midland. On our time off, we thought it was a big deal to go to Midland—but it was such a one-horse town back then. Everyone was drilling the Spraberry at the time, and mostly it was small one-man shops. Most people in the industry considered it quasi-legitimate. They’d drill one

zone and then it would deplete, then they’d move up hole and drill another zone and so on, so a lot of reserves were left behind pipe. People always knew more oil was there, but it wasn’t economic to produce then.

“Now it’s arguably the most important oil field in the world—you shut down the Permian and oil prices would soar. The U.S. grew oil production in 2015, ‘16 and ‘17 faster than any country ever has in history.

“Now some people say it’s going to plateau at 10 million a day, but I don’t buy that—I think it’ll be closer to 7 million. The production per foot is starting to plateau because we’ve about run out of new efficiencies; we’re hitting diminishing returns in terms of pushing the technology.

“I’m a big fan of the Permian. Yes, it peaks out eventually, but it’s going to be the most legit with the longest legs. A lot of activity will be required to keep it at 7 MMbbl/d, which should be a boon for the service industry.”

CEO members of the Permian Strategic Partnership published an op-ed in the Midland Reporter-Telegram assuring that the Permian’s future should not be in question.

“While the oil and gas business is inherently cyclical, we are convinced that what is happening in the Permian today points to a resilience that is different from the boom and bust cycles of the past.

“We have analyzed various scenarios and believe that, even in a downturn, Permian production will continue to grow in the coming years.”

That’s good news for area citizens, and for the 400-odd companies that have filed for drilling permits in the basin. Mizuho Securities analyst Paul Sankey noted in November that many of his clients “are getting very optimistic about 2021. Seems a long way off, but oil observers are thinking that after 2020, oil markets get very tight. We agree. With US E&P restructuring hard, there is a terrific medium term set-up for oils.” 

GLOSSARY OF TERMS

Barrel—the basic unit for measuring oil. A barrel is equal to 42 U.S. gallons.

Blowout—An uncontrolled, accidental release of well pressure either to the surface or to another formation (in this case, called an underground blowout).

BTU (British thermal unit)—A unit of measurement for energy representing the amount of heat necessary to raise the temperature of one pound of water by one degree Fahrenheit.

Casing—Steel pipe used to protect the wellbore from caving in. When casing is cemented, it forms a hydraulic seal with the rock formations, preventing well fluid from migrating up or down the outside of the casing.

Completion—A generic term describing the process of making a well ready to produce natural gas or oil. Completion involves installing permanent equipment, such as a wellhead, and often includes hydraulic fracturing.

Directional Drilling—The drilling of a well that departs materially from the vertical direction.

Dry Hole—When no oil or gas are found in the exploratory well, or the quantity of oil or gas that was found is insufficient or uneconomic to justify the expense of bringing the well into production.

Fishing—Slang for retrieving pipe, tools, cable or objects that have dropped into the well.

Horizontal Drilling—A method of drilling where the drill bit is turned in a horizontal direction in an effort to produce hydrocarbons from a number of areas located at the same approximate depth.

Hydraulic Fracturing (also referred to as frac'ing or fracking)—An essential completion technique in use since the 1940s that facilitates production of oil and natural gas trapped in low-permeability reservoir rocks. The process involves pumping chemicals, water and sand at high pressure into the target formation, thereby creating small fractures in the rock that enable hydrocarbons to flow to the wellbore.

Henry Hub—An interstate pipeline interchange that also serves as the delivery point for Nymex natural gas futures contracts, located in Vermillion Parish, Louisiana.

Log—A continuous downhole record as a function of depth of information on the rocks and fluids encountered in a wellbore.

LNG (Liquefied natural gas)—Natural gas becomes a liquid at a temperature of minus 258 degrees Fahrenheit and may be stored and transported in the liquid state.

Lease—A legal document executed between a mineral owner and a company or individual that conveys the right to explore for and develop hydrocarbons and/or other products for a specified period of time over a given area.



CONFERENCE & EXHIBITION

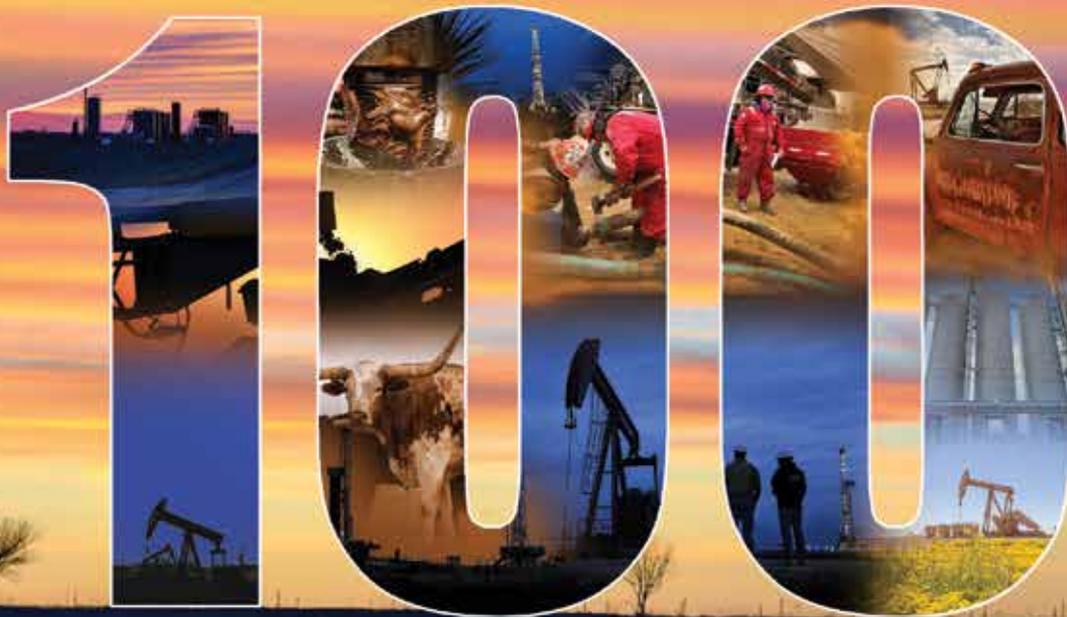


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Methane—Commonly known as natural gas, it is the most common hydrocarbon gas, colorless, odorless and flammable.

MMCF (Million cubic feet)—A volume unit used to measure gas. Also used as Mcf (thousand cubic feet), Bcf (billion cubic feet) and Tcf (trillion cubic feet).

Mud—Mixture of water and chemicals that occupies the borehole during the drilling or completion of a well. It exerts hydrostatic pressure on the reservoir to balance the natural formation pressure and prevent accidental influx of formation fluid into the borehole. Prevents the sides of the well from caving in as the hole is cut.

Perforating—A downhole perforating gun, lowered by wireline, fires shaped charges through the casing into the desired rock formation, resulting in perforations through which reservoir fluids may flow into the wellbore and to the surface.

Permeability—The measure of the resistance to the flow of fluid through the rock. High permeability means fluid passes through the rock easily.

Porosity—The measure of a rock's ability to hold a fluid. Porosity is normally expressed as a percentage of the total rock which is taken up by pore space.

Parent-child wells—The "parent" is the first well drilled on a well pad, and the child is the next well nearby. Spacing between parent and child can affect well performance and ultimate recovery of the reserves, with children typically producing less than the original parent well. If wellbores are spaced too closely there can be interference, which lowers the aggregate production from the pad. It is common to drill 4, 6 or even 8 wells on a pad.

Play—An area in which hydrocarbon accumulations or prospects with similar characteristics occur.

Prospect—An area that is the potential site of an oil or gas accumulation. A lease or group of leases which an operator intends to drill.

Reservoir—A porous and permeable subsurface formation that contains oil or gas and is surrounded by rock that separates the oil or gas contents from other reservoirs.

TIL (Turn in line)—This refers to the time a completed well is hooked up to a production system such as a pipeline and begins actual production to the market, and the operator begins to receive revenue.

Tubing—High-pressure pipe runs inside the casing through which the oil or gas is produced.

Working interest—Percentage of ownership in a joint venture, partnership, consortium, project, acreage or well.

Workover—An oilfield term meaning 'overhaul.' Wells must be worked over to address cleaning, wear and corrosion of the downhole equipment or pressure issues.

WTI (West Texas Intermediate)—Also known as Texas light sweet, a grade of crude oil used as a benchmark in oil pricing. This grade is described as medium crude oil because of its relatively low density, and sweet because of its low sulfur content.

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