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# Tuscaloosa Marine Shale

*The Playbook*



A supplement to

Oil and Gas  
Investor

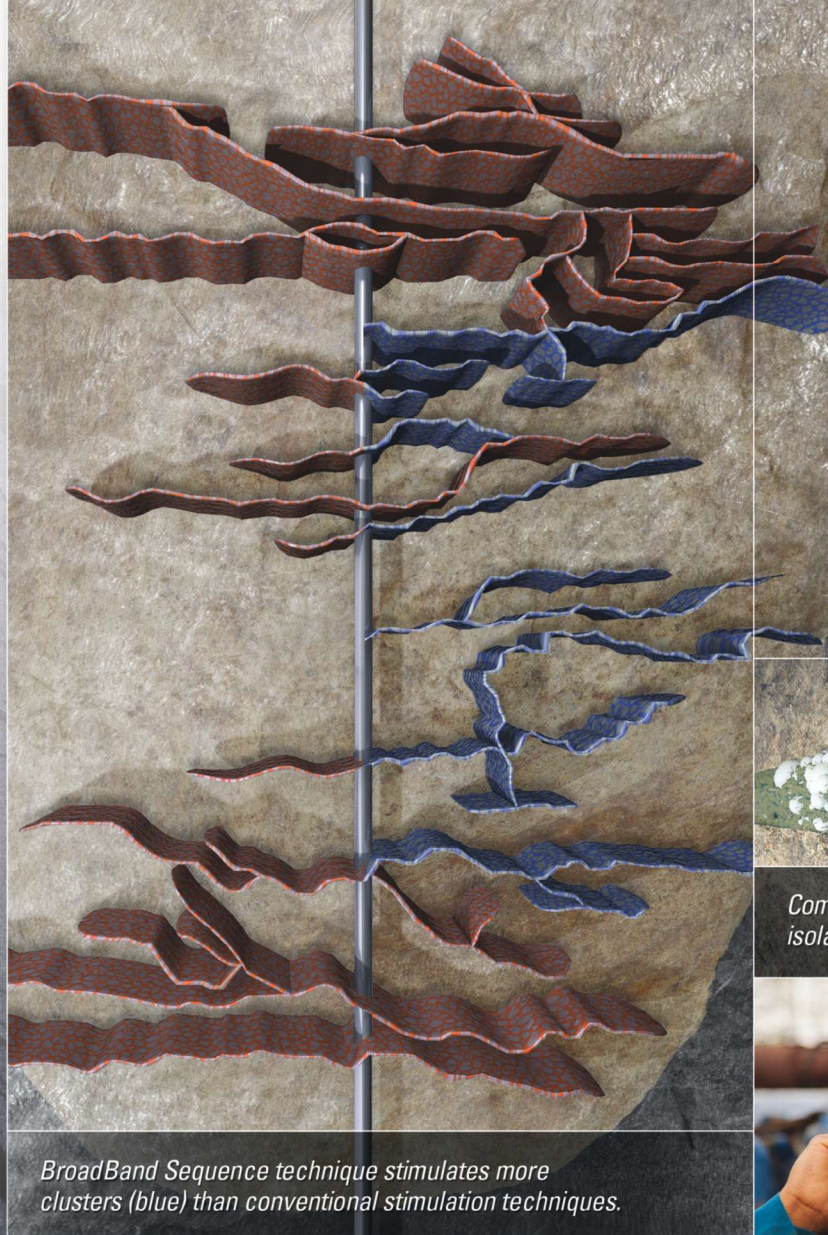
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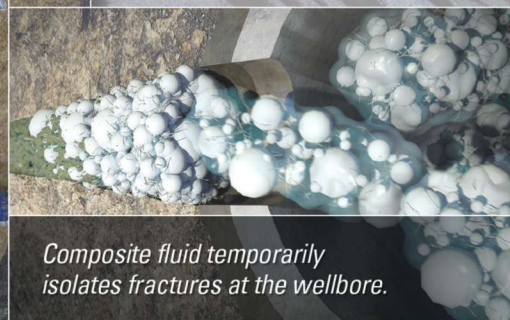


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## Tuscaloosa Marine Shale: *The Playbook*

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

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On the cover, Ensign Energy Services Inc.'s Rig 753 worked on the lateral for Goodrich's Crosby 12H-1. (Photo by Mieke Mahi)

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A Goodrich field operations team leader samples Tuscaloosa Marine Shale cuttings. (Photo by Mieko Mahi)



# Operators See Economic Potential in Tuscaloosa Marine Shale Play

The industry is becoming more aware of the economic potential of the TMS as a primary hydrocarbon source.

**By Steve Thornhill**  
Contributing Editor

**T**he petroleum industry has been aware of the Upper Cretaceous Tuscaloosa Marine Shale (TMS)—the middle part of the Tuscaloosa Formation—for decades. After all, geoscientists have proven with geochemistry that the shale is the source rock for the prolific Lower Tuscaloosa reservoir sands that have produced oil from conventional reservoirs since the 1940s. The Texas Pacific #1 Blades, a vertical unstimulated well completed in 1978, has produced more than 24,000 bbl of oil to date, until recently, because of the shale's poor permeability. However, even though the TMS was known to contain free oil, the TMS was not generally considered an economic drilling objective. With the successful advent of horizontal drilling, geosteering and multistage hydraulic fracturing, the industry's view of petroleum source rock hydrocarbon production has changed.



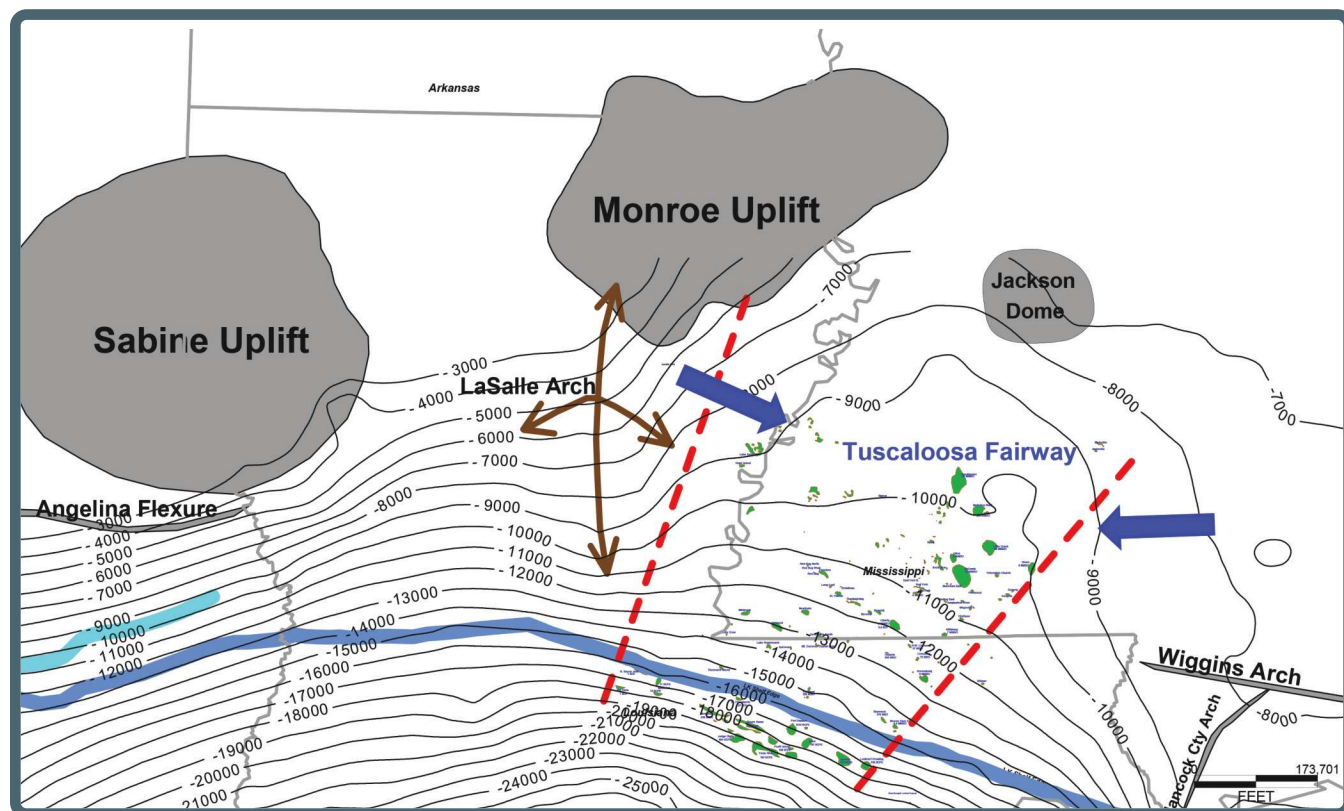




**ALTHOUGH IT'S ONE OF THE LEAST EXPLOITED** of the North American shale plays, the TMS offers strong returns in the sweet spot.

*(Image courtesy of Encana Corp.)*





The fairway for the TMS lies in the extreme eastern part of the ankle of the Louisiana boot and in the adjacent portion of southern Mississippi. (Image courtesy of Amelia Resources LLC)

Unfortunately, early horizontal TMS wells were not promising, considering the high drilling and completion costs. For example, early efforts included three wells drilled in 2007 and 2008. These three wells had laterals ranging from 1,650 ft to 4,100 ft and each one had three-staged frack treatments. Cumulative productions ranged from 10,700 bbl of oil to 28,800 bbl of oil. However, with numerous wells currently being drilled with laterals ranging from 4,500 ft to 8,575 ft, 16 to 32 staged fracks, and IPs ranging from 302 bbl/d of oil to 1,540 bbl/d, the industry has become aware of the shale's economic potential as a primary hydrocarbon source.

With the shale's boundaries largely based on formation depth and associated liquid hydrocarbon generation, the current TMS unconventional oil play is located on the Gulf Coastal Plain in a 45-mile- to 60-mile-wide band that roughly parallels the present Gulf of Mexico (GoM) coastline.

The play straddles the east and west Mississippi/Louisiana boundary in the east and contin-

ues west to the Texas/Louisiana border where it's truncated by the Sabine Uplift. The play's eastern extent is truncated by the combined Hancock Ridge and Wiggins Arch uplifts, just east of the southeastern north/south Louisiana/Mississippi border. Overall, the play's aerial extent covers about 11,700 sq miles, with estimates running between 2.9 million and 7.4 million productive acres. The play is thought to contain hydrocarbon reserves estimated up to 7 Bbbl. To the south, the Tuscaloosa is found at far greater depths where it plunges over the buried Cretaceous shelf edge. However, with greater depths, Tuscaloosa hydrocarbon generation changes to gas.

Just how did the TMS come into being? The TMS story begins 90 million years ago during the Upper Cretaceous. Much of south Louisiana and Mississippi was inundated by the marine waters of the Rio Grande Embayment. Flowing into the west side of the embayment was the Western Interior Seaway, a narrow waterway that ran in a



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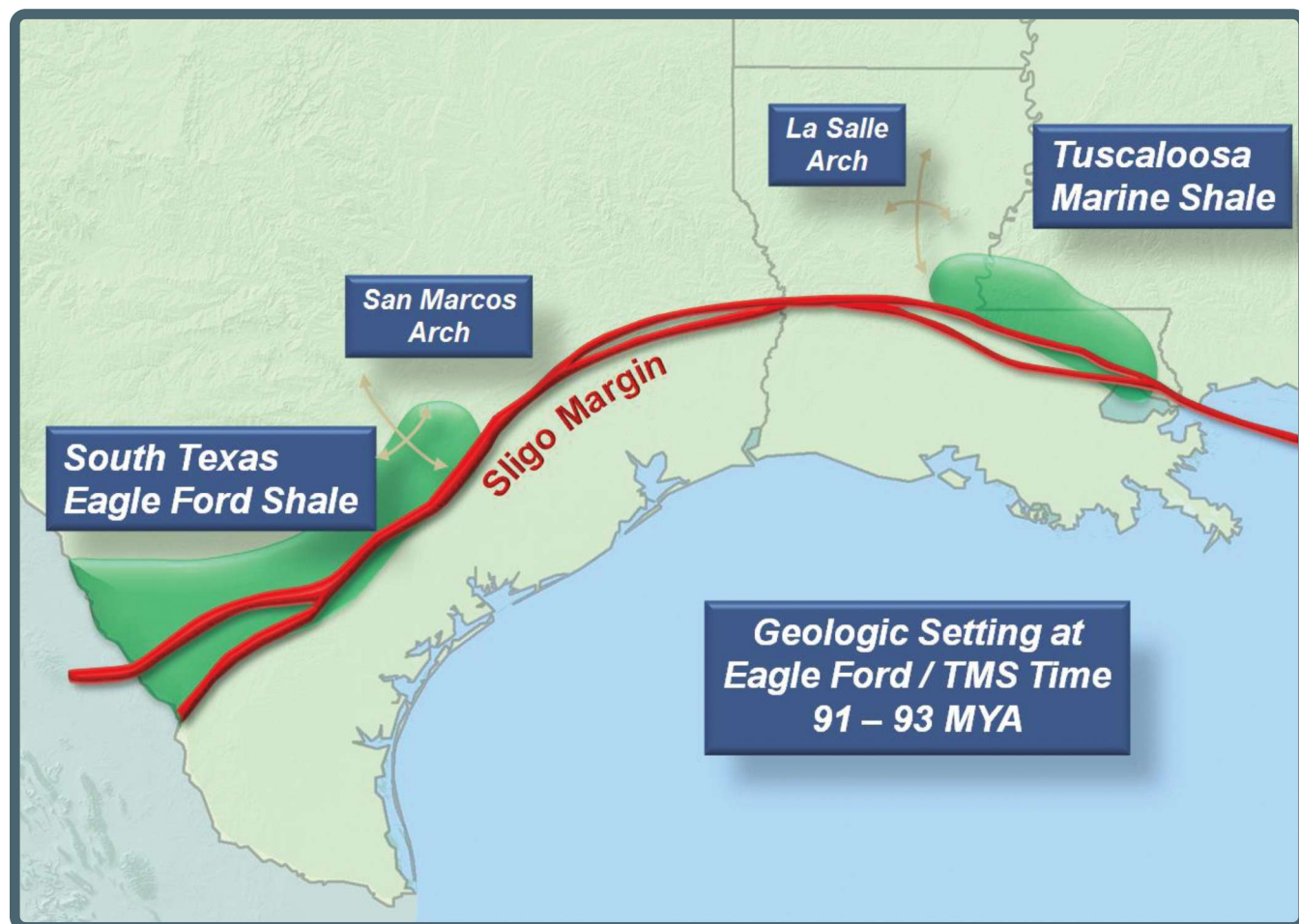
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The Sligo margin illustrates the kinship between the Eagle Ford Shale in South Texas and the TMS on the north-south Mississippi-Louisiana border. (Image courtesy of Goodrich Petroleum Corp.)

south/southeast direction from what today would be the Arctic Ocean to the GoM.

During the Late Cretaceous, the Appalachian Mountains, located to the play's northeast, and the Ouachita Mountains, located to the play's northwest, were much younger, taller and were eroding prodigious amounts of sediment. That sediment along with organic detritus was carried by river systems and deposited in deltas reaching far out into the Rio Grande Embayment.

In addition, based on multiple data sources, geoscientists are convinced that during this period the Cretaceous was experiencing global warming caused by an abundance of atmospheric CO<sub>2</sub> gas, the result of ongoing vigorous volcanic and magmatic activity. The resulting greenhouse effect, coupled with an upwelling of basic nutrients,

caused vigorous organic growth in the warm, shallow coastal marine waters. The organic growth eventually overwhelmed the water's oxygen capacity, causing hypoxic (low oxygen) and anoxic (no oxygen) conditions and the wholesale die-off of marine organisms in the embayment. Because of the low/no oxygen conditions, organic material raining on the seafloor wasn't consumed by benthic scavengers and bacteria, nor was it oxidized. Instead, ongoing sedimentary deposition buried the organic material where it was slowly broken down by anaerobic bacteria as well as the heat and pressure of burial. Over time the anaerobic bacteria died as well, leaving the organically rich shale layer that we know today as the TMS. The Upper Cretaceous wasn't the only time in the earth's history when these hydrocarbon-accumulating con-



ditions occurred. Geoscientists have found evidence supporting several other global anoxic episodes in the Cretaceous oceans alone.

### The Tuscaloosa Formation

The Tuscaloosa Formation is generally known to consist of three members, with the members' boundaries based largely on marine transgression/regression cycles. The three members include a lower transgressive massive sand member, a middle static transgressive marine shale member and an upper regressive sand/clay member. In the play area, the Tuscaloosa Formation is underlain by the Dantzler Formation and overlain by the Eutaw Formation, which is Eagle Ford-age equivalent. The top of the TMS is encountered in the play area at depths between 10,000 ft in the north and 15,000 ft in the south. The entire play area is just north of the buried Cretaceous shelf margin. To the south of the shelf margin, the formation depth drops off precipitously.

The Lower Tuscaloosa Massive Sand Member was the principal target for drillers during the earlier Tuscaloosa trend play. This member was formed during a major marine transgression that took place shortly after a marine regression that caused a geological unconformity between the Tuscaloosa and the earlier Dantzler Formation.

The Middle TMS Member is not only the lower member's source rock but also the current target for the developing unconventional TMS play. The middle marine shale member represents a prolonged static transgressive peak, the culmination of the earlier marine transgression.

The Upper Tuscaloosa Sand/Shale Member represents a marine regression caused by falling sea levels. The Upper Tuscaloosa is so similar to the overlying Eutaw Formation that it's often difficult to differentiate between the two formations, even though the Eutaw unconformably overlies the Tuscaloosa.

### The TMS

The TMS is found at oil-productive depths ranging from as shallow as 10,000 ft in the north to more than 15,000 ft in the south as it approaches the buried Cretaceous shelf margin. In addition, the shale is overpressured from 0.65 psi/ft to 0.7 psi/ft.

| SYSTEM     | SERIES     | GROUP            | FORMATION                                 |                                      | DESCRIPTION                                                            |
|------------|------------|------------------|-------------------------------------------|--------------------------------------|------------------------------------------------------------------------|
|            | NEOGENE    |                  | POST-ANAHUAC (UNDIFF.)<br>ANAHUAC<br>FRIO |                                      | MASSIVE SANDS WITH SHALE<br>PREDOMINANTLY LIMESTONE<br>SAND AND SHALES |
| TERTIARY   | OLIG.      | VICKSBG.         | UNDIFFERENTIATED                          |                                      | CLAY, CALCAREOUS SAND                                                  |
|            | Eocene     | JACKSON          | YAZOO CLAY<br><br>MOODYS BRANCH           |                                      | GRAY MARINE CLAY<br><br>FOSSILIFEROUS MARL                             |
|            |            | CLAIBORNE        | COCKFIELD                                 | SHALE MEMBER<br>'LIME' MEMBER        | SAND AND SHALE                                                         |
|            |            |                  | COOK MOUNTAIN                             |                                      | SHALE<br>MASSIVE LIMESTONE                                             |
|            |            |                  | SPARTA                                    |                                      | REGRESSIVE SANDS AND SHALES                                            |
|            |            |                  | CANE RIVER                                |                                      | SHALE MEMBER (ZILPHA)<br>MARL MEMBER (WINONA)                          |
|            | WILCOX     | UNDIFFERENTIATED | (OVERLAYING<br>TALLAHATTA<br>INCLUDED)    | DELTAIC SANDS AND SHALES             |                                                                        |
|            | PALEOC.    | MIDWAY           | PORTER'S CREEK<br><br>CLAYTON             |                                      | DARK GRAY MARINE SHALES<br><br>CHALK                                   |
|            |            | SELMA            | SELMA CHALK (UNDIFF.)                     |                                      | CHALK                                                                  |
|            | CRETACEOUS | GULF             | EUTAW                                     | EUTAW (EAGLEFORD)                    |                                                                        |
| TUSCALOOSA |            |                  | UPPER TUSCALOOSA                          | SANDS AND SHALES                     |                                                                        |
|            |            |                  | MARINE SHALE                              | DARK GRAY MARIE SHALE                |                                                                        |
| COMANCE    |            | WASHITA-FREDSBG. | LOWER TUSCALOOSA                          | STRINGER<br>MASSIVE SAND             | LENTICULAR SANDS AND SHALES<br>WHITE, COARSE-GRAINED                   |
|            |            |                  | DANTZLER                                  | SANDS AND SHALES                     |                                                                        |
|            |            | TRINITY          | UNDIFFERENTIATED                          | PREDOMINANTLY LIMESTONE              |                                                                        |
|            |            |                  | PALUXY                                    | VARIABLY COLORED SANDS AND<br>SHALES |                                                                        |

A general stratigraphic chart includes the three members of the Tuscaloosa Marine Shale. (Source: *Basin Research Institute bulletin, Louisiana State University; modified from Howe, 1962*)

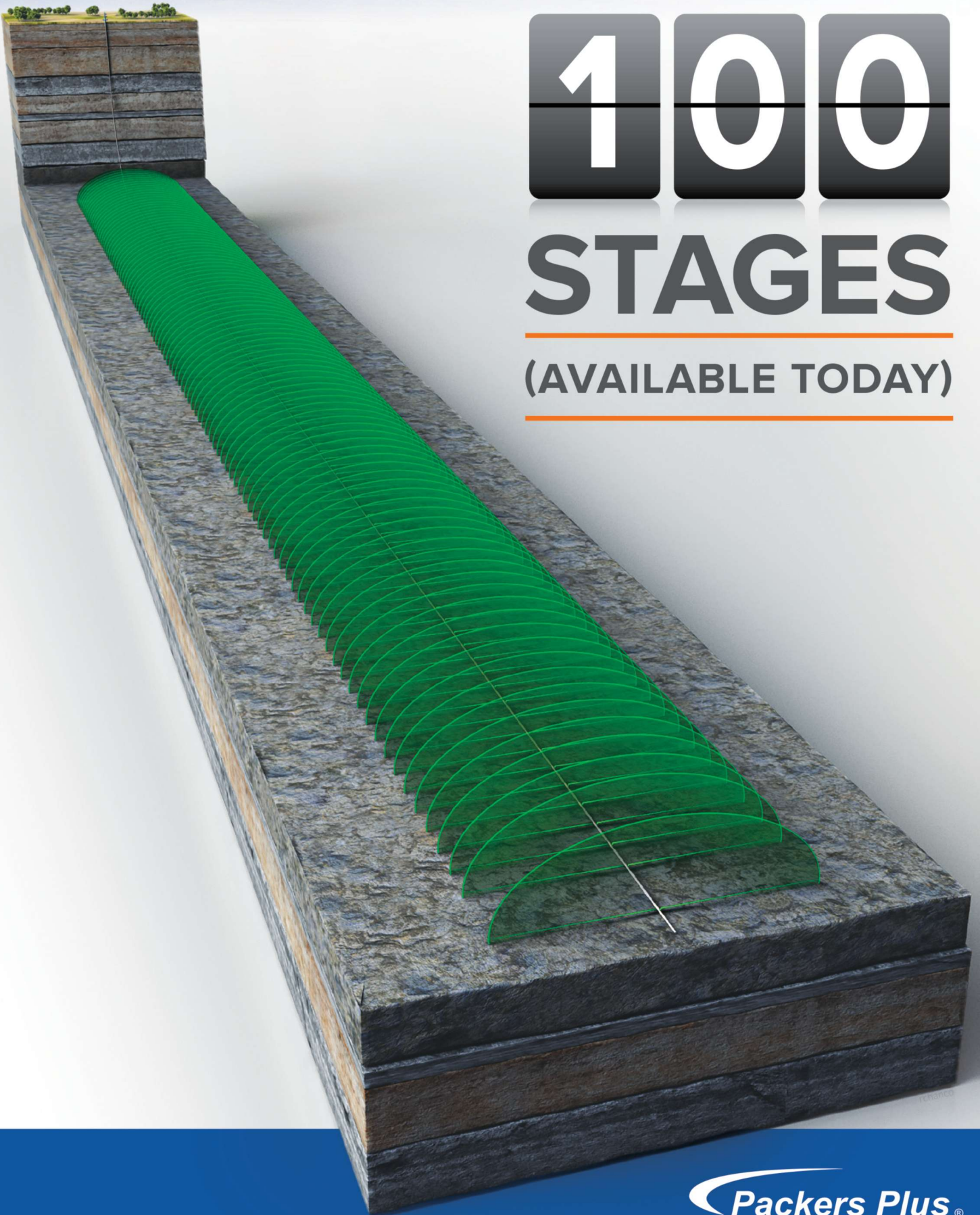
The shale's gross thickness varies from 500 ft to 800 ft thick through the oil-productive areas. However, oil men have found that the most oil-productive shale zones have elevated resistivity typically greater than 0.5 ohms. The net prospective interval has been found to vary in thickness between 0 ft and 325 ft because the entire interval doesn't have this elevated resistivity.

The shale is divided into two zones: an upper and lower zone with a 10-ft-wide highly fractured "rubble zone" in between. While both zones have elevated



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total organic carbon (TOC), the lower zone typically has a higher log resistivity than the upper zone making it the more attractive target of the two zones. However, drillers have found that, because of the overpressured formation, the highly fractured rubble zone can be difficult to drill through without running the risk of a stuck drillpipe and a lost well.

The TMS is composed primarily of highly laminated light to dark gray or brown, splintery, brittle, calcareous silty to clay-like shale with occasional sand stringers. The shale's porosity ranges from 5% to 10%, and its permeability ranges from 10 nD to 100 nD. The shale has been described as having an amorphous algal-based kerogen that produces oil with a relatively high gas-oil ratio, making it almost or certainly Type II kerogen. The shale's TOC ranges from 1.5% to 3.5%, and the shale's Ro ranges from less than 0.6% in the shallower play areas to 1.2% in the deeper areas.

Early in the play's development, operators were concerned with the shale's overall clay content and the fact that it contained clays that swelled upon contact with water. Core analysis has revealed that while the shale might contain between 25% and 50% clay, with swelling clays typically making up only about 16% of the clay, the overall clay percentage drops significantly in the deeper, more hydrocarbon-rich layers. The reality is operators have been pleased to learn that because the overall clay content and swelling clay percentage is dropping considerably in the formation's high-resistivity oil-productive areas, these same areas are the areas that are best to produce from. Of additional positive economic interest, operators are not only achieving very economic IPs, but they're producing high-quality 38°API to 45°API gravity crude with a high 1,400 Btu to 1,500 Btu gas content and an increasing gas-oil ratio with depth, which are making the play's economics even more attractive. ■



The bridge over the Mississippi River at Natchez is the only bridge for about 140 aerial miles. (Photo by Mieko Mahi)



# TMS Sparks Eagle Ford Visions

Large and small operations see potential in stratigraphic equivalent of popular shale.

**By Don Lyle**  
Contributing Editor

Large and small operators followed the Eagle Ford trend from South Texas through East Texas and found an equivalent that offered promising tests in the Tuscaloosa Marine Shale in Louisiana and Mississippi.

It's deep—from 10,500 ft to 14,000 ft—and wells are expensive—up to \$17 million—but fewer than 50 wells have tested the formation, and only a handful of operators are active drillers.

As operators gain more information, costs drop and production rises. They've zeroed in on the sweet spots of the play, and land prices in those areas are climbing when acreage still is available.

The best wells top 1,000 boe/d, and that's the attraction.

Profiles in this section will examine the active drillers, the watchers on the sidelines and the companies working the land play.

## Key Players

### Amelia Resources LLC

- *Land: Overriding royalty interest in 220,000 net acres*
- *Prospect generation pays off*

Privately held Amelia Resources LLC, long-time believer in the Tuscaloosa Marine Shale (TMS), backs its marketing program with 23 years of experience in the trend and a constantly updated play status.

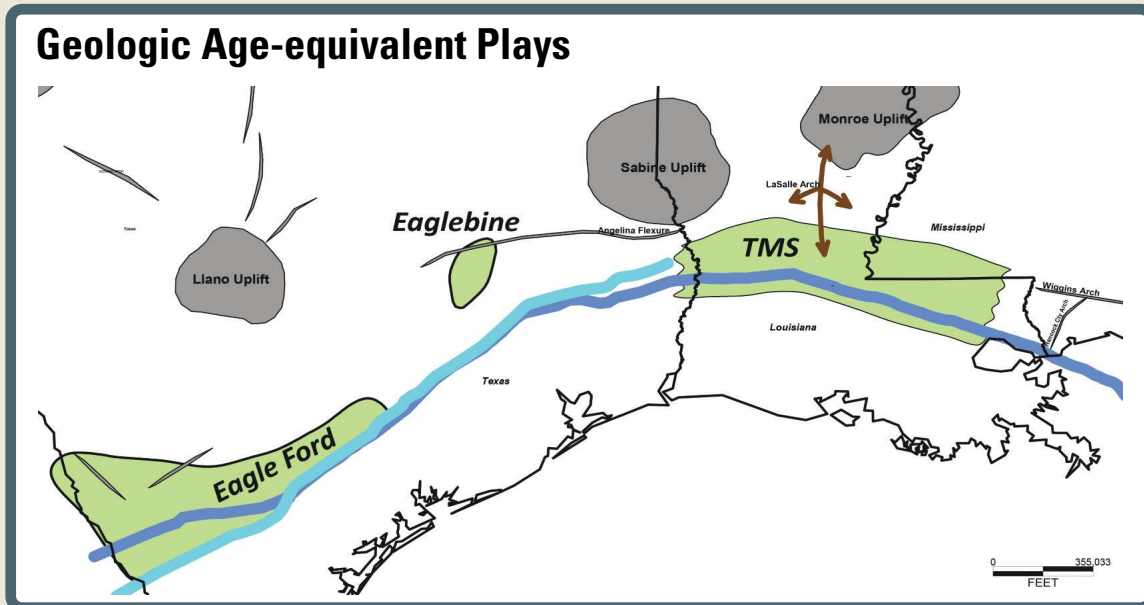
President Kirk Barrell runs his own online blog ([tuscaloosatrend.blogspot.com](http://tuscaloosatrend.blogspot.com)) with information about the play, his company's holdings and updates on activities of all the major operators working the shale formation directly above the prolific Tuscaloosa sands.

The company hosted a data room marketing TMS acreage for its partners and sold 95,000 net acres at year-end 2013. Amelia currently is marketing 118,000 acres in seven packages ranging from 2,200 to 50,000 acres.

The Eagle Ford-age equivalent play should offer EURs between 500 Mboe and 850 Mboe with IP potentials in the 700 boe/d to 1.55 Mboe/d range. That flush production should decline by 78% to 83% during the first year online, according to a November 2013 presentation. The sweet spots, with current hydrocarbon prices, lie in up to 2.6 million prospective acres in central Louisiana and southern Mississippi that are oil prone. The full prospective area could be as large as 7.4 million acres.

The company has evaluated more than 1,000 wells in the TMS in Louisiana, Mississippi, Alabama and Texas. That evaluation includes the use of well logs, core analysis, geochemistry, seismic and petrophysics to confirm and define the most economically attractive areas of the TMS.

According to Barrell, "Drilling improvements, along with high initial flow rates, are bringing more attention to this oil play. We believe that the repeata-



Some industry experts believe the Tuscaloosa Marine Shale play offers better economics than the Eagle Ford play. (Image courtesy of Amelia Resources LLC)

bility and economics of the play will be extremely competitive with other U.S. oil plays.”

Comparing the current status of the TMS—with only 42 completions on the books—with other plays, he said the current TMS compares with the Eagle Ford in 2009.

Calculating 2.6 million prospective acres with 350 bbl/acre-ft of productive reservoir, the full oil-prone part of the play should yield 9.175 Bboe of reserves with a 6% recovery factor, Barrell said.

Operators have drilled laterals up to 9,000 ft with proppant volumes ranging from 475,000 lb to 600,000 lb per stage.

Recent initial potentials range from 1,000 boe/d to 1,550 boe/d. The Goodrich Petroleum Crosby 12H-1 produced 176,000 boe in 15 months.

Drilling improvements in 2014 reduced drill times to 30 days on average from 45 days in 2013.

#### Comstock Resources Inc.

- *Land: 60,000 net acres*
- *Starting a drilling program*

Comstock Resources Inc. entered the Tuscaloosa Marine Shale (TMS) play in late 2013, built on that entry position and will start drilling wells in 2014.

In November 2013, the Frisco, Texas, company said it entered into agreements to acquire leases on

55,000 gross (53,000 net) acres in Louisiana and Mississippi for \$54.5 million.

At the time, Comstock said, “The company believes the acreage being acquired is prospective for oil in the Tuscaloosa Marine Shale formation and is near successful wells drilled by other industry participants. The leases cover acreage in Wilkinson and Amite counties in Mississippi and East Feliciana and St. Helena parishes in Louisiana. Comstock expects to complete the acquisitions in the fourth quarter and is pursuing other lease acquisition opportunities in this and another play prospective for oil development.”

In May 2014, Comstock submitted bonus bids totaling \$80,495 for Louisiana state leases in East Feliciana and St. Helena parishes, but it landed only one of those bids, a \$32,895 offer for 129 acres in St. Helena Parish.

In releasing its second-quarter results for 2014 in August, Comstock said its position in the TMS had grown to more than 60,000 net acres.

The company also said it planned to initiate a drilling program in the formation with three gross wells during 2014. The company set aside \$32.7 million of its \$510 million budget for 2014 to drill those 2.7 net wells. Most of its remaining expenditures will go into its Eagle Ford properties in South Texas.



### Denbury Resources Inc.

- *Land: 145,000 gross acres*
- *Partnered with Encana Corp.*

Denbury Resources Inc. acquired much of its Tuscaloosa Marine Shale (TMS) land through its 2010 acquisition of Encore Acquisition Co. in 2010 and gained more through its EOR projects along the north-south Louisiana-Mississippi border.

The Encore acquisition gave Denbury 210,000 net acres along that border. Encore drilled four horizontal wells to the TMS in 2007 and 2008. Three of those wells were producers, and Encana might have completed the fourth well, the Board of Education 1H. Following its partnership agreement with Encana, Denbury held a 15% interest in 105,000 acres with potential for TMS pay and larger interests in another 45,000 acres associated with its EOR operations.

Since Denbury's primary interest in the area lies in its EOR projects, it turned over operations of its TMS holdings to Encana under the 2009 partnership agreement. Encana covered Denbury's costs in the earlier wells.

### Devon Energy Corp.

- *Land: 297,000 acres*
- *Put its land up for sale in 2013*

Devon Energy Corp., one of the early backers of the Tuscaloosa Marine Shale (TMS) play, drilled wells, found pay and later decided to sell its major holdings in Louisiana.

It engaged Scotia Waterous (U.S.) Inc. to help sell the properties in East Feliciana, West Feliciana, St. Helena and Tangipahoa parishes. Devon spent \$50 million acquiring the leases. In July 2013, Goodrich Petroleum Corp. said it purchased Devon's two-thirds interest in 277,000 acres in the TMS for \$26.7 million.

Devon was one of the few companies drilling wells to the shale by early 2011, and it was drilling horizontal wells in East Feliciana Parish. The properties and development were part of a Devon joint venture with China's Sinopec.

At the time, the company still was trying to evaluate liquid content. The shale section on its properties ranged from 200 ft to 400 ft thick at depths from 11,000 ft to 14,000 ft, according to informa-

tion released during the company's conference call for its first-quarter 2011 earnings release.

By the time the company put the properties up for sale in 2013, it had drilled eight wells, including six horizontal, on its properties with another well, the Weyerhaeuser 72H awaiting completion. Initial potentials on the horizontal wells average about 600 boe/d, Scotia Waterous said.

Among its wells, according to an Amelia Resources presentation, Devon's Murphy 63H-1 tested with an initial potential of 460 boe/d, the Richland Farms 74H-1 at 285 boe/d, the Thomas 38-1 at a 30-day initial potential of 470 boe/d, the Soterra 6H-1 at 176 boe/d, the Beech Grove 68H-1 at 137 boe/d, the Weyerhaeuser 14H-1 at 390 boe/d and the Weyerhaeuser 72H-1 at 354 boe/d.

The Beech Grove well produced 13,604 boe in 16 months online, the Soterra well produced 26,122 boe in 12 months, the Richland Farms well produced 46,879 boe in 10 months, the Murphy well produced 30,212 boe in six months, the Weyerhaeuser 14H produced 69,807 boe in eight months, and the Thomas well produced 39,430 boe in five months.

At that time, with seven wells drilled, Devon's average lateral extended about 4,200 ft to an average total depth of 17,750 ft. It had completed more than 100 fracture stages with an average 17 stages per well using more than 200,000 lb of proppant per stage.

### Encana Corp.

- *Land: 200,000 net acres*
- *One of six company growth assets*

Encana Corp. continued its move to a liquids-focused company in 2014 and bolstered that commitment by placing the Tuscaloosa Marine Shale (TMS) on its high-priority list among growth assets.

It also maintained its position as the play's most active driller on the 200,000 net acres on which it holds an average 60% working interest. Denbury is a minority partner on some of those properties.

In early 2014, the company focused its activities in the central and eastern portions of the play. That focused land position allows the company to drill for best performance rather than drilling to meet commitments to hold land.

In a year-end 2013 presentation, Encana said it held 302,000 net acres of land with room for 1,300



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Workers prepare a tank battery for high production of fluids from TMS wells. (Image courtesy of Encana Corp.)

wells. In March 2014, Encana entered into an agreement with a third party that covers about one-third of the company's lands to help accelerate its evaluation of the play. Having multiple companies operating in an early-life resource play accelerates appraisal and assists in unlocking its full potential.

Bringing another experienced company in to invest capital, delineate the play and share information helps continue to lower costs and improve the economics of the play.

Nearing mid-year 2014, Encana divested some of its more gas-prone properties and acquired a stake in the oil-rich Eagle Ford. Its commitment to oil showed in first-half 2014 as the company's oil production rose 49% year-to-year and gas liquids production increased 38% in the same period.

Its liquids-prone growth areas, including the TMS, received 80% of the Canadian company's capital investment in the first part of the year to enable a 50% increase in net wells drilled.

The company's growth areas include the Niobrara play in the Denver Basin, the Montney Formation in Alberta, the San Juan Basin in Colorado and New Mexico, the Duvernay in Alberta, recently acquired Eagle Ford properties and the TMS.

Early results from the TMS are encouraging, according to the company's website. It planned to complete its appraisal of the formation on its properties with nine to 12 new net wells in 2014. All of the wells drilled by mid-year 2014 "are generally meeting expectations. Six net wells have been drilled year-to-date, and two rigs will run through year-end."

Amelia Resources credited Encana with the longest lateral in the play at 8,932 ft and the largest number of frack stages at 30 on the Anderson 17H. It also said the company's Anderson 18H-1 produced 110 Mbbl of oil in nine months online. Encana uses between 700,000 lb and 1 MMlb of proppant per stage.

By mid-2014, Encana had drilled 11 TMS wells, and all of them were on production. Eight of those wells are in Mississippi, and three are in St. Helena Parish, La. At that point, the company's most recent wells cost about \$16 million each to bring to production.

According to the Amelia presentation, Encana drilled one of the better wells in the play. Its Weyerhaeuser 60H-1 tested for an initial potential of 1,100 boe/d.

In a September 2014 presentation, Encana said the TMS had an estimated 4 Bboe to 5 Bboe in place, and its properties had the potential to produce more than 50,000 bbl/d of liquids.

It said 80% of its 200,000 acres of land were in the top tier for production. In resource play hub mode, the play should generate returns between 35% and 40%. The company plans to reach that point in 2017. The returns assume a New York Mercantile Exchange price of \$4/MMBtu for gas and a \$90/bbl price for West Texas Intermediate oil. The company has a gross inventory of 1,000 wells and anticipates costs dropping between \$11 million and \$13 million.

For 2014, the company planned to complete its appraisal program while improving costs and demonstrating the repeatability of the type curve for its wells. It also will further delineate production from its acreage.

It planned to spend between \$110 million and \$125 million in 2014 to drill 12 to 14 wells and finish the year producing between 1.6 Mbbbl/d and 2.1 Mbbbl/d of condensate.

### EOG Resources Inc.

- *Growing organically*
- *Stalking major plays*

EOG Resources Inc. dipped its drillbits into the Tuscaloosa Marine Shale (TMS) play, but it found no barn-burner wells. Its latest presentation doesn't list the formation among its top-priority plays.

It has plenty of work awaiting its drilling teams. It's the largest landholder and oil producer in the Eagle Ford and a major player in the Bakken/Three Forks. It opened the Niobrara play in the Denver Basin and recently added the Second Bone Spring in the Delaware Basin to its drilling program.

The Eagle Ford, Bakken/Three Forks, Delaware Leonard and Second Bone Spring, Powder River Basin Parkman and Turner, and the Codell in the Wyoming section of the Denver Basin all offer the company an after-tax rate of return of more than 100%. The Delaware Basin Wolfcamp yields more than 60%, and the Wyoming Denver Basin Niobrara, Midland Basin Wolfcamp and North Texas Barnett Combo all return more than 30% after taxes.

Of the \$8.1 billion to \$8.3 billion EOG plans to spend in 2014, \$7.1 billion is going into the Eagle Ford, Bakken/Three Forks, Permian and Rockies assets.

A presentation by Amelia Resources listed some TMS figures for EOG. It drilled its wells to completion at a cost of \$11.5 million.

Its Dupuy 20H-1, completed in 2012, showed a 30-day initial potential of 420 boe/d and produced 29,085 boe in three months online. Its Gautier 14H-1 offered 252 boe/d in its first 30 days.

It completed the 1 Paul 15H in Avoyelles Parish, La., in late 2013 flowing 181 bbl/d of oil, 140 Mcf/d of gas and 118 bbl/d of water to open a new pool in the TMS in Vick Field.

As late as June 2014, EOG still was working the TMS. According to IHS Inc., it staked the 1 Indigo 25H in Vernon Parish, La., about 55 miles west of its previous wells in Avoyelles Parish, possibly in partnership with Indigo II Louisiana Operating.

### Goodrich Petroleum Corp.

- *Land: More than 300,000 net acres*
- *Most active driller*

Goodrich Petroleum Corp. has good reasons to like the Tuscaloosa Marine Shale (TMS). It drilled some of the best wells in the play, and its executives believe the play offers better economics than the Eagle Ford in South Texas.

The company's 1 C.H. Lewis 30-19H tested for a peak 24-hour rate of 1,450 boe/d with 1,387 bbl/d of oil and 377 Mcf/d of gas on a 16/64-in. choke from perforations in a 6,600-ft lateral with 26 fracture stages, according to IHS Inc. Its earlier Crosby 12H-1 well tested with an initial potential of 1,300 boe/d through a 15/64-in. choke and a 30-day potential of 1,137 boe/d.

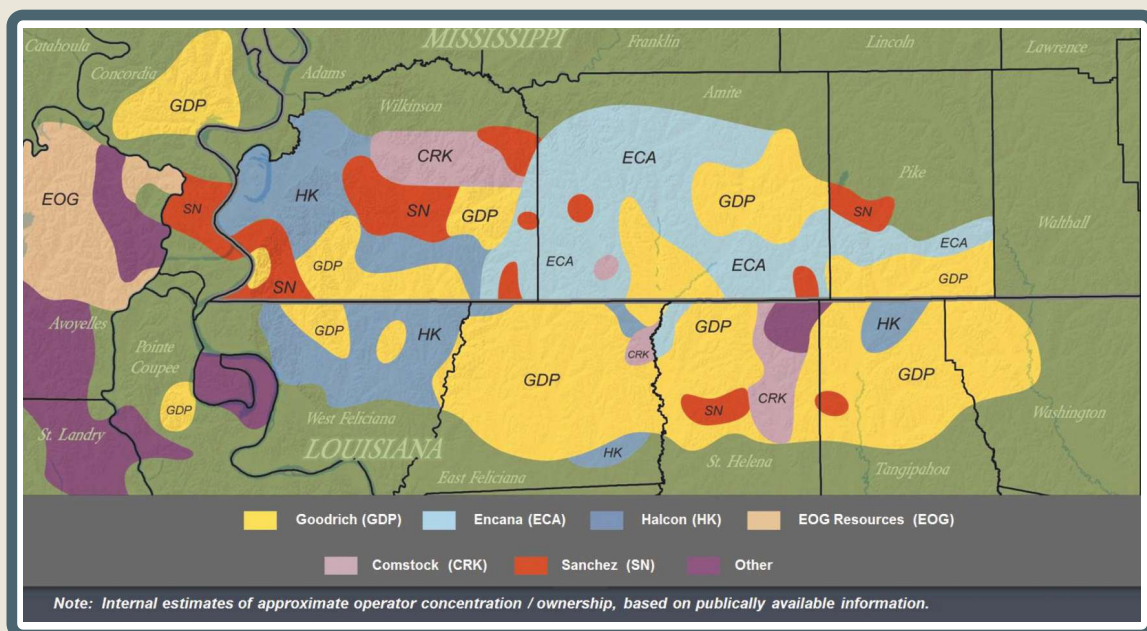
In early September 2014, Goodrich said its Denkmann 33-28H-2 well in Amite County, Miss., tested at a peak 24-hour IP rate of 1,250 boe, including 300 Mcf of gas, after completion of 22 fracture stages in a 6,000-ft lateral.

At that time, the company was running three rigs in the play, had started flowback on its Bates 25-24H-1 in Amite County and was fracturing its CMR/Foster Creek 31-22H-1 well in Wilkinson County, Miss. It also was completing the CMR/Foster Creek 24-13H-1 and the Spears 31-6H-1.

It was drilling its Verberne 5H-1 and the Spears 31-6H-1 offsetting its Blades 33H-1 well in Tangipahoa Parish, La., and its CMR/Foster Creek 8H-1 on a two-well pad offsetting the Crosby 12H-1.

Goodrich executives said they cracked the code for the TMS and backed that claim with initial





Major players in the TMS already have captured much of the land along the Mississippi-Louisiana border where the best wells have come in. (Image courtesy of Goodrich Petroleum Corp.)

potential numbers that far surpass other operators in the play. For example, according to figures published by Amelia Resources, in 2013, its average IP was 1,100 boe/d compared to 700 boe/d for the closest competitor.

Reviewing Goodrich's second-quarter 2014 conference call in August, Kirk Barrell, president of Amelia Resources, said only 42 wells had been completed in the TMS, a point reached by the Eagle Ford in 2009. He also agreed with Goodrich's reasoning that the less naturally fractured section of the TMS will offer shallower decline rates.

Goodrich picked up its initial 74,000 acres in the play for \$175 per acre. Later, when Devon backed away from the TMS, Goodrich bought two-thirds of its 277,000 acres for an average \$180 per acre.

According to Goodrich, "We're very comfortable today with what we see from a geologic standpoint of going ahead and drilling wells. In fact, we don't really even see much need, at least in most of our acreage, for drilling pilot holes. I would characterize, at least in our view, that the sole, or the largest single risk to the play, is just one of economic performance versus well costs."

The company said the TMS discovery well was drilled by Humble Oil in 1962 in Amite

County. That dry hole cored 3 ft of oil saturation in the formation.

A single well to the formation costs Goodrich \$13 million, but it can complete development wells with 6,000-ft laterals and 22 fracture stages for \$10 million. It pays an 18.5% royalty but no severance taxes until payout, when a 12.5% tax kicks in. Wells offer gross reserves of 600 Mboe to 800 Mboe and net reserves of 489 Mboe to 652 Mboe.

Depending on the level of reserves and finding and development costs, with a New York Mercantile oil price of \$95/bbl, the company's internal rate of return ranges from 28% to 57% for a single well and 57% to 115% on a development well.

Undiscounted payout takes 1.7 years to 2.5 years on a single well and one year to 1.7 years on development wells. Those numbers offer an economic potential better than the Eagle Ford.

In July 2013, Robert Turnham Jr., president and COO, said Goodrich would spend \$50 million in the TMS that year and could spend as much as \$150 million in 2014.

"Under the right scenario, we would love to even double that number and spend as much as \$300 million," he added. That scenario would require additional capital, perhaps through a partner.



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### Halcón Resources Corp.

- *Land: About 316,000 net acres*
- *Active shale driller*

Halcón Resources Corp. management, pioneers in the Haynesville Shale in Louisiana and the Eagle Ford in Texas, established a strong position in the emerging Tuscaloosa Marine Shale (TMS) in Louisiana and Mississippi.

The company controls 72,686 acres in the western portion of the play and another 242,990 acres in the eastern portion. Some 45% of its eastern properties lies in Wilkinson County, Miss.

Halcón already has producing wells in its portfolio, and it plans to add more. According to a September 2014 presentation, the company plans eight gross operated wells and participation in another 10 to 12 nonoperated wells in second-half 2014.

The company enlisted Apollo Global Management LLC in its program. That company will invest up to \$400 million in Halcón's HK TMS LLC subsidiary to accelerate the company's activity.

It produced 173 boe/d from the TMS in second-quarter 2014.

HK TMS holds all of Halcón's properties in the TMS, and Halcón held all of the stock in HK TMS. An Apollo contribution of \$150 million gave it 150,000

HK TMS preferred shares with an 8% annual yield. Apollo can acquire up to 250,000 additional shares.

With the preferred shares, HK TMS agreed to assign up to a 4% overriding royalty interest in 75 net wells to be drilled and completed on its property.

In a June 2014 release, the company said its Horseshoe Hill 11-22H-1 well in Wilkinson County produced 1,208 bbl/d of oil and 1.1 MMcf/d of 1,551 Btu gas during a 24-hour IP test. It ran the test through a 19/64-in. choke. Halcón estimated the well would produce about 212 bbl/d of NGL for a total IP rate of 1.548 Mboe/d. It drilled the well with a 7,060-ft lateral and completed it with 26 fracture stages, of which 21 stages were pumped and three were partially pumped when less proppant was placed than the company planned. It drilled the well to total depth in 39 days.

The company drilled the Black Stone 4H-2 in the same county in 28 days with a 5,400-ft lateral and spudded the Fassman 9H-1 with a second rig to drill with a 6,030-ft lateral. It plans a 7,660-ft lateral on the recently spudded SD Smith 1H, also in Wilkinson County.

During its second-quarter 2014 earnings conference call, the company said it believed it could reduce drilled days by 15% to 20%. It also said the average initial potential of producing, nonoperated wells in which it

### TMS 605 Mboe Type Curve

Investment Sensitivity to Completed Well Cost <sup>(1)</sup>



Investment Sensitivity to NYMEX Oil Price <sup>(2)</sup>



Type Curve Details

|                      |                                          |            |
|----------------------|------------------------------------------|------------|
| Gross EUR            | Oil (MBbl)                               | 566        |
|                      | Gas (MMcf)                               | 229        |
|                      | <b>Total (MBoe)</b>                      | <b>605</b> |
| Diffs <sup>(3)</sup> | Oil (% of NYMEX)                         | 101%       |
|                      | Gas (% of NYMEX)                         | 138%       |
| Other                | IP (Boe/d)                               | 1,470      |
|                      | Spud to Production                       | 90 days    |
|                      | b factor                                 | 1.5        |
|                      | Di                                       | 87%        |
|                      | Df                                       | 6%         |
|                      | Lateral Length (ft)                      | 7,200      |
|                      | Avg. Royalty Burden <sup>(4)</sup>       | 22%        |
|                      | Avg. Working Interest                    | 66%        |
|                      | Avg. Net Revenue Interest <sup>(4)</sup> | 51%        |

Halcón can realize a 50% internal rate of return on its TMS wells with a \$100/bbl New York Mercantile Exchange oil price. (Data and image courtesy of Halcón Resources Corp.)

holds an interest near its property, has been about 1,100 bbl/d of oil plus gas, or more than 1,300 boe/d.

### **Helis Oil & Gas Co.**

- *Land: 51,899 acres*
- *Facing local opposition*

Helis Oil & Gas Co. instituted a community information program to counter opposition to its plan to drill a well in the Tuscaloosa Marine Shale (TMS).

The company leased property in St. Tammany Parish, La., and applied to establish a unit some 64 miles from the nearest TMS production. Local concerns, however, threatened the project, and Helis established a website at [helisenergyproject.com](http://helisenergyproject.com) to explain its drilling plan and answer questions posed by nearby residents.

According to Louisiana Environment Action Network, the company leased its land from P&F Lumber Co., St. Tammany Land Co., Poitevent Interest, PF Monroe Properties and Markel Interest. The leases have varied expiration dates.

In an Aug. 3, 2014, statement, the company said it had committed in late May to first drill a vertical well and evaluate results before deciding on further drilling activity.

### **Indigo II Louisiana Operating LLC**

- *Land: 282,000 acres*
- *Partnering with EOG Resources*

Indigo II Louisiana Operating LLC, an operating arm of Indigo Minerals LLC, holds a large fee mineral and leasehold position in the Tuscaloosa Marine Shale (TMS) play.

Its properties are spread over a three-Parish area of central Louisiana, and the company also has a small mineral position in Amite County, Miss.

About half of the core 282,000 acres in central Louisiana consists of fee minerals in which the company holds a 100% working interest and a 100% net revenue interest. The other half is traditional leasehold.

Indigo was an early leader in the TMS play, drilling its first vertical pilot hole to the TMS in 2010 in northern Vernon Parish and one of the first horizontal wells in the play in mid-2011 in Rapides Parish, La. That well, the Indigo-Bentley Lumber 34H-1, was completed with a 4,100-ft lateral and tested with an IP rate of 543 boe/d. Unfortunately, multiple fish in the

hole, caused when attempting to drill out fracture plugs, reduced the well to low-volume production from only one or two fracture stages in the TMS.

Indigo plans to monitor activity in the play and plans additional drilling to the shale in 2015.

A portion of Indigo's mineral and leasehold position, located in Vernon Parish, is tied into a joint venture (JV) with EOG Resources. EOG also contributed a large lease position in the parish to the JV and took over as operator.

The EOG-Indigo Minerals 25H-1 well, the initial well in the JV, was spudded in August 2014 and scheduled to a measured depth of 17,318 ft with completion scheduled late in fourth-quarter 2014.

### **Justiss Oil Co.**

- *Specializes in prospect generation*
- *Permitted easternmost TMS well*

Justiss Oil Co. of Jena, La., specializes in prospect generation, participation in joint ventures, and acquisitions and divestitures. The company adopted the Tuscaloosa Marine Shale (TMS) as part of its prospect inventory.

In November 2011, the company permitted the horizontal ZAP Minerals et al TMS well in southern Sabine Parish, close to the Texas-Louisiana border. No drilling results have been shown. If successful, the well would be the westernmost producer in the TMS play.

### **KEW Drilling Co.**

- *Land: 34,000 net acres*
- *Selling TMS properties*

KEW Drilling Co. put its property holdings in the Tuscaloosa Marine Shale (TMS) on the sale block through Tudor, Pickering, Holt & Co. in August 2014.

The Dallas company's property is "highly consolidated" and lies mostly in Amite County, Miss., an area in which other operators have reported success in the TMS. The company said its property is offset by holdings of Comstock Resources, Encana Corp., Goodrich Petroleum Corp., Halcón Resources Corp. and Sanchez Energy Corp.

KEW said its property is in the oil-mature part of the play and most of its leases include options for two- and three-year extensions. Its position has the potential for about 600 horizontal well locations.



### Manti Exploration Co.

- *Seeks oilfield profits*
- *Multifaceted company*

The Manti Exploration Co. arm of Manti Resources is one of a group of divisions that gives the parent company access to energy industry profits, including those of the Eagle Ford, Bakken and Tuscaloosa Marine shales.

The privately held parent also is involved in advanced technology and health care. Its energy subsidiaries include Manti Exploration, Manti E&P, Manti LP, Pawdner Drilling and Axis Industrial Services.

The Covington, La., parent and its subsidiaries seek high-yield, high-risk opportunities.

### Minichi Energy LLC

- *Land: Portion of 271,000 net acres*
- *Purchased from Anadarko Petroleum*

Minichi Energy LLC entered both the Tuscaloosa Marine Shale (TMS) and Austin Chalk plays in Louisiana with a massive land purchase from Anadarko Petroleum.

Two separate purchases, completed in August 2014, gave the company 283,000 gross (271,000 net) acres of oil and gas leases in West Feliciana, East Feliciana, Pointe Coupee, Avoyelles and St. Landry parishes.

The eastern properties overlie the oil-prone segment of the TMS, while land in the eastern parishes gives the company Austin Chalk production potential. Minichi now calls itself one of the largest leaseholders in the two plays.

Until the purchase, most of the company's drilling and other services focused on the Marcellus Shale in northern Pennsylvania.

### Sanchez Energy Corp.

- *Land: 58,000 net acres*
- *Drilled first well*

Sanchez Energy Corp. rates the Tuscaloosa Marine Shale (TMS) behind its prime properties in the Eagle Ford, but the unconventional oil and gas development company has big plans for its TMS properties.

For contrast, the company held some 226,000 net acres of land in the Eagle Ford at the end of June 2014 and only 58,000 net acres in the TMS.

In its operations statements, Sanchez lumps its smaller shale play under the heading "TMS and

other" without going into detail about the other. It had three producing wells, apparently all in the other category, and it has three gross (one net) rigs running with two gross wells awaiting or undergoing completion at the end of second-quarter 2014.

In its second-quarter 2014 report, Sanchez said it drilled its first TMS well, the Dry Fork East #2H, in Wilkinson County, Miss. During cleanout, before running production casing, the drillstring parted "due to defects in the drillstring," the company said. It planned to sidetrack the lateral portion of the well and run casing in the new bore.

During testing in the original wellbore, the lateral portion yielded strong hydrocarbon shows. Sanchez said it would run one rig continuously in the TMS during 2014 with expectations of spudding up to four gross operated wells. It also planned to participate in 10 to 15 nonoperated wells in which it holds interests from 1% to 25%.

According to IHS Inc., the Dry Fork well was scheduled to a total depth of 19,805 ft at a 12,200-ft true vertical depth.

Sanchez planned to drill an offset well, the 1H Dry Fork East, with similar depth measurements. It also plans the 1H and 2H Dry Fork West wells nearby and permitted the 1H and 2H Packnett and the 1H and 2H Redhead TMS wells, all in Wilkinson County. Its farthest west location is the 1H Morris Unit.

### Weyerhaeuser Natural Resources Co.

- *Land: 67,416 net acres*
- *Land for lease*

Weyerhaeuser Natural Resources Co. has no plans to drill wells, but it would like to get into the Tuscaloosa Marine Shale (TMS) play by sharing land it uses for its lumber operations.

After outlining the play, the company said it holds unleased mineral prospects in four Louisiana parishes. It has 30,346 acres in Livingston Parish, 6,637 acres in Tangipahoa Parish, 12,065 acres in St. Tammany Parish and 18,368 acres in Washington Parish, all in Louisiana.

Of the four parcels, the only parishes considered in the hot part of the play are Tangipahoa Parish and St. Tammany Parish. Helis Oil & Gas currently is working on an education program to smooth local opposition to its proposed well there. ■

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# Technology in the TMS Remains a Moving Target

Contractors are working in concert with operators to drive down costs while ramping up production in one of the nation's newest shale sensations.

**By Blake Wright**  
Contributing Editor

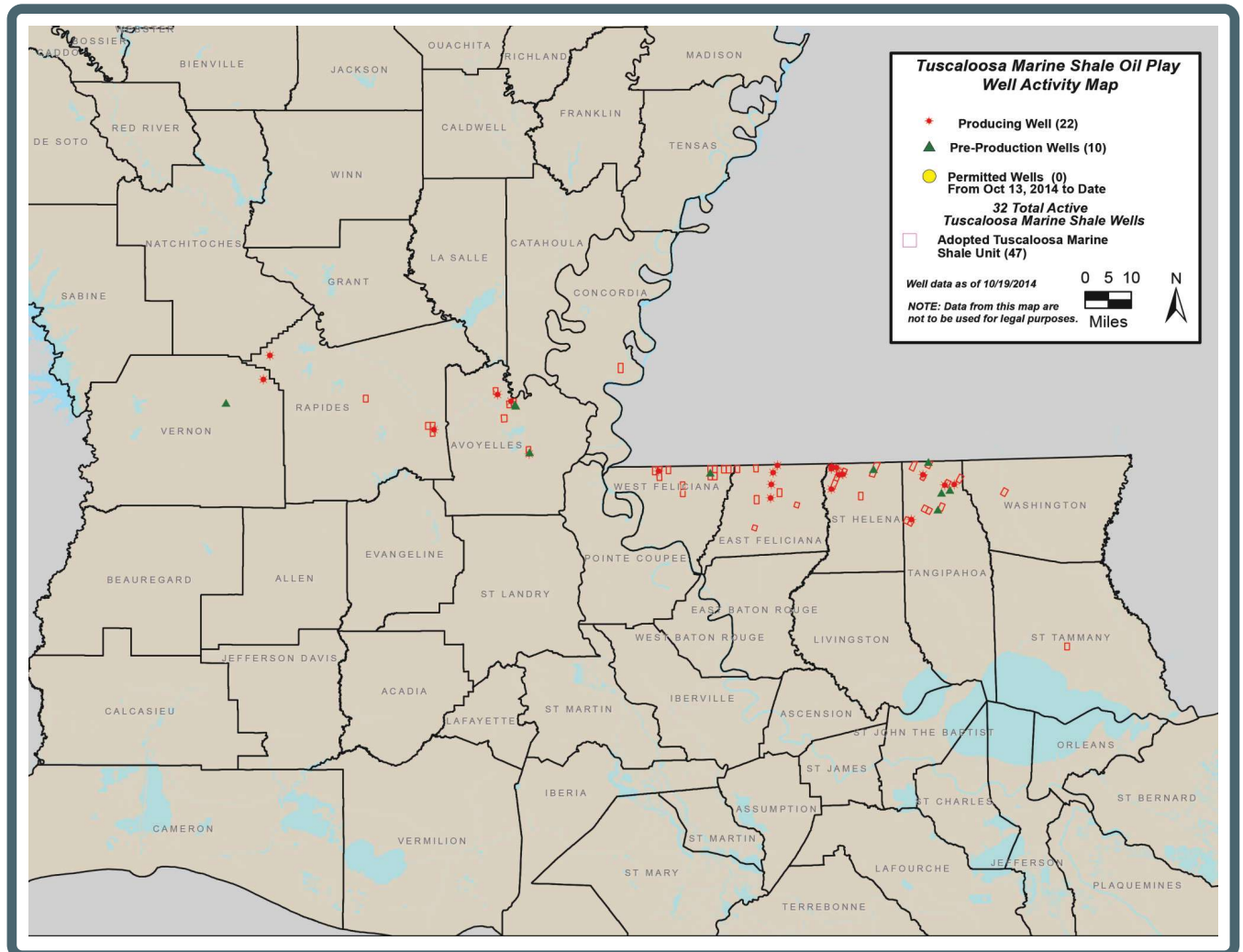
**T**he Tuscaloosa Marine Shale (TMS) is a unique beast in the broadening mix of domestic shale plays offering both specific drilling and production challenges for operators to overcome as the still immature trend is delineated and tested for commerciality. With a core spanning an estimated 5,900 sq miles across central Louisiana and its border with Mississippi, operations in the play have progressed over recent years as oil companies with holdings in the area have been moving from location to location to better define the trend's productive boundaries. As of mid-October 2014, there were only 32 active wells on the Louisiana side of the play, but there are more on the Mississippi acreage and a backlog of permits to add to that tally. While activity is ramping up, it remains early days for the trend as operators work on drilling efficiencies and hydraulic fracturing applications to get the best IP rates from these wells.

The TMS geological trend is fairly deep in comparison to other high-profile shales in the U.S. like the South Texas Eagle Ford and Pennsylvania's Marcellus. The formation runs between 11,000 ft and 15,000 ft below ground with a thickness of between 500 ft and 800 ft, depending on the location. The Eagle Ford play, by comparison, runs at depths between 4,000 ft and 12,000 ft with a thickness averaging about 250 ft. The TMS and Eagle Ford do have some geological similarities. Both were deposited along the North American Coastal Mar-

gin in Late Cretaceous times; however, the TMS has a little less carbonate in it and more clay and sand coming from the Tuscaloosa Delta. In fact, it was the clay content of the TMS that was one of the early, primary issues operators predicted could impact wells in the region.

The concern by operators was centered on how the enhanced clay content would react to a frack job. Specifically, operators wondered if the clays would swell once the water hit them and what impact that swelling could have on frack integrity and overall production flows.

"From the standpoint of clay, one of the challenges is that the mix of clays is more immature than in many of the other plays—texturally immature," said Peter Kaufman, geologic adviser in Schlumberger's Geoscience and Petroleum Engineering (GPE) business. "You see multiple different clay species here. One of the technologies that we've been applying to try to understand that better has been elemental yields measured with our Litho Scanner high-definition spectroscopy service. It enables us to distinguish the different types of clay and understand how that clay type varies vertically within the TMS and across the play laterally. Operators are applying these technologies to try to better understand those clay systems, because it is complex. Very subtle changes in lithology have an impact on reservoir, completion and drilling quality and it is important to quantify these changes to optimize well results."



Well activity on the Louisiana side of the TMS is shown as of Oct. 19. (Source: Hart Energy)

While geologically different, the advanced fears of the clay's potential sabotage of successful fracking work have been mostly dismissed. Operators have proven that the sweet spot of the formation—the bottom 70 ft or so—can take a frack without complication. Independent Goodrich Petroleum, one of the play's top operators after buying out Devon Energy's TMS holdings in 2013, took to using a "clay stabilizer" with its wells in the play to make sure any swelling was kept to a minimum.

The company's Crosby 12H-1 well drilled in Wilkinson County, Miss., in early 2013 flowed with an IP rate approaching 1,300 bbl/d of oil off of a 6,700-ft lateral and 25 frack stages. It is not widely known if the clay stabilizer had any impact on the success of the well, but onlookers believe the low

cost associated with its use has kept the formula in the mix for TMS wells since the Crosby test.

"Goodrich threw in a clay stabilizer to help make sure the clays don't swell," confirmed one acreage player in the region. "It turned out to be one of the best tests to date. In my mind, I don't really know if it had an impact or not, but I think the theory is to just keep using it because it is not that expensive. The Crosby well, for example, has one of the highest clay percentages around the wells that have been cored, and it's one of the best wells to date. It was a key well to say that clay is not an issue in the play at this point."

Since the Crosby well, other impressive IPs have been recorded by Halcón Resources at its Horseshoe Hill 11-22H-1 probe (1,548 boe/d),



also in Wilkinson County, and Goodrich's own Encana Anderson 17-H2 well (1,540 b/d) in Amite County, Miss.

### Natural fractures

One challenge that has proven more stubborn to operations than the presumed clay issues is the existence of a heightened natural fracture network in the formation above the target zone. The fractures, which are a help for production purposes, are a hinderance while drilling, proving problematic for some operators while tripping in and out of the hole, resulting in some well loss. The fickleness of the formation was felt as recently as this summer by TMS newcomer Sanchez Energy. Its first well in the play, Dry Fork East #2H, hit a snag when, after reaching target depth, the drill-string parted prior to running production casing. Sanchez blamed faulty drillpipe for the incident. The setback to the Wilkinson County, Miss., well has not discouraged Sanchez, which said the lateral exhibited "strong hydrocarbon shows" during drilling.

"The high clay content, along with high natural fracture density, has led to hole-stability issues while drilling the lateral," said Neal Modeland, southeast business development technical manager for Halliburton. "Oil-based mud and large amounts of lost-circulation material are needed to protect against these issues."

The natural fracture network has forced operators to hone in on specific drilling procedures with particular requirements to obtain optimal results. If operators drill with their mud weight a little too high, they can end up opening up the fractures and moving mud into them. However, if they run with the mud weights too low, they risk having the wellbore collapse due to the mechanical and clay instability of the formation.

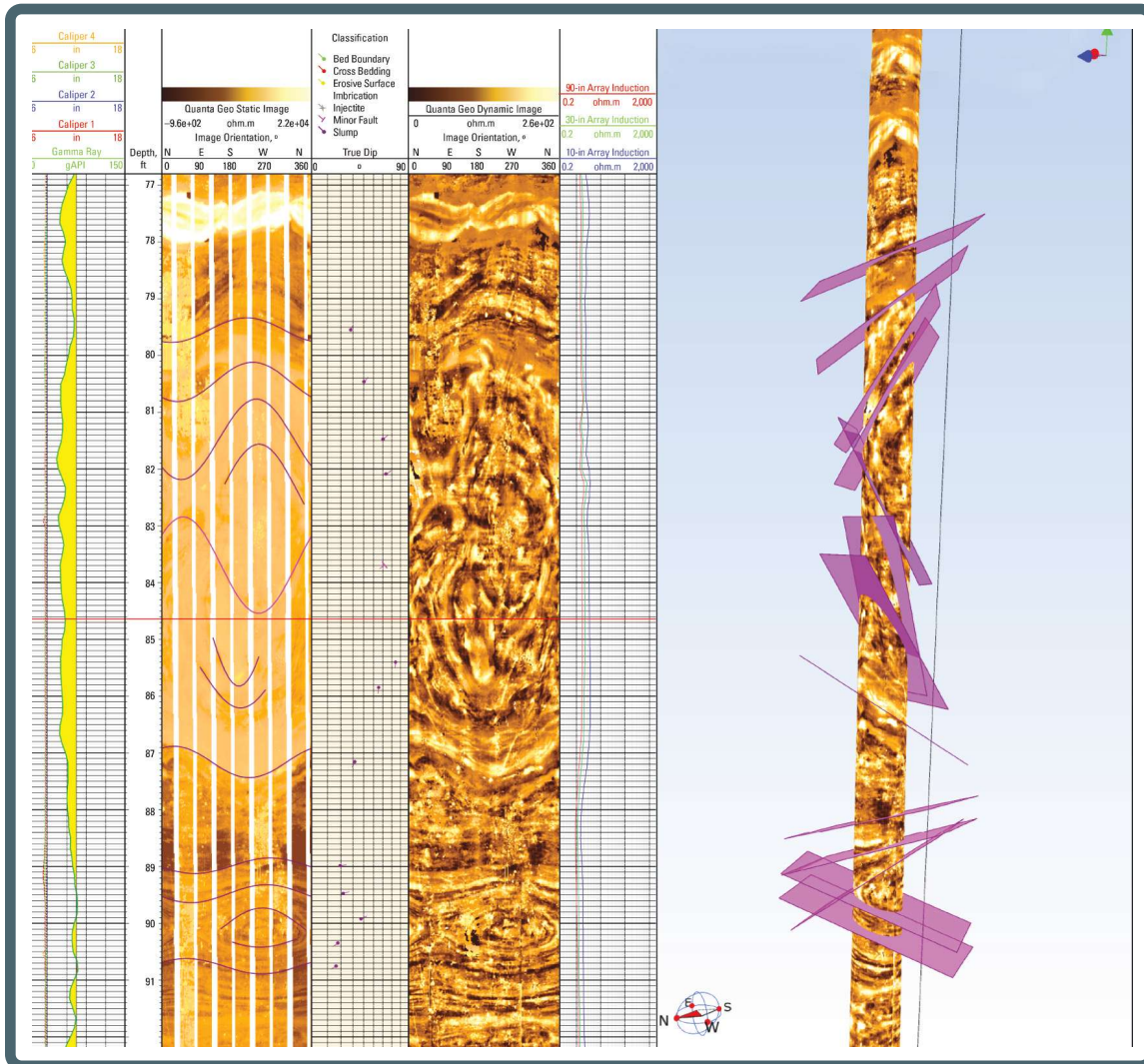
"Operators really have to thread a fairly narrow needle to get into the 'Goldilocks zone' and get the mud weights just right as well as engage in operational drilling practices that do not compromise the well," Kaufman said. "They need to be very careful not to damage the wellbore with surge and swabs so that they do not damage the formation while tripping pipe and ensure they are doing an effective job of cleaning the cuttings. You have a very narrow mud weight window because of the natural fractures

and clay instability. You have to get your mud weight right and drill it gently. It is not a formation that tolerates much abuse."

For its part, Schlumberger is offering a suite of logging services that can aid operators in navigating the hazards of clay and fractures as they plan their wells. Up until about a year ago, most of the well logs that existed in the TMS were old resistivity and sonic logs, which did not do a very good job of defining the characteristics of the play. Furthermore, the vintage Lower Tuscaloosa wells that provided the well control for the play were drilled with water-based mud, which resulted in extremely poor hole conditions through the TMS interval. This resulted in poor data quality for any nuclear logs. Today, operators are drilling with oil-based muds, and hole conditions are generally excellent. As a result, operators are able to apply technologies like Schlumberger's Litho Scanner high-definition spectroscopy service to understand the mineralogy of the formation. Along with that comes magnetic resonance technology to try to understand what producible porosity exists within the matrix. There are also high-end sonics, and the Schlumberger Sonic-Scanner acoustic scanning platform is extremely important for characterization of both reservoir and geomechanical properties.

Another valuable measurement for unconventional reservoir characterization is the Quanta Geo service, a new oil-based borehole imaging tool that the oilfield service company just launched. The Quanta Geo service assists operators by offering geological images that can be used to aid mapping the natural fracture network.

"It is extremely important to understand the natural fracture network before you start designing your fracturing job," said John Cadenhead, strategy manager with the Schlumberger Unconventional Resources Group. "Once you define the fracture network around a lateral, we can insert the model directly into our Mangrove engineered stimulation design in the Petrel platform software to design a stimulation job that will honor the natural fracture network and place the proppant volumes in the right place. You have to understand the reservoir stresses in order to design the proper fracturing job." Cadenhead continued, "Initially, with all new plays you must experiment with different volumes, different



Quanta Geo service's photorealistic images enable a visual interpretation of subsurface geology. (Photo courtesy of Schlumberger)

fluid types and different proppant types to gain an understanding of what might work best. The TMS is very early in its life, and every shale is different. We have been through the process many times across North America. We cannot blanket copy job designs from other plays. Instead, we are going to have to design treatments that the TMS will accept. That is the part of the cycle that we are in now."

### Well optimization and fracking

As the learning curve in the TMS declines, so does the cost and schedule of the average well in the area. Cost to date has been related to the depth and extension of frack jobs performed on each well. Some operators are

using up to 600,000 lb of proppant per stage, and with laterals stretching out as long as 8,000 ft the stage count can easily eclipse 25. All of those costs go right to the bottom line, which is why operators are on the hunt for robust IPs and slow decline curves.

In the earliest days of the play, frontier-minded operators were taking between 45 and 65 days to get a well down and completed. It was cost and schedule, along with other factors, that prompted play-opener Devon Energy to throw in the towel on the TMS and sell its two-thirds stake in 277,000 acres in the trend's core area to Goodrich for \$26.7 million last year. Today, operators have narrowed the well cycle to about 25 days on average, with the bulk of



the improvement in schedule coming in just the past 12 months.

“As more and more wells have been drilled (as well as more operators jumping in), the drilling practices have become more optimized and, more importantly, the appropriate landing target has been identified,” said Stephen Ingram, Halliburton’s director of business development for the Gulf of Mexico. “These achievements have resulted in a lower cost of drilling, reduction in casing integrity issues and improved production.”

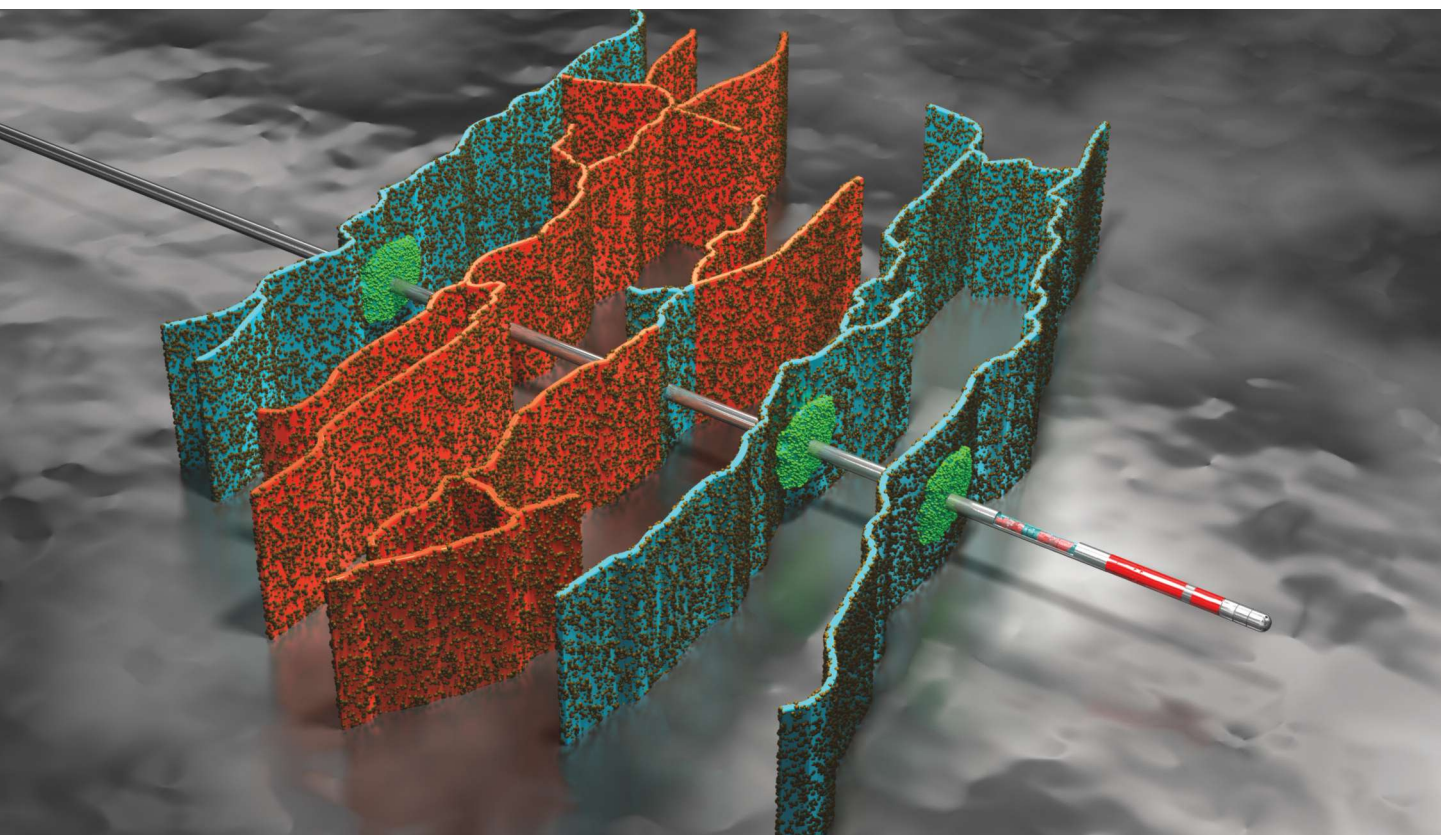
For its TMS suite, Halliburton consistently employs a handful of solutions to operators aiming for good placement and performance of horizontal completions based on formation evaluation of the lateral to help select perforation intervals. Services include the contractor’s AccessFrac PD (proppant distribution) diversion to increase even distribution of stimulation treatment in multicluster staging, and the SandWedge proppant surface modifying agent to keep clay fines in place if or

when they detach and move toward plugging the fracture pack. AccessFrac also has a history of being able to overcome casing integrity issues to allow for a successful frack job and avoid well loss.

Halliburton also conducts customized chemistry, especially in the realm of surfactants, to aid the movement of the lower-gravity oil in the expected narrow fracture width.

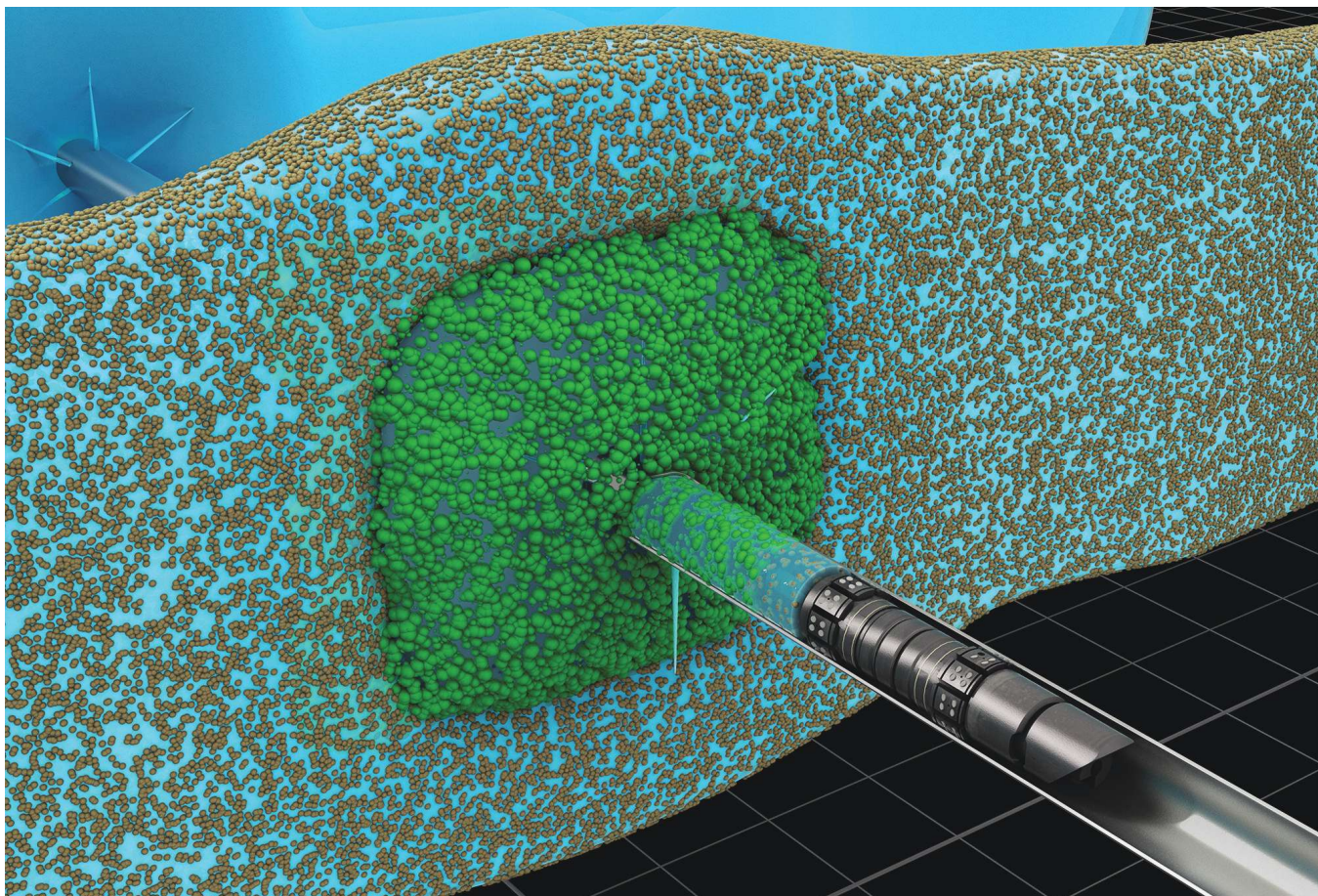
When it comes to fracking TMS wells, the jury is still out on the best cocktail to use to get the most out of any single wellbore. Operators have experimented with a variety of slickwater and gel solutions to test well response. Currently, it is a hybrid of the two that seems to be winning favor among those with activity programs. The value of a hybrid frack is that it allows farther migration of proppant into the fracture network, thanks to the gel content. The use of hybrid fracks is not solely a TMS phenomena. These cocktails are gaining favor throughout domestic shales.

“So you create it with slick water, and then you come in with your gelled fluid and transport



Halliburton’s AccessFrac service uses biodegradable diverting material that is able to withstand the rigors of fracturing and then completely dissolve. *(Image courtesy of Halliburton)*





A close-up cross section of Halliburton's AccessFrac technology is shown. The technology uses diversion at the perforations to improve proppant distribution for new multizone completions. *(Image courtesy of Halliburton)*

proppant into the network you've created," explained Alejandro Pena, stimulation expert at Schlumberger. "That's something that slick water alone is significantly less efficient at doing. I'm not going to say what the exact recipe would be, because it is still very early in the TMS, but I will say that we're going to have to experiment down that route, and it probably will lead to an optimized treatment design comprising both slick-water and gelled fluids."

Early indications have found a 70:30 slickwater/gel mixture being a preferred frack ratio; however, as the understanding of geomechanics and reservoir characteristics continues to improve and prospective lateral targets change as operators delineate the play, that cocktail can, and will, likely fluctuate. Different situations might call for different stimulation recipes. Over the past several months,

the TMS has been a sort of laboratory hosting some aggressive experimentation when it comes to blasting deep, long-lateral, high-stage wells with large amounts of proppant, but contractors stop short of calling it a "new norm."

"Initially, we were seeing designs that had a significant degree of variation, but now most of the operators are following the designs from the good wells," said Terry Woods, North American GPE business manager of operations for Schlumberger. "At the end of the day, the TMS has a relatively high fracture gradient, and it is our desire at this point, as we delineate the play, to contact the most rock that we can and see what the IPs can deliver. We do believe that stimulation geometries are generally complex, largely associated with the natural fractures. We need more data to validate this, and overall it is too early to make a call on stimulation recipes."



### Flattening the cost curve

True to any play still in its infancy, cost remains the number one factor that stands to inhibit exploitation. The wells are deep and expensive compared to other shale plays around the U.S. This means they have to perform in-kind for it to make sense for operators to pour money into TMS programs and not redirect those funds to a lower-risk, higher-return set of projects. The play requires big rigs and a ton of proppant to coax the desired IPs from the rock. Over the past half-year, operators like Goodrich, Halcón and Encana have come forward with success stories from the play—repeatable initial rates between 1,200 bbl/d and 1,500 bbl/d of oil, with a window targeting about 600,000 boe EUR. Still others, including Comstock Resources and EOG Resources, continue to be active in the area.

the lower target, which is a great thing. Going from 50 to 60 days, and now with process improvements, we're down below 29 days, [and] we're moving the targets in the right fashion. It's a process. We want to continue to move that needle and get those benchmarks to perform even better than what we're seeing today even with some of the better wells."

Another nonstarter the play is now faced with is falling oil prices—generally bad news for everyone in the business but more so for the longevity of an emerging and expensive shale play. The good news is that service groups and contractors appear undeterred by commodity softness and are moving into the area to set up support operations for operators. Fluids specialist Newpark Resources recently committed to a new service hub for the TMS. The drilling fluid storage and manufacturing center will

**"THE TMS HAS A LOT OF POTENTIAL,** but as we have learned from other resource plays, we have to move up the learning curve quickly to achieve the best economic results."

—John Cadenhead, strategy manager, Schlumberger Unconventional Resources Group

"Expense comes from the deeper depths and we're just starting to move up the efficiency curve," Cadenhead said. "Operators do not want to drill 60-day wells. One takeaway for us is that we can look for successful processes analog in other plays in order to inject acceleration into the TMS learning curve. We see evidence from that just in the recent drilling improvements. The TMS has a lot of potential, but as we have learned from other resource plays, we have to move up the learning curve quickly to achieve the best economic results. IPs of modern, best-practice TMS wells range from 700 to 1,500 barrels of oil per day, which is very good, but still variable. Thus, there is quite a bit of work still required to increase our overall understanding of this reservoir."

"The TMS is in the early stages, but we still have to be economic with the play," Schlumberger's Woods said. "In order for the play to move forward, obviously getting our drilling and completion days down to acceptable levels in order to meet the economic hurdles is the goal. We are clearly seeing that over a short period of time drilling is rapidly getting optimized in

be situated in the town of Summit in Pike County, Miss., about a half hour from the Louisiana/Mississippi border. The facility will use an existing 40,000-sq-ft building owned by the county.

For now, operators like Goodrich remain committed as well. The independent plans to bump its rig count in the area from three to five by year-end and has \$225 million of its total \$350 million in capex earmarked for the TMS in 2014, a figure it said could double in 2015 if a partner is brought onboard or funding is increased. The company has even made overtures about selling off other assets, like its limited Eagle Ford exposure, to raise capital to plow into the TMS should the play continue to perform. Goodrich CEO Robert Turnham said recently that the high proppant volumes and hybrid frack cocktails could allow the TMS to emerge as "one of the premier oil plays in the nation." For now, however, it will have to be content with another, more appropriate title—one of being the most expensive oil plays in the nation. ■



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# Big Production Plans for TMS Will Stretch Existing Infrastructure

Truck-to-barge is the present reality, while modest gas gathering takes hold.

**By Gregory DL Morris**  
Contributing Editor

The Tuscaloosa Marine Shale (TMS) popped back into the headlines this summer when private-equity group Apollo Global Management invested in Halcón Resources in the play to the tune of \$150 million. That could grow to \$400 million. Halcón is one of the top holders with at least 200,000 acres. The other two are Goodrich Petroleum and Encana Corp., while EOG, Comstock and Sanchez also have significant positions. The big three have big ideas for the oil-rich pocket with a checkered history. If even a portion of the development plans out, it will open a new front in midstream development, one focused on getting crude from a small basin out to a wide range of markets.

To the touts, the TMS is triple blessed, with light, sweet crude, existing infrastructure and close proximity to vast refining demand. To the doubters, the TMS has been a tease, where an estimated 7 Bbbl of recoverable resource, better than 90% oil, is more than 10,000 ft down and guarded by crumbly rock and a “rubble zone,” which have vexed developers so far.

While the Apollo deal grabbed the attention and showed that producers and investors were determined to make another go at the TMS, Halcón also released word of plans for a marine loading terminal at Port Natchez, Miss., in Adams County. The company confirmed plans for the riverfront facility but said “it is not ready to disclose formal details yet.”

Halcón also plans gas gathering and processing. As with the river terminal, there are few details, but the company plans to support its TMS production by building a three-phase gathering system with centralized aggregation points throughout the play. The benefits of centralized aggregation are that it can be expected to reduce costs and allow for more efficient transportation of crude and produced water, Halcón said. Initial plans call for a processing plant at the central facility with access to one or more gas residue outlets. There would be room for additional capacity as production increases. The original proposal called for permitting for a processing plant to begin in third-quarter 2014, but as of Oct. 1 that could not be confirmed.

To some observers, the TMS looks like the early days of the Bakken all over again, with midstream waiting on commitments from producers and producers counting on takeaway capacity to be there waiting when the oil comes to the surface. That said, the river is less than 50 miles from most wellheads, and truck transport at that distance is inexpensive and expandable at current and near-term volumes.

When producers planning ambitious expansions in the TMS say they are relying on existing infrastructure for getting IP volumes to market, that will mean Genesis Energy terminals to a significant degree. The firm operates a multimodal terminal at



Port Natchez, that handles truck, rail and barge transfers. Another facility at Port Hudson, La., handles truck and barge and is pipeline-connected to 600,000 bbl/d of refining capacity along the Mississippi River. There is a third truck transfer station at Liberty, Miss., which is ultimately connected to the Capline system.

The Capline is owned by Marathon Petroleum, BP and Plains All American and is operated by a Marathon subsidiary. Capline is a 40-in. crude oil line, 632 miles long, with a capacity of 1.2 MMbbl/d. The Capline originates in St. James, La., and terminates in Patoka, Ill. It delivers to terminals in Collierville, Miss., and Patoka.

Producers with expansion plans in the TMS note

that the Capline has plenty of spare capacity, but Marathon declined to comment. “We have not provided any forward-looking statements about the system, so we can’t provide any comments beyond that,” a company official said. “I will say that we do continuously evaluate the challenging dynamics of the nation’s growing production.”

Notably, some of the biggest names in midstream are taking a wait-and-see approach to the TMS. Enbridge, DCP, MarkWest and Kinder Morgan all said they are monitoring developments in the play but have no current plans for development. Enterprise Products, the big dog in liquids processing, did not respond to inquiries. More interestingly, an official with Plains All American said, “We did some due



## *Export notions*

"If you look at the API gravity and other characteristics of TMS crude, it is not that different than condensate," said Charlotte Batson, CEO of Tuscaloosa Energy Services. Producers reported TMS in the range of 42°API to 46°API gravity. Condensate is usually defined at 50°API to 55°API.

To be sure, the export window was opened just a crack and only in private letters to just two companies, Enterprise Products and producer Pioneer Natural Resources. Other requests for the same clarification, formally a commodity classification, have been put on "hold without action" by the department's Bureau of Industry and Security.

"Some refiners define oil at 42 to 50 as super light crude," Batson said. "It seems possible that with minimal processing and stabilization it could be exported under the Department of Commerce criteria that recently allowed for condensate exports. Refined products exports are through

the roof. Now [there's] many a slip twixt cup and lip, but I know that it has been suggested [that] TMS crude could be exported if refined just enough."

Others, just as stoked about the overall potential of the TMS, are less sanguine about the possibility of exports. Bob Deere, CFO of Genesis said, "TMS produces light crude; that is not condensate. It is light but still oil. There is more to condensate than just the API gravity. Condensate has no refining value. Crude does." That said, he added, "We continue to watch developments. If there is a change in regulations to allow exports, we do have a new connection to our Louisiana pipeline that will be completed by the middle of next year that will connect to the Port of Baton Rouge, Louisiana, that will allow us to load or unload barges or tankers up to Aframax size."

diligence into the topic, but we have nothing to share publicly." What exactly can be read into that, especially in context of the simple dismissals by other pipelines, is open to interpretation.

Given the ready access to river and pipe, rail transport is not expected to play a significant role, at least for outbound TMS crude. However, inbound crude by rail, especially pure bitumen or slightly diluted "railbit" inbound could be blended with light, sweet TMS crude as ready refinery feedstock. And indeed, the Canadian National Railway Co. (CN) has direct access through the play. The CN is also a major carrier of frack sand and has single-line access from its branches at key sand mines in Wisconsin. The railroad declined to detail its plans for the TMS.

### **More than a trace at Port Natchez**

In contrast, local operators in the TMS are eager to talk about their growth plans. "We have assets in place, and we try to offer options to the producers," said Bob Deere, CFO of Genesis. "The Natchez facility was built to accommodate heavy crudes coming in by rail from Canada. The light, sweet TMS crude will make an excellent blendstock for the regional refineries. Alternatively, they can sell directly into

the large established refinery market in Louisiana. We continue to watch the pace of upstream developments and work with producers."

Beyond that, Deere continued, "Depending on where the production starts to be concentrated, we can always build new lines to facilities. Once the crude is on the water, we can trade up and down the river. We run a fleet of 62 barges and 24 pushboats. Another four barges and 10 boats are on order to be delivered this year and next. The barges are typically in the 30,000- to 38,000-barrel capacity [range]."

While the TMS is among the oiliest plays in the unconventional realm, there is still associated gas, even if just a small percent of liftings. By year-end 2014 there will be a gathering and processing system. Canyon Midstream Partners expects to have the Foster Creek plant in Wilkinson County, Miss., with initial capacity of 10 MMcf/d in service by year-end to serve the ambitious drilling and production plans by Goodrich Petroleum.

Goodrich, the largest producer in the play, also has taken the lead in developing midstream connections. It has struck a deal with Canyon Midstream Partners for gas processing due in service by year-end and has secure truck transportation for the limited crude production so far.

But given the ambitious drilling program that Goodrich and others are planning, trucks will not be sufficient. “It is not too far from the Mississippi River, so truck-to-barge is a good option for now,” said Robert Turnham, president of Goodrich. “In the long run, the best logistics is a pipeline, because 92% to 96% of the production is oil. The Capline goes through the play and up to Memphis [Tenn.] and Chicago and has a lot of excess capacity.”

On the gas side, Turnham said, “There is very little, but what we do get is very rich. At the moment, we are stripping on site, selling the NGL and flaring the rest. We have to do that until we have sufficient volume to gather. That should be within the year.”

Canyon “will scale operations into that capacity,” said Michael Walsh, the company’s president. “We have designed the facility for expansion because we believe in the potential of the play. There is associated gas in the TMS, albeit at relatively modest volumes.” In other basins where gas volumes are low, producers have reported that they would be inclined to reinject, but the TMS is overpressured to start, obviating that option.

### The 5% solution

“We are likely to see more of these smaller processing plants in the play as it grows,” Walsh said. “The experience people have had in the Bakken is instructive. As oil production scales up, gas processing becomes more important. The continuing transformation of the U.S. energy sector creates exciting opportunities for an entrepreneurial, creative and experienced midstream company, and Canyon intends to be at the forefront in partnership with our customers.”

Being much more remote than the TMS, and with little existing infrastructure, Bakken producers resorted to flaring. That expedient became a wasteful embarrassment to the industry and a flashpoint for regulators and protesters. Gathering has been expanded, but some flaring is expected to be necessary for years in some cases. Walsh’s comments indicate that both producers and midstream operators do not wish to start down the road to flaring in the TMS.

In September, Canyon secured a four-year, \$50 million credit facility, which can be expanded to

\$100 million. Proceeds from the credit facility will fund Canyon’s expansion plans in the TMS as well as projects in the Permian and Eaglebine. Wells Fargo Securities was sole lead arranger and sole bookrunner, and Royal Bank of Canada acted as syndication agent.

Canyon struck its first deal with Goodrich exactly a year earlier. In September 2013, a Canyon subsidiary, Arroyo Midstream Partners, signed a gas-processing and marketing agreement with Goodrich in the TMS. Arroyo is a joint venture between Canyon and Gas Processors Inc. (GPI), an owner and operator of gas-processing equipment based in Columbia, Miss. GPI has been operating in Mississippi and Louisiana since it was formed in 2002. It has operations in five states with a fleet of 45 modular, skid-mounted processing units.

Walsh confirmed that Canyon has had discussions with other producers but is quick to add, “Today we are oriented toward Goodrich.” He adds that gas has shown no meaningful presence of hydrogen sulfide or CO<sub>2</sub>, so the processed volumes are going directly into the interstate system while extracted liquids are being taken to market by truck. “We have been getting good prices,” Walsh said. “As volumes grow, we will evaluate the needs for an NGL pipeline, but for the foreseeable future, trucking is a very cost-effective method.”

Canyon is involved in crude gathering in West Texas but so far has not had a hand in the limited crude movement in the TMS. “We are in discussions with Goodrich and others on that,” Walsh said, but there is nothing to report so far.

In addition to the Foster Creek project in the TMS, Canyon expects to have its James Lake project in the Permian completed by year-end. The James Lake System will include a 105-MMcf/d cryogenic processing plant in Ector County, Texas, 60 miles of 12-in. trunkline and six field compressor stations providing low-pressure gathering services in Ector, Andrews, Winkler, Martin, Dawson and Gaines counties in Texas. Canyon also is expanding the processing and gathering capacity on its Trinity River Midstream system in Houston and Madison counties in Texas to accommodate growing production from the Eaglebine play.





A pumpjack at work in southeastern Mississippi in late November.  
(Photo by Mieko Mahi)

### Crude premiums, transport bargains

“Producers in the TMS are in an incredibly strong position because of the existing infrastructure in the region” said Charlotte Batson, CEO of Tuscaloosa Energy Services. “There are 2 million barrels of river-front refining capacity within 150 miles of the play, from Valero in Memphis down to the Gulf Coast. This one is going to be bigger than the Bakken. The major producers are already looking at scalable gathering and transloading operations. Beyond the immediate area, the entire inland waterway system opens refining and processing markets from Pittsburgh to Corpus Christi, [Texas].”

While producers are touting their LLS differential to WTI in crude prices, the other number that looms just as large is the transport cost. Batson cited industry estimates where the postage is a scant dollar or two per barrel from Liberty, Miss., to Natchez, Miss.—trucking not included. But that is still in sharp contrast to \$15 to \$18 per barrel from Stanley, N.D., to St. James, La. “Economics like that

are compelling,” she said, “especially given the outlook for declining oil prices.”

At present, the bulk of the shipment is still by truck either to the river or to Liberty, Miss., which has developed into an area pipeline hub. Acknowledging that producers and pipeline companies are keeping their cards close to their vest, Batson said, “I think they are all actively discussing possibilities. The existing interstate pipes are certainly a big part of the producers’ plans. That is what makes the TMS different—the transportation strategy. There are gaps in the pipeline network, but segments are being reversed and others are being filled in.”

Another variable in the equation for the TMS midstream sector is the light, sweet crude itself. Even as operators enjoy the current LLS differential, producers know that booming domestic production from the Bakken already has backed out most of the import business for those honey barrels, meaning volume competition might become a factor.

Also, it is well known that much of the Gulf Coast refining capacity, especially the biggest tide-water facilities, have long been optimized for heavy sour barrels that can be had at relative discounts on the world market. Ironically, the configuration for distant crudes might make producers less interested in local liftings. Refineries can always run lighter and sweeter, so the question is crude costs, all in, at the feedpipe. Whether or not regional crudes (trading at a premium but cheap to move) can compete with global crudes (trading at a discount but expensive to move) remains to be seen.

“The feedslate mix in refineries on the Gulf Coast has been changing,” Batson said. “There has not been a big deal about it, but the refiners are reconfiguring their feedslates a little lighter and sweeter.” Another market for TMS crude, she suggested, is a diluent for bitumen, which is currently a key market for condensate.

All of this, Batson concluded, “is very, very exciting. The play is not quite proven economical, although pockets have been. Current production is about 5,000 barrels a day. So it is exciting to see this level of commitment by producers this early in the game. They are counting on the transportation and processing infrastructure being there when commercial production begins to ramp up.” ■

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# TMS: A Future Light, Tight Oil Play

Although well counts are currently low, production is expected to steadily increase as operators drill additional wells.

**By Jessica Garrison**

Stratas Advisors, a Hart Energy company

The Tuscaloosa Marine Shale (TMS) is an emerging oil shale play in southern Louisiana and Mississippi. Although the TMS is still in the assessment-delineation phase, major operators have begun production and continue to increase drilling activity in the play. The Tuscaloosa Trend was deposited during the early Upper Cretaceous period within the Cenomanian-Turonian age. The Tuscaloosa group is composed of three main subgroups: the Lower Tuscaloosa coarse sands and shales, the marine shale (TMS) and the Upper Tuscaloosa sands, shales and clays. Deposition of the lower units occurred during a major transgressive event, while the Upper Tuscaloosa sands represent the regressive phase of the cycle.

The TMS is mainly dark gray to black with fissile and sandy characteristics, making it an excellent source rock for conventional and unconventional exploration. The unit has a large natural fracture system, providing high permeability with good porosity. The average total organic carbon content of the productive section is between 1.5% and 3.5%. The TMS varies in thickness, up to 800 ft in the deeper portions in Louisiana and gradually thinning toward Mississippi, where it averages about 500 ft. The productive portion of the shale unit is highly overpressured, between 10,000 ft and 14,500 ft deep and 100 ft and 250 ft thick. The majority of drilling has taken place at about 12,000 ft. A study conducted by Louisiana State University's Basin Research Institute has estimated a potential reserve of 7 Bbbl of oil in place within the TMS unit.

Figure 1 depicts the overall valuation index of the TMS. The valuation maps are derived by the weighted compilation of the underlying thickness and the structure of the formation as measured in geologic base maps. The darker shaded regions reflect the areas of the play that have higher-quality hydrocarbons leading to higher productivity, which will ultimately determine the areas of interest for future drilling opportunities. Current activity is focused within the "core" of the play including Wilkinson and Amite counties in Mississippi and St. Helena, Tangipahoa, and West and East Feliciana parishes in Louisiana. As further delineation of the play occurs, the ultimate "sweet spot" will be defined.

The TMS was first discovered in the early 1940s when a vertical well encountered a highly overpressured zone as the operator was drilling for the conventional resources. In the 1990s, operators continued to drill through this overpressured zone to develop the conventional Lower Tuscaloosa sands. Development of the conventional Tuscaloosa group continues on today with about 1,400 vertical wells targeting the formation. During the early onset of unconventional drilling and hydraulic fracturing, initial wells were drilled to test the reliability of the TMS unit.

Focused exploration in the TMS began in 2005 when Encore drilled the Joe Jackson No. 4, which had a 1,650-ft lateral and just three fracture stages. Encana moved into the play in 2011 in Amite County, Miss. Activity picked up in 2013 when

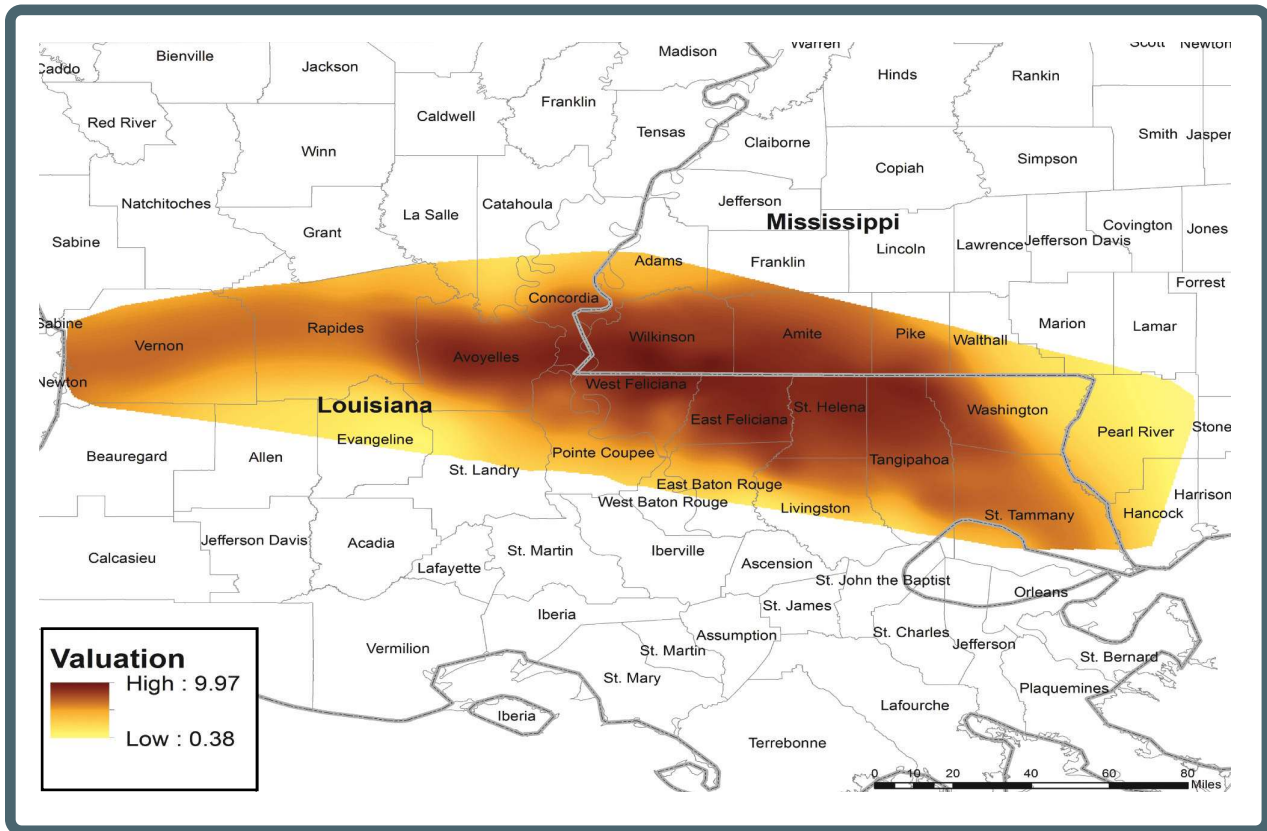


Figure 1. Valuation map of the Tuscaloosa Marine Shale. (Data and images by Stratas Advisors, a Hart Energy company)

major players such as Goodrich Petroleum and Halcón Resources began assessing and delineating their acreage positions. Although the play is currently between the assessment and delineation stages, about 2 million acres have been leased to major operators such as Encana, Devon Energy, Goodrich, EOG Resources, Comstock Resources and Halcón. The largest acreage holder in the play to date is Halcón Resources with 316,000 net acres, followed closely by Goodrich, which holds 306,400 net acres, and Encana with 302,000 net acres. Several small-cap operators, such as Sanchez Energy and Indigo Minerals, also have invested highly in the play. Currently, Sanchez Energy holds about 57,000 net acres within the core of the TMS. Acreage acquisitions are becoming more prevalent in the TMS as operators move more resources into the play. During third-quarter 2014, Comstock Resources announced the addition of acreage within two core oil plays: the Eagle Ford and TMS. The company now holds a total of 60,800 gross acres (58,100 net) compared to a previous amount of 55,000 net acres in second-

quarter 2014.

In third-quarter 2014, Halcón Resources entered into an agreement with Apollo Global Management LLC to invest about \$400 million into Halcón's subsidiary, HK TMS LLC. Halcón's wholly owned subsidiary operates the company's acreage within the emerging TMS, across Mississippi and Louisiana. Apollo now holds 100% of HK TMS LLC common shares and will act as manager of the company's activities. This newly signed agreement is expected to accelerate Halcón's growth within the play.

Although well counts are currently low, production is expected to steadily increase in 2014 as operators drill additional wells and continue to allocate further resources to the development of their acreage. Goodrich is currently running three rigs, expects to run up to five rigs in the play by year-end 2014 and plans to drill a two-well pad in Wilkinson County, Miss. Several operators have announced plans for increasing drilling efficiencies and completion techniques. Goodrich is planning to use



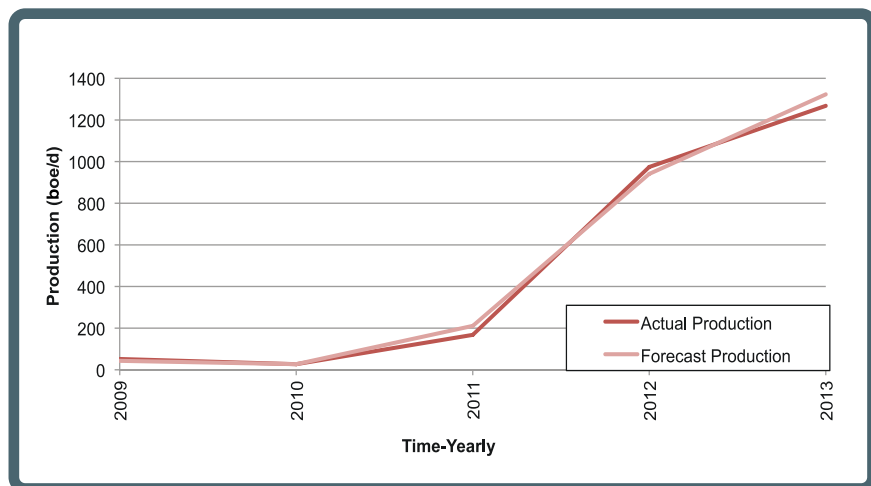


Figure 2. Backtest of Encana Corp.'s Production History

more efficient rigs and more refined mud weights during the drilling process. Goodrich also plans to use more refined drilling techniques to land the laterals in the lower units of the shale formation to ultimately maximize production. Similarly, Halcón Resources plans to improve drilling efficiencies by reducing the overall drill time by 15% to 20% by year-end 2014.

Encana, a leading operator in the TMS, has announced plans to drill between 10 and 12 wells in 2014 while operating an average of two rigs. The operator has drilled six wells since the beginning of 2014. Comstock Resources will begin drilling wells during 2014 with the expectation of spudding three gross wells in 2014. As the major players in the TMS increase their inventory, small-cap and private operators also

will likely increase inventory and contribute to the play's growth. Goodrich and Encana are the main contributors to the play's overall production and have remained so since 2012. The operated production forecast for the play remains conservative until more of the TMS is developed and operators increase productivity. Prior production estimates were derived from the generation of manual type curves based on operator-disclosed well results. In third-quarter 2014, Hart Energy's Stratas Advisors created type curves by using the actual historical well production profiles that have been recently updated and released by the states. Stratas Advisors matched the historical production profiles of these wells to the type curves, thereby representing an accurate measure of a well's production and estimated resources available. Figure 2 represents a matched production backtest for Encana Corp. that was used to forecast the operator's historical production and forecast. The backtest allowed Stratas Advisors to create type curves based on the operator's actual production profiles to generate a forecast that accurately describes its activity within the play. The backtest, shown for Encana, was matched at a percentage difference of less than 6%, indicating a precise match to the operator's historical production rates.

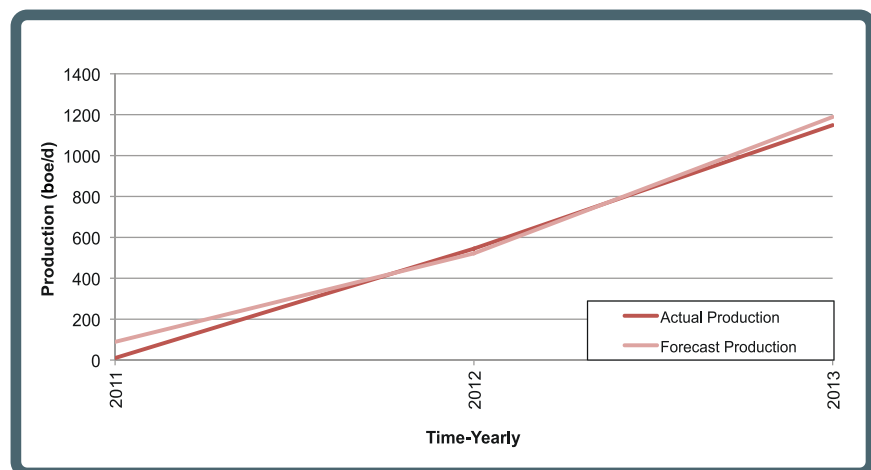


Figure 3. Backtest of Goodrich Petroleum's Production History

Similar to the backtest created for Encana, Stratas Advisors matched the production history of Goodrich Petroleum to a percentage difference of less than 9%, as shown in Figure 3. Since entering the play, Encana and Goodrich have both steadily increased production through 2013. Each operator has projected an increased production rate for 2014 and remains on track for meeting those expectations leading to a more reliable production forecast.

The generated backtests for Goodrich and Encana have allowed Stratas Advisors to compile individual operators'

playwide production to show an accurate measure of the TMS's activity levels since 2009. As Halcón and Comstock begin acreage delineation, the core of the play will become more established, leading to a production spike. Stratas Advisors' IP forecast represents a conservative estimate of playwide production if operators do not increase their pace of development or refine drilling techniques to lower well costs. Figure 4 illustrates Stratas Advisors' base-case production forecast representing a conservative forecast through 2035. A production increase is expected in 2014 as Halcón and Comstock begin to complete their current well inventory and tie in wells to infrastructure.

Although producing well counts are currently low, a conservative forecast throughout the remainder of the period is highly unlikely as operators report increasing efficiencies and increased well counts. Since the play's inception, Goodrich and Encana have both reported a decrease in drilling times and more refined drilling techniques to counteract the shale unit's high pressure. The top operators of the play also are announcing an increase in well counts and were expecting to drill upward of 10 to 15 new wells in 2014. As these wells are tied to production, the play should see a steady increase in production rates.

If the TMS continues to prove successful, the pace of development will accelerate as operators increase well counts and improve well results. A production forecast has been created by Stratas Advisors to illustrate acceleration in activity, as shown in Figure 5.

The TMS is predominately an oil play, at 93% oil, 6% gas and 1% NGL. Goodrich recently has announced a well result for the company's SLC Inc. well that averaged 96% oil. The operator also has reported 90% oil from its Beech Grove well. The hydrocarbon splits seen will continue to be refined as operators report well results and the core of the play is more refined.

The overall economics of the play have remained high since the play's inception.

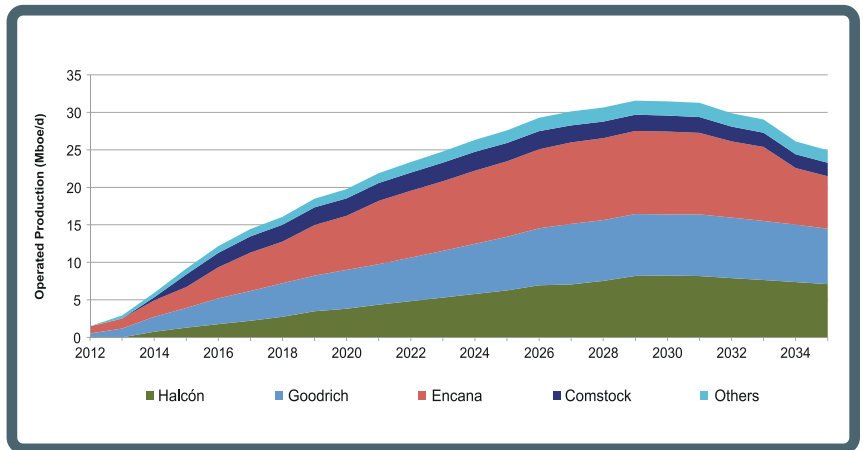


Figure 4. TMS Production Forecast—Base Case

Well costs must be lowered (capex) to make the play's production more profitable given the current wells drilled. Stratas Advisors ran an economic scenario using a well in Goodrich's inventory in St. Helena Parish, La. Goodrich's Weyerhaeuser 14H well began production in early 2012 and has about 24 months of production history, as shown in Figure 6. The well showed an average gas-oil ratio of 496 with an assumed 1 gal/min. Goodrich has announced multiple well costs for a single-well pad, multiwell pads and two-well pads. Using the company's single-well cost of \$13 million, the well showed a pretax net present value (NPV) of -\$3.7 million and a post-tax NPV of -\$2.6 million, as listed in Table 1.

Using standard costs of \$4/Mcf of gas, \$37.80/bbl of NGL and \$80/bbl of oil, Stratas Advi-

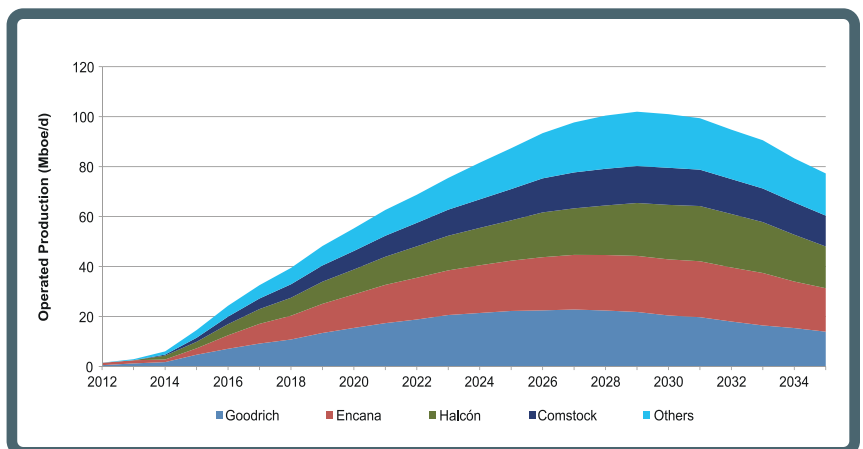


Figure 5. TMS Production Forecast—High Case



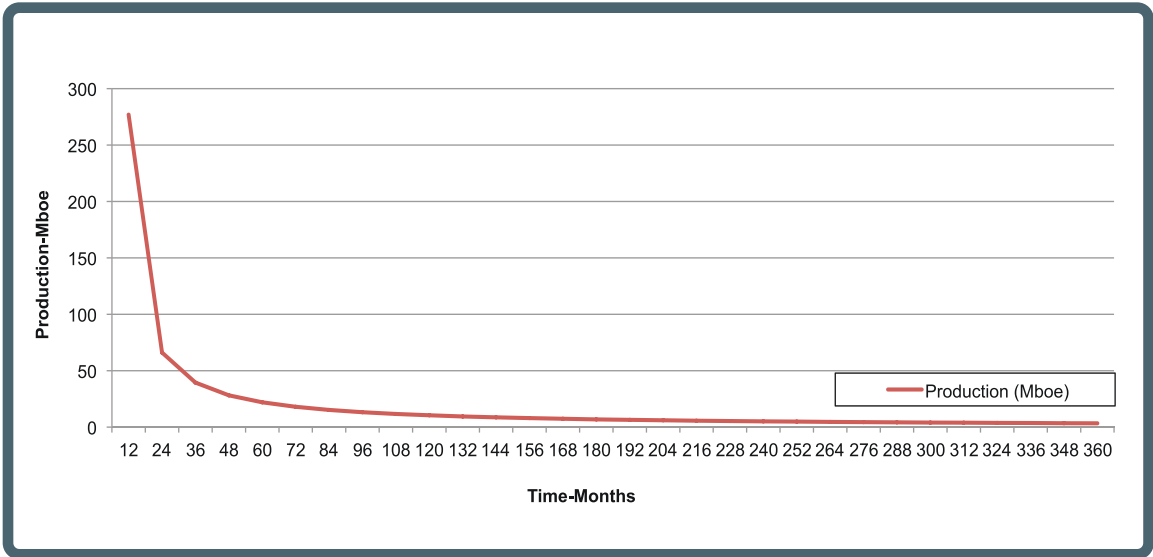


Figure 6. Goodrich's Weyerhaeuser 14H Well Type Curve

sors ran a breakeven well cost scenario to determine the cost per well that Goodrich would need to achieve to show a positive NPV. A well cost of \$9 million would give Goodrich a positive pretax NPV of \$0.26 million. At this well cost, the pretax breakeven amount would be \$73.94/bbl, and the post-tax breakeven cost would be \$76.97/bbl. The operator already has begun to lower its well costs since entering the play and will likely continue to do so. Other operators are expected to follow suit in lowering well costs as drilling efficiencies increase. Encana has announced the continuation of improved well costs and hopes to achieve a cost

per well of about \$11 million to \$13 million. Under this cost, the operator's economics should follow closely with the figures described in Table 1. Halcón Resources describes similar well cost targets to Encana and Goodrich, between \$11 million and \$13 million.

Currently, the play has few wells producing. However, as operators continue to drive down well costs, it is likely more operators will push into the play and begin development. Given the current estimates of oil in place, with refined drilling strategies and lowered well costs, the TMS could prove to be the next great oil shale play. ■

| WELL NAME        | PAD CHARACTERISTICS | CAPEX (\$MILLION) | PRETAX NPV (\$MILLION) | POST TAX NPV (\$MILLION) | PRETAX BREAKEVEN (\$/BBL) | POST TAX BREAKEVEN (\$/BBL) |
|------------------|---------------------|-------------------|------------------------|--------------------------|---------------------------|-----------------------------|
| Weyerhaeuser 14H | Single-Well Pad     | \$13              | \$(3.70)               | \$(2.60)                 | \$103.45                  | \$110.89                    |
|                  | Two-Well Pad        | \$11.50           | \$(2.20)               | \$(1.70)                 | \$92.38                   | \$99.12                     |
|                  | Multiwell Pad       | \$10              | \$(0.74)               | \$(0.86)                 | \$81.32                   | \$87.35                     |
|                  | Breakeven Well Cost | \$9               | \$0.26                 | \$(0.27)                 | \$73.94                   | \$76.97                     |

Table 1. Well Economics from Goodrich's Weyerhaeuser 14H Well

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

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**THE ANTEBELLUM STANTON HALL HOME** in downtown Natchez is just north of many TMS wells.

*(Photo by Mieko Mahi)*



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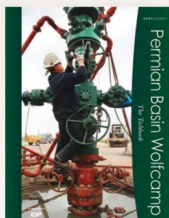
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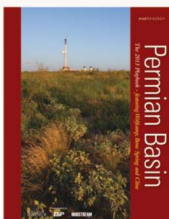
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