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~ OKLAHOMA 2010 DRILLING  
HIGHLIGHTS

~ MISSISSIPPIAN REEDS SPRING  
FORMATION

~ A STRATIGRAPHIC LEGACY  
PRESERVED

~ AND MORE

*The*  
2011 AAPG  
MID-CONTINENT  
SECTION MEETING



Oklahoma City, Oklahoma  
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## Oklahoma 2010 Drilling Highlights

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This article is a summary of Oklahoma drilling activity that became public in 2010. Activity or key wells that were unavailable before January 1, 2011 will appear in next year's summary. Except where noted, all data were supplied online by Petroleum Information/Dwights LLC dba IHS Energy Group, all rights reserved. Production volumes reported are through August, 2010 and thus may understate production for some new wells or plays. Without this excellent database a report of this kind would not be possible. Editing was performed by Neil Suneson and cartography by Russell Standridge, both from the Oklahoma Geological Survey.

### General Activity

The number of working drilling rigs is a fundamental

barometer of oil and gas activity in any area. The Baker Hughes Company has tracked monthly rotary drilling rig counts for many years for regions all over the world. As documented in last year's installment of this article (Boyd, 2010), after a peak of 219 in September, 2008 Oklahoma's rig count reached a low of 69 working rigs in September, 2009. Since that time the numbers have been steadily climbing, with the last week of 2010 reaching 160 working rigs. However, although average annual activity is up by one third between 2009 and 2010, we are still a long way from the levels enjoyed previously (Figure 1).

In past years, with gas drilling accounting for as much as 3/4s of all wells drilled, the price of gas has been the most important factor controlling activity in Oklahoma. This is no longer the case. Although the price for both gas and oil col-

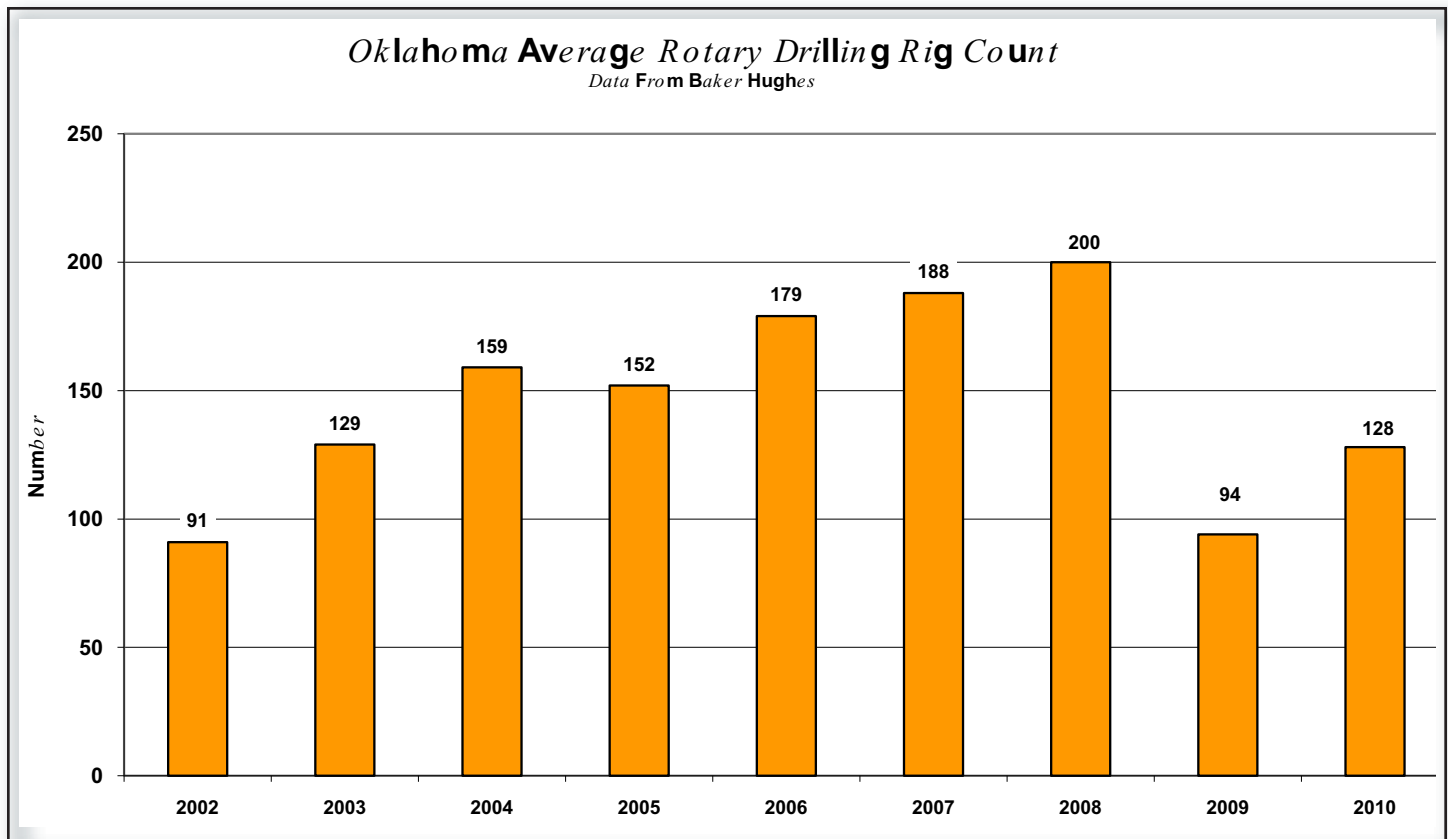


Figure 1. Oklahoma Annual Rotary Rig Count from 2002 to 2010. Data from Baker Hughes (2011).

## Oklahoma Oil and Natural Gas Prices

(Data From O.C.C., 2010)



Figure 2. Oklahoma Annual Average Oil and Gas Price on a Barrel of Oil Equivalency from 2002 through 2010. Data from Soltani (2010).

## Oklahoma 2010 Well Completion Results

(Data from IHS Energy - registered through 1-1-2011)

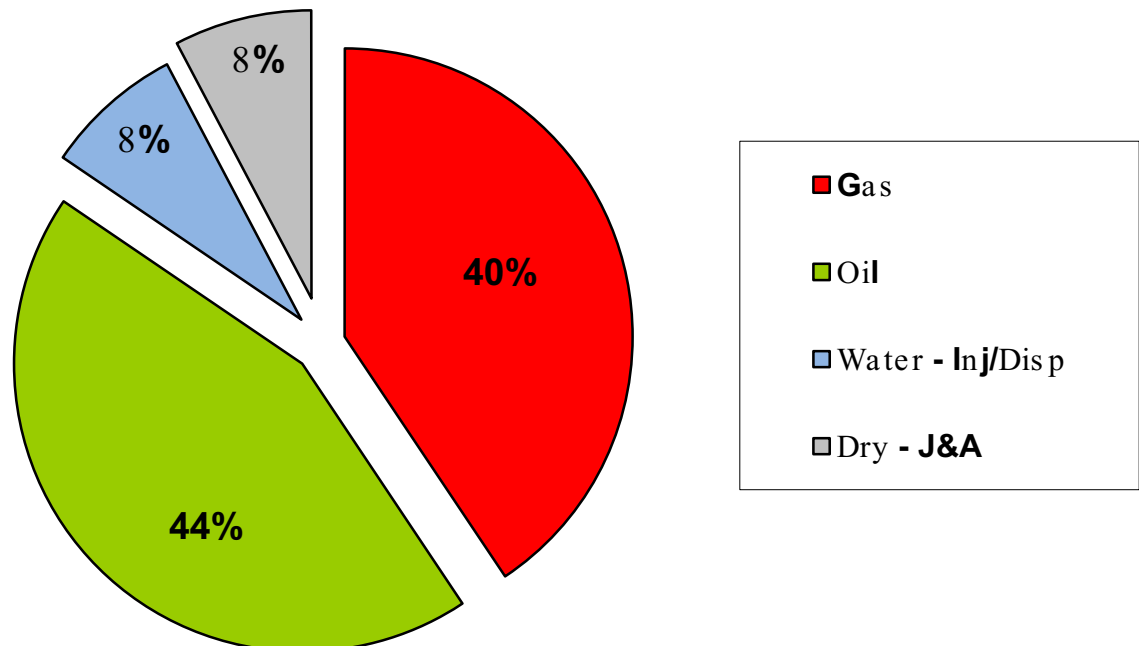


Figure 3. Oklahoma 2010 Well Completion Results (for wells reported through January 1, 2011). Data from IHS Energy (2011).

lapsed at the end of 2008, gas was hit harder, and since that time it has not recovered as well as oil (Figure 2). From 2003 to 2008 the price of natural gas in Oklahoma went from about \$5 per thousand cubic feet (MCF) to \$7.31. This increase on a barrel of oil equivalency (BOE) (using the standard 6 MCF per barrel conversion) equates to an increase from \$30/BOE to about \$44/BOE. Oil in the same period began at the same place, \$30/Bbl, and then rose continuously to nearly \$100/Bbl. Thus near-parity between oil and gas prices in 2003 changed into oil becoming more than 2.5 times more valuable in 2009 and 2010. This trend looks like it will continue, with gas prices not getting their usual bump during the peak heating season and oil maintaining a steady rise. At this writing oil is priced about 3.5 times higher than natural gas on a BOE basis.

The average 2010 wellhead natural gas price in Oklahoma is projected to be approximately \$4.67 per MCF (Soltani, 2010). This is an improvement over 2009, but is still apparently below the price necessary to restart concerted gas-targeted drilling. The long-term course of natural gas prices will be primarily controlled from a demand standpoint by the speed at which the U.S. economy recovers and the weather - both difficult to predict. On the supply side there are prolific shale-gas plays across the U.S., and like the Woodford in Oklahoma, these continue to be drilled (and produced) in a market already glutted with natural gas. Price predictions are impossible, but until the bulk of what is considered to be prospective shale-gas acreage is held by pro-

duction, which will afford operators the luxury of drilling infill wells when prices are higher, high shale-gas production will continue to have a downward pressure on prices (Figure 2).

Languishing gas prices, rising oil prices, and the expectation that these trends will continue has created a situation not seen in this State since 1992 - that is - more oil than gas drilling. The relative increase in oil-targeted drilling would be even more pronounced if horizontal Woodford gas drilling was not included. These wells, which accounted for about one third of all the gas drilling in the State in 2010, are largely being drilled to hold acreage that would otherwise expire. Clearly, in this low-price gas environment elective gas drilling is on hold (Figure 3).

Water-injection and disposal wells represent about 8% of 2010 drilling with dry holes accounting for an additional 8% of total drilling (Figure 3). An overall 92%+ success rate is comparable to previous years and shows that drilling for both oil and gas in Oklahoma continues to be overwhelmingly developmental. This reflects the maturity of the Oklahoma industry where 120 years and over 600,000 wells have made true exploration difficult. In today's environment the 'exploration well' is often an isolated horizontal test drilled into a reservoir that has proven itself to be sub-economic in nearby vertical producers. Although the economic risk of such wells is significant, the chance of drilling a non-producing dry hole is usually less than the mechanical risk associated with the drilling operation itself.

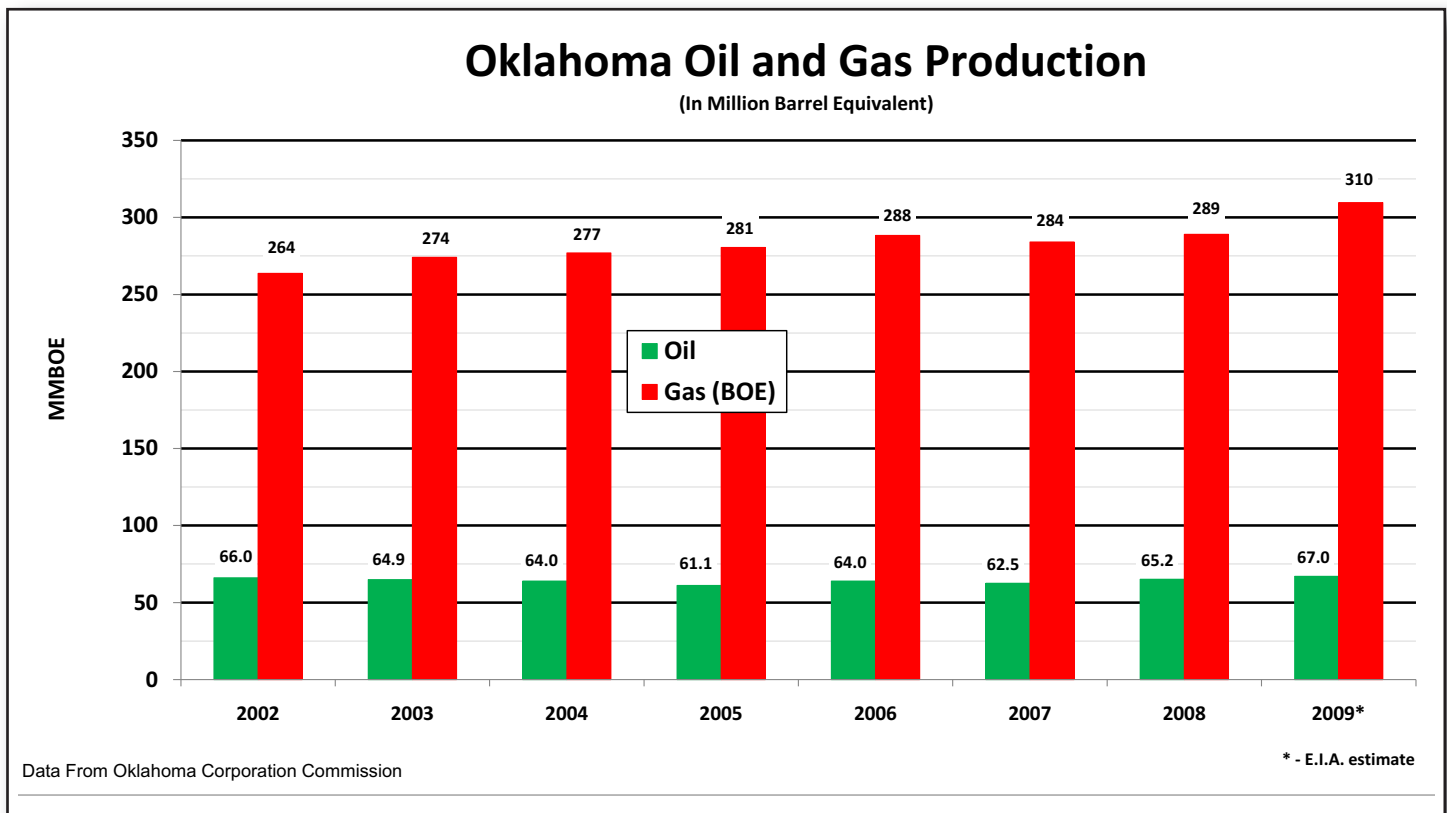


Figure 4. Oklahoma Oil and Gas Production on a Barrel of Oil Equivalency from 2002 to 2009. Data from Soltani (2010). Due to reporting delays, 2009 data taken from E.I.A. (2011).

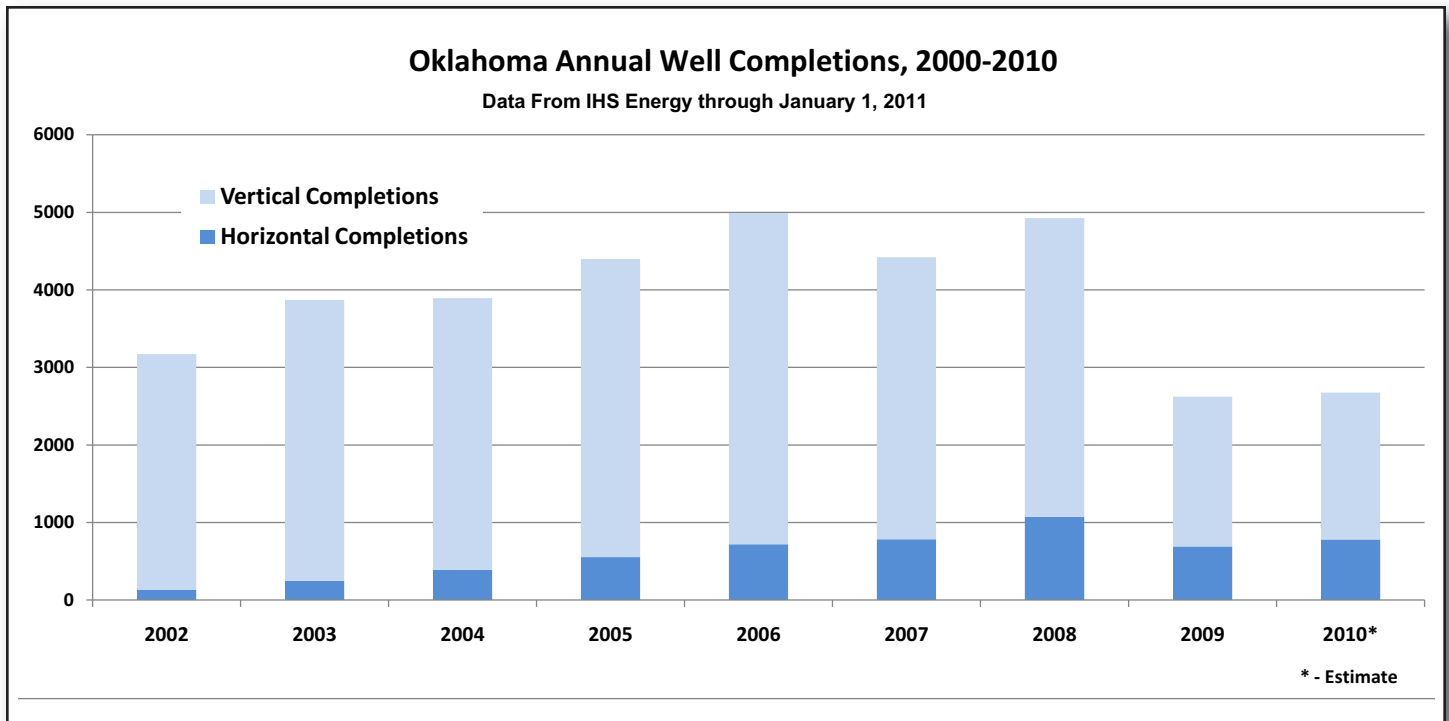


Figure 5. Oklahoma Annual Well Completions Comparing Vertical and Horizontal Drilling. Data from IHS Energy (2011) through January 1, 2011.

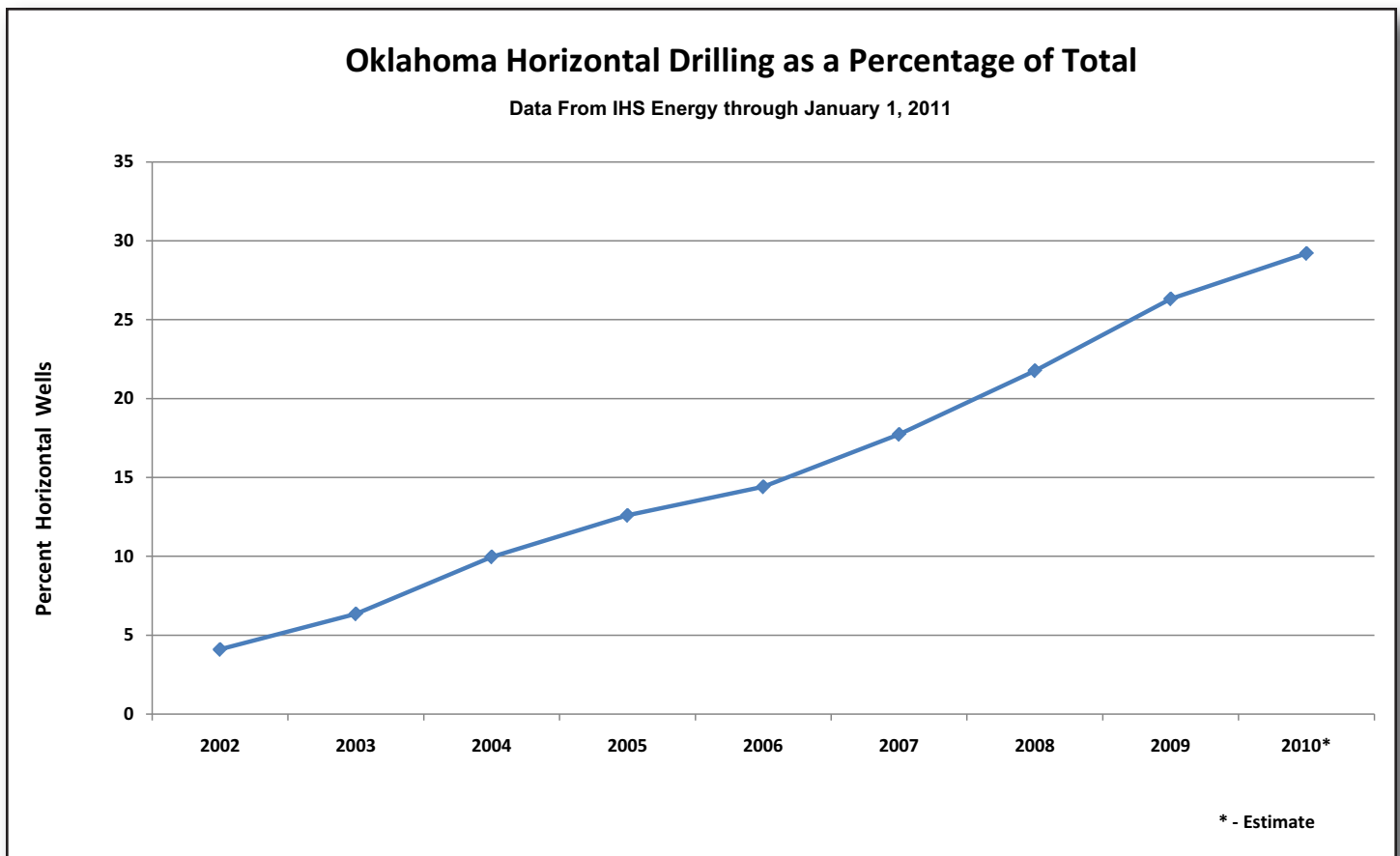


Figure 6. Oklahoma Annual Horizontal Drilling as a Percentage of Total Completions. Note: in terms of footage drilled 2010 horizontal wells accounted for 50% of State drilling. Data from IHS Energy (2011) through January 1, 2011.

The 638 wells that began producing in 2010 added 15.5 thousand barrels (MBO) + 497 million cubic feet (MMCF) per day (8% and 10%, respectively) to State production.

Continued active horizontal drilling for shale gas (243 Woodford completions registered through January 1<sup>st</sup>) has helped maintain for the last two years (despite relatively low

prices) the general increase in Oklahoma gas production. Gas production in 2002 represented the bottom of a decline that began in 1990, and was the lowest annual production since 1966. Since the 2002 low, State gas production has risen 17% due in large part to horizontal completions, which in the last reported month accounted for 26% of the State's total gas production.

The low reached by gas in 2002 was reached by oil in 2005 (Figure 4). This marked the bottom of a slide in oil production that began at the end of the drilling boom in 1984. Since then, oil production has climbed 10% due to price-driven vertical-development and increased horizontal drilling. Horizontal wells in the last reported month accounted for about 12% of Oklahoma's oil production. As will be discussed later, because of an industry focus on identifying and expanding horizontal oil (hydrocarbon liquid-rich) plays, their share of the State's oil production will likely continue to rise. Gas continues to dominate Oklahoma's BOE production, but the pronounced price differential with oil narrows the economic advantage enjoyed by natural gas. This 'oil premium' makes the industry, royalty owners, and the State budget less dependent on natural gas, but the price of gas will remain the key factor in the overall economic health of the State.

Reporting delays necessitate a revision of State drilling statistics each year. Since the last installment of this article 541 completions were officially registered for 2009 and 124 for 2008. In fact, last year 22 completions were added to the 2002 totals. Such delays and the fact that these are not consistent from year to year make annual comparisons of drilling activity difficult. As in previous years all comple-

tion numbers for 2010 were increased by one third to reduce the impact of reporting delays. Total completions in 2010 registered through January 1, 2011 were, coincidentally, 2,011. Boosting this to account for wells not yet reported brings last year's total to 2,675 (Figure 5). This is slightly above 2009 levels, which would be expected with a higher rig count, but with more (longer to drill) horizontal completions.

Drilling activity generally rose from 2002 through 2008 (Figure 1). This activity, which followed increasing prices, fell sharply in 2009, reflecting the sudden price drop at the end of 2008. The reduction in drilling was especially pronounced for vertical wells which fell by half in 2009 (Figure 5). The number of horizontal wells drilled also fell that year, but as a percentage of all drilling the increase in horizontal drilling has been remarkably consistent (Figure 6). In fact, over the last decade, the number of horizontal completions in Oklahoma has risen from 2% to nearly 30% of the total number of completions. Today, horizontal wells account for nearly 50% of the total footage drilled in the State.

Hundreds of companies drilled wells in 2010, but Chesapeake Operating continues to be by far our most active operator (Figure 7). The 185 completions registered through January 1<sup>st</sup> are a third fewer than the 272 completions that were assigned to them in 2009. However, these wells still represent 9% of all drilling in the State and are equal to the number drilled by the next two operators combined. Chesapeake is active in almost every area of the State, but their two favorite plays were the Desmoinesian Granite Wash (horizontal) in Washita County and horizontal Mississippian Lime (horizontal) in Woods and Alfalfa Counties.

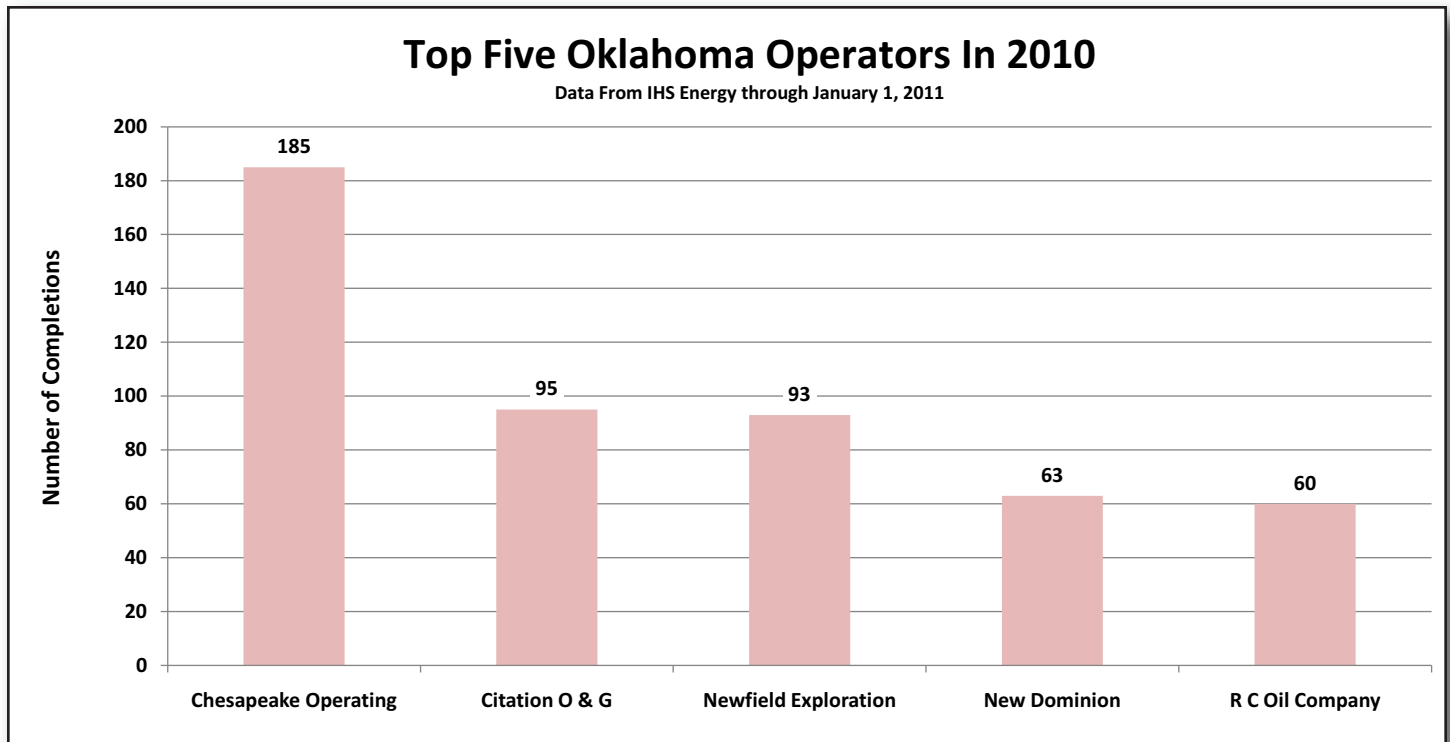


Figure 7. Top Five Operators in Oklahoma in 2010 based on the number of completions registered through January 1, 2011. Data from IHS Energy (2011).

Based on completion numbers, the second most active operator in 2010 was Citation Oil and Gas, who drilled or recompleted 95 shallow-oil development wells and injectors in southern Oklahoma, mostly in Sho-Vel-Tum, Fitts, and Healdton Fields. Newfield Exploration's activity was mostly in horizontal Woodford Shale gas development in the western Arkoma Basin. New Dominion's drilling is associated almost exclusively with Misener-Hunton dewatering projects in Seminole County. R C Oil Company, a newcomer to the ranks of the five most-active operators, drilled 60 very shallow (< 1,000 ft) Bartlesville oil development wells concentrated in Nowata County. Just missing the list with 59 completions registered through January 1<sup>st</sup> was Devon Energy. Their activity was restricted exclusively to horizontal Woodford Shale gas, equally split between the Arkoma Basin and the Anadarko Shelf.

## Horizontal Drilling

In the last reported month (August 2010) Oklahoma's 3,916 producing horizontal wells were making 22 MBO + 1,355 MMCFPD. Oklahoma has numerous conventional and unconventional low-permeability reservoirs; this has helped make horizontal drilling by far the most important drilling/completion technique to be recently applied in the State. Horizontal-drilling technology has made formerly unproductive areas and reservoirs profitable and revitalized reservoirs that have been producing for decades. It is no exaggeration to say that major State operators are now almost entirely occupied with identifying places and reservoirs where horizontal drilling and completion techniques can be put to use. All of the significant wells listed in this report are horizontal completions, and almost all of the highest-impact drilling activity in the State is horizontal. This is not to say that there are not operators who are prospering by drilling and completing vertical wells, but certainly horizontal drilling will continue to grow.

In addition to increased wellbore exposure to low-permeability reservoirs, horizontal drilling is useful in dewatering dual-porosity oil reservoirs. Dewatering is the process by which reservoir pressure is reduced in fields with natural water support through aggressive water production. This production triggers associated gas expansion in poorer (unswept) parts of the reservoir, forcing gas and oil into the natural- and/or induced-fracture systems and ultimately into the wellbore.

Almost every significant productive reservoir in the State has been drilled horizontally somewhere, but some have been systematically exploited in well-defined area(s) which can be described as geologic plays. Three of these, while still producing, are largely inactive in terms of new drilling. Chesapeake utilized horizontal-drilling technology in the mid- to late-1990's to pursue mostly oil in the Sycamore carbonate in southern Oklahoma. Most of these wells are located in Sho-Vel-Tum Field and the Golden

Trend. Another largely inactive horizontal play was made by EOG Resources in western Texas County. They drilled about 70 horizontal gas wells between 2000 and 2003 in the Council Grove Group, mostly in Unity SW and Guymon-Hugoton Fields. In an aggressive dewatering project that utilized horizontal drilling, New Dominion targeted the Arbuckle Group in the Oklahoma City Field. Here they drilled 52 horizontal laterals from 17 surface locations and are disposing water into the Arbuckle on the downthrown side of the field fault (Boyd, 2010).

Using an arbitrary 100-well cutoff there are now six established, active horizontal plays in Oklahoma and there are several more that appear destined to reach this milestone. Drilling statistics for the most active horizontal plays over the last nine years are shown in Figure 8. The 2010 totals for each have been increased by 33% in an attempt to account for the reporting delays described previously. This gives a more accurate year-to-year comparison and hopefully shows the direction that activity in these plays is taking. Figure 9 shows the productive areas and 2010 drilling for the six major horizontal-drilling plays. The productive outlines encompass wells drilled and completed prior to 2010, with the colored dots showing 2010 wells that were registered through January 1, 2011.

All production cited is from IHS Energy with a last recorded month of August, 2010 (IHS Energy, 2011). Oil and wet gas production are reported in the IHS database, but natural gas liquids (NGLs), which come out during processing, are not. For some plays these can be significant. High NGL yields will dramatically improve economics by, in essence, turning some of the low-priced gas into high-priced liquids. Condensate and oil are usually not distinguished. Where this is ambiguous all hydrocarbon liquids production is called oil.

## Hartshorne Coal

The largest horizontal play - with 1,665 wells drilled thus far - is the Hartshorne Coal located in the center of the Arkoma Basin. Hartshorne coalbed methane has been exploited with horizontal wells for more than a decade, but low natural gas prices have depressed drilling activity in this play for the last two years and only 22 completions are registered for 2010 to date. All of these were drilled by Canaan Resources and Unit Petroleum in the western part of the established producing area. Acreage issues aside, there appears to be ample room to expand this play eastward when prices permit. The 935 actively producing horizontal Hartshorne Coal wells have an average cumulative recovery of 267 MMCF and a current rate of 57 MCFPD.

## Woodford Shale

The next largest horizontal-drilling play in the State and the one that is by far the most active is the Woodford Shale.

## Major Oklahoma Horizontal Drilling Plays

Data From IHS Energy through 1-1-2011

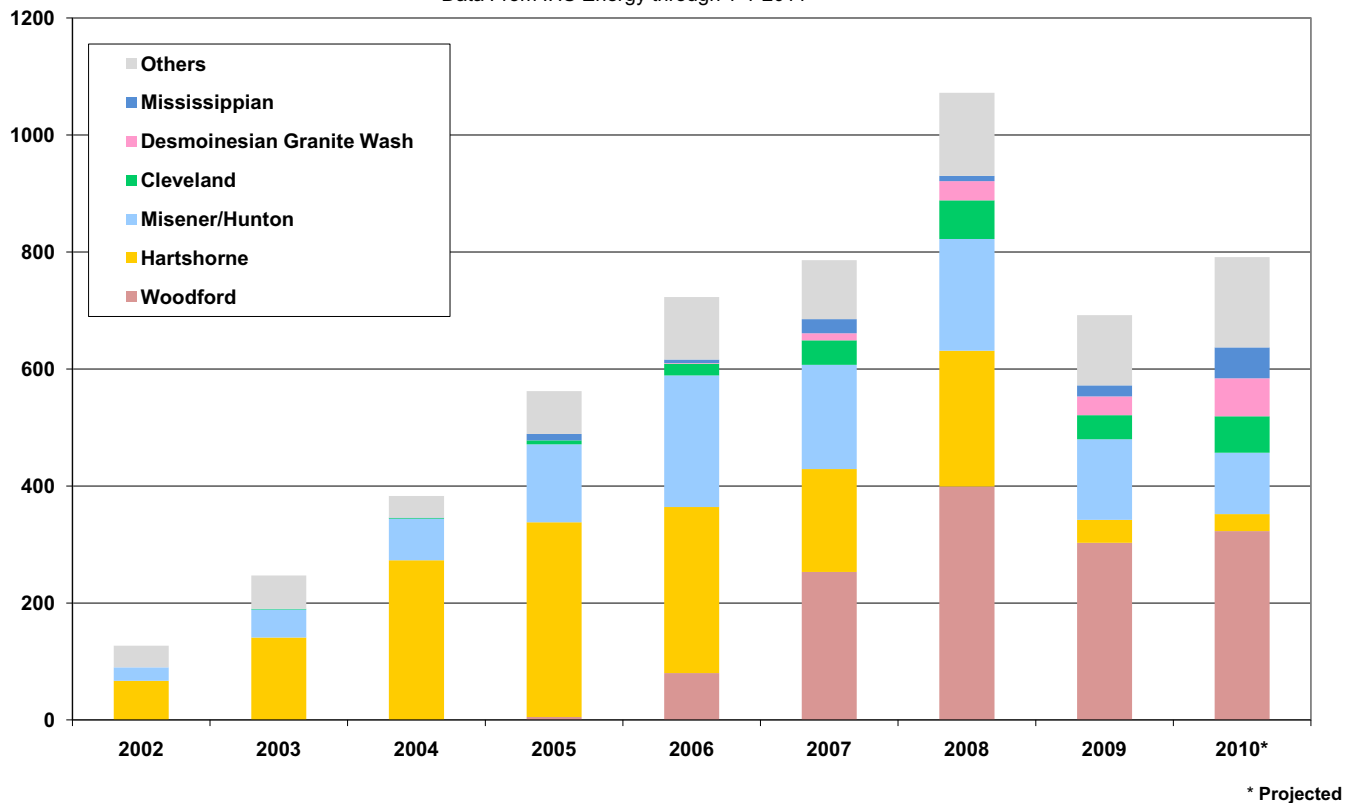


Figure 8. Major Oklahoma Horizontal Drilling Plays (> 100 completions) and other horizontal drilling from 2002 to 2010. Data from IHS Energy (2011) through January 1, 2011.

In only four years of active drilling it now boasts 1,281 producing wells of which 243 have been registered, thus far, for 2010. There are three primary producing trends. The oldest and largest is in the western Arkoma Basin in Hughes, Pittsburg, Coal and Atoka Counties. Like 2009, most of the 2010 activity in this area was within the area of established production and eastward towards the center of the basin. This activity has linked several isolated producing areas and appears destined to expand the play throughout central Pittsburg County (Figure 9). The most active operators in 2010 were Newfield Exploration, Devon Energy, and Antero Resources. The 929 horizontal Woodford producers in this area have average cumulative production of 709 MMCF and a current rate of 838 MCFPD. Hydrocarbon-liquids production in most of this area is negligible.

The second major horizontal Woodford producing area was discovered by Devon Energy on the Anadarko Shelf in western Canadian County. This productive area expanded significantly in 2010 with several one and two township step-outs. This Woodford play has moved into Caddo and Blaine Counties and appears poised to expand both southeast and northwest, along strike, into Grady and Dewey Counties. Devon Energy and Cimarex Energy were by far the most active operators in this area for 2010. There are now 117 horizontal Woodford wells producing here and these

have average cumulative production of 698 MMCF and 7 MBO. Average per well production for August 2010 in the Anadarko part of the play was 1.6 MMCF + 16 BOPD.

A third trend of major horizontal Woodford Shale production is about 40 miles long and located along the northern edge of the Ardmore Basin in Carter, Johnston, and Marshall Counties. In 2010 this was the least active part of the Woodford play with no major extensions to the previously established producing area (Figure 9). Chesapeake, BNK Petroleum, and XTO Energy are the most active operators. The 54 producing wells registered in this area have average cumulative production of 288 MMCF and 11 MBO. Average per-well production for August 2010 was 106 MCF + 20 BO per day.

### Misener/Hunton

Dewatering has found its greatest application in the Hunton (Misener/Hunton) reservoir where over 1,000 horizontal wells have been drilled. This play has remained consistently strong with over 100 wells completed in each of the last six years (Figure 8). Production through reservoir dewatering has been pursued in this reservoir in a number of areas. Aside from a handful of wells in Logan County in the Edmond West Field, the bulk of recent activity has been con-



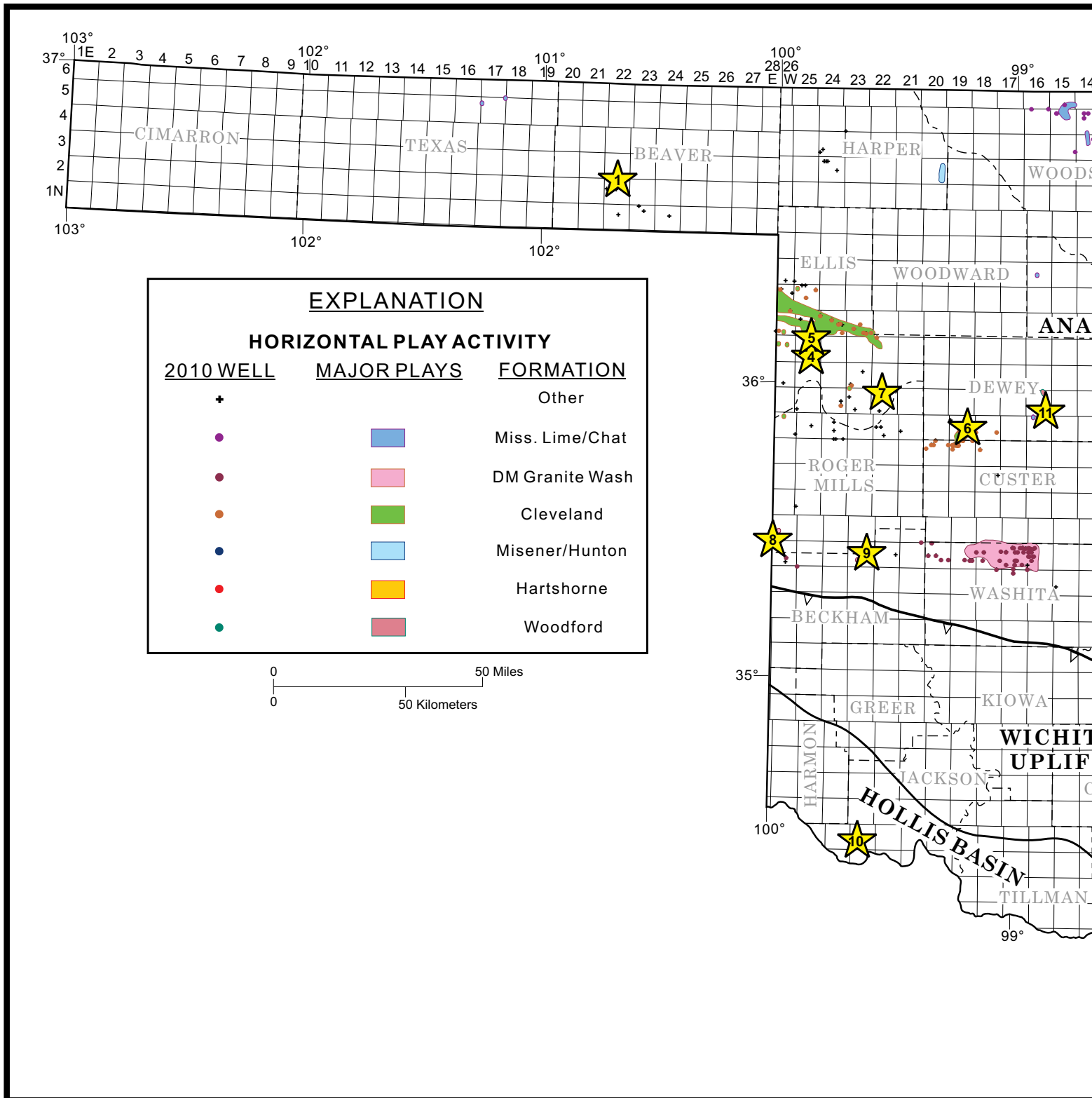
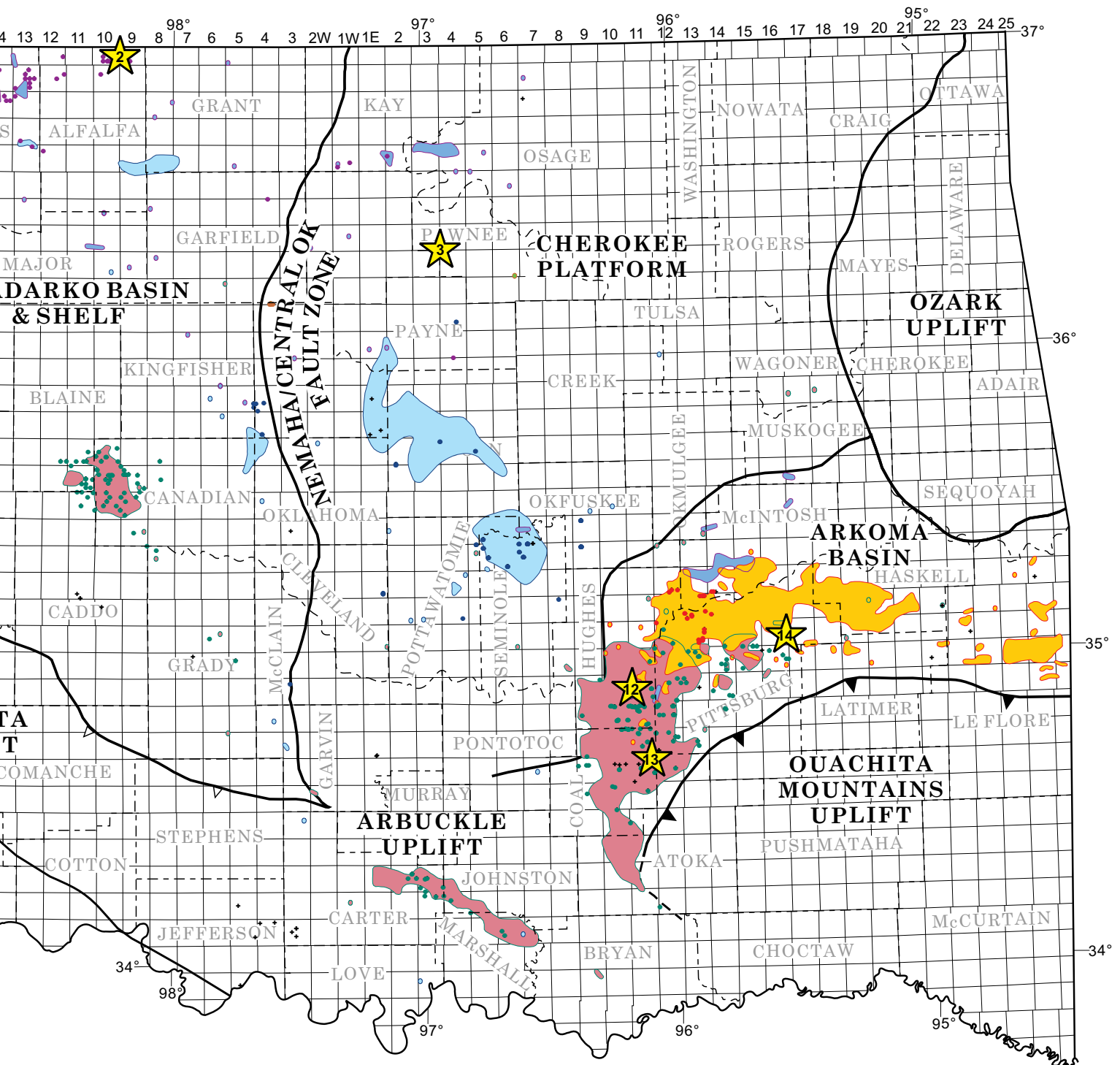


Figure 9. Map of horizontal play production and 2010 horizontal drilling in Oklahoma showing the location of significant wells listed in this report. Shaded areas denote limits of contiguous production for major plays (> 100 completions) prior to 2010. Wells registered through January 1, 2011 as 2010 completions are shown as color-coded dots. Well data and production are from IHS Energy (2011). Geologic province boundaries are modified from Northcutt and Campbell (1995).



centrated in central Oklahoma mostly in and around Seminole, Lincoln, and Okfuskee Counties. As was the case last year, New Dominion is the dominant operator in this play, accounting for more than half of all horizontal Misener/Hunton wells drilled in 2010. The secondmost active operator was OEX-1, who has 18 wells registered to date. Activity for both operators was mostly relegated to previously established areas of production. Because this play requires a major drop in reservoir pressure before significant hydrocarbons are produced - a process that can take years - the productivity of new wells or areas cannot be confirmed based on initial potential tests. Horizontal Misener/Hunton wells have produced about 2 million barrels (MMBO) and 188 billion cubic feet (BCF), generating an average recovery per completion of 9 MBO + 554 MMCF.

### **Cleveland**

Unlike the first three horizontal plays, the remaining have more significant liquids production and so have tended to benefit from the relative strength of oil prices and their resurgence in the last year. Horizontal Cleveland Sandstone drilling, which fell by a third in 2009, is now back to its 2008 level with 62 completions in 2010. Unlike last year when operators tended to stay close to established production, a major expansion of the older productive areas and the addition of new areas of production occurred in 2010.

The main productive area in Ellis County, which extends into the Texas Panhandle, has expanded with new wells pushing horizontal production to the southern edge of the county. The 2009 satellite area in southwestern Dewey County in the report last year has expanded south into Custer County and is now several times larger. Based on drilling trends, it seems likely that these two major productive areas will meet in the future (Figure 9). Despite the high oil volumes registered on initial tests and their general classification as oil wells, on a BOE basis horizontal Cleveland production is roughly two-thirds natural gas. To date the play's cumulative production in Oklahoma is 3.3 MMB + 46 BCF (7.7 MMBOE), giving the average well 27 MBO + 365 MMCF.

### **Granite Wash**

There are several reservoirs called 'Granite Wash' that are being explored for and developed in the Anadarko Basin. These reservoirs span nearly the entire Pennsylvanian System through the Lower Permian and are composed of thick, low-permeability sediments shed from the Wichita Uplift to the south. As such, they vary in lithology based on the formation exposed on the uplift at the time of deposition. Most of the reservoirs have been produced from vertical wells for decades with varying degrees of success, but the advent of horizontal drilling and completion techniques has reduced the dry-hole risk and made some reservoirs enormously economic.

The Des Moines Granite Wash horizontal play, located in the deepest part of the Anadarko Basin, is by far the most important of the granite wash reservoirs to date. Forty-nine new completions in and near north-central Washita County have been reported thus far for 2010, with Chesapeake the most active operator. This drilling has expanded the main producing area about ten miles west to the far northeastern corner of Beckham County. In addition, several distant step-outs have been completed as far west as the Texas border (Figure 9). Vertical wells have produced Des Moines Granite Wash since the mid-1980s, but horizontal production only began in April 2007. Through August of last year the wells in this play have registered an average recovery of about 1 BCF and 68 MBC in less than two years. This play is notable for spectacular rates on initial potential tests and wells with payouts often measured in months. Although its high condensate yield makes this horizontal play particularly attractive, like the Cleveland, the Des Moines Granite Wash on a BOE basis is about two-thirds gas.

Although the Des Moines Granite Wash is the only horizontal wash play with a significant production history, there are several others that appear destined to expand. Naming conventions make these difficult to distinguish from non-wash reservoirs, and some may overlap with reservoirs sourced from the north. However, wells located in Beckham, Washita, Caddo, southern Roger Mills, and southern Custer Counties are likely wash reservoirs including those identified by operators as Atoka, Skinner, Cherokee, Missouri, Pennsylvanian Missourian, Hoxbar, Marchand, and Hogshooter. Reservoirs using the same names produce in horizontal wells in northern Roger Mills and Ellis Counties, and although they seem to produce in a similar fashion are probably sourced from the north and/or east and so are not true 'wash' reservoirs.

### **Mississippi (Lime / Chat)**

A much more scattered horizontal play is targeting what is identified by operators as the Mississippi Lime and/or Chat. These are different reservoirs but are combined on Figure 9 due to inconsistent naming. The Chat produces horizontally mostly in Osage and Kay Counties and appears to have had relatively little drilling activity in 2010. Most of the horizontal drilling activity seemed to be targeting the Lime and was more spread out.

The Mississippi Lime is a regional carbonate found across most of the State. It has produced from what are often marginally economic vertical wells for decades. Horizontal drilling has made this reservoir economic over a much wider area. Although it can develop minor porosity and permeability, reservoir quality tends to be poor. It is often fractured, and horizontal drilling affords the opportunity to enhance natural fractures with multi-stage acid-fracture stimulations. The Mississippi Lime is thick and oil-prone across much of the northern half of the State, giving it the potential

to become the areally largest and perhaps the most productive horizontal oil play in Oklahoma (Figure 9).

The horizontal Mississippian wells completed in 2010 were clustered mostly around the main area of production in Woods and Alfalfa Counties. This part of the play is dominated by Chesapeake and SandRidge, who have each leased several hundred thousand net acres in the last 18 months. Production statistics are preliminary - only 17 wells have any records. To date, wells in this area have average cumulative recoveries of 18 MBO + 51 MMCF and a daily production in August 2010 of 37 BOPD + 131 MCF. Clearly, one of its attractions is the fact that this is a true oil play, with oil representing about two thirds of BOE production.

The Mississippi Chat is a thin, siliceous zone of variable reservoir quality that intermittently develops on top of the Mississippi Lime. Like the Mississippi Lime it has produced for decades from vertical wells. It can now be identified seismically, and horizontal wells drilled on seismic anomalies have allowed operators to maximize reservoir exposure. Because it is permeable these wells are often untreated.

The Oklahoma oil and gas industry has applied horizontal-drilling technology to dozens of other reservoirs across the State and will continue to test the limits of where it can be applied. Many of the horizontal wells drilled thus far are clearly sub-economic, but this may be as much due to the manner in which the wells were drilled and completed as any inherent geological factors. The learning curve from first (often marginal) production to efficient, consistent, money-making development is a process measured in years. There are a number of reservoirs that were not discussed that, based on initial potentials, show promise. These wells, which are classified as 'Other' in Figure 8 and shown as black dots in Figure 9, may develop into larger horizontal-drilling plays in the future.

## Significant Wells in 2010

The following is a list of what are believed to be among the most significant wells registered for Oklahoma in 2010. Although all were registered in the past year, due to reporting delays, some have completion dates prior to 2010. The wells listed were identified from a weekly review of the IHS Energy *EnergyNews on Demand* Midcontinent activity reports released online throughout the year. An initial list of 107 candidates compiled from this publication was reduced to a final 14. Such a list is subjective and may miss wells that could eventually become noteworthy. Due to confidentiality issues, wells that may be notable for technical reasons will probably be missed. For instance, those that confirm some new type of trapping style or proved the benefit of a new drilling or completion technique will be difficult to identify until information is disseminated years later.

Over the past several years, horizontal wells have occupied a progressively larger share of the significant well listings. In 2010 they completed their takeover with all wells

on the list now horizontal completions. Those identified have established economic production in a new reservoir or significantly extended production of a horizontal play that is already a major producer. To keep this listing to a manageable size, related or nearby wells were added to the discussion in some cases. Wells with some production history are given precedence over those with only impressive initial potential tests. The major Oklahoma horizontal plays, 2010 drilling, and the location of the notable wells discussed here are shown in Figure 9.

1) Sec. 34-3N-22ECM (Beaver County): Hadaway Engineering, above the sprawling Mocane-Laverne Field, extended horizontal Marmaton production with their Clyde 1-34H well. Completed in April 2010, this well is producing from a 6,589 - 10,633 ft lateral located at a true vertical depth (TVD) of 6,266 ft. After a one-stage fracture treatment of about 1.9 million pounds of sand the initial potential (IP) was 140 BO + 108 MCF + 1440 BWPD. In less than four months the Clyde has made 63 MBO + 18 MMCF with a rate in the last month of 222 BOPD - more than the I.P. Horizontal Marmaton production in Beaver County extends into the Texas Panhandle with ten of the 16 Oklahoma completions coming in 2010. A true oil play, the eight wells with reported production have already made 229 MBO and 83 MMCF. Horizontal Marmaton oil production was also established last year in Ellis County, making it possible that these two areas may eventually connect. Initial potentials in Ellis County range to almost 600 BOPD.

2) Sec. 19-29N-9W (Alfalfa County): In a major eastward extension of horizontal Mississippi Lime production on the Anadarko Shelf, SandRidge completed the 1-19H Victor. Completed in September 2010, this well does not yet have reported production. However, the initial potential is 421 BO + 3.1 MMCF + 3,957 BWPD. The productive lateral extends from 4,961 - 9,315 ft (TVD 4,855 ft) and was treated with about 800,000 pounds of sand. In this part of the horizontal Mississippi Lime play there are 21 wells with some reported production. These have produced 500 MBO and 2 BCF and about 60 BOPD per well.

3) Sec. 31-22N-4E (Pawnee County): Pablo Energy quietly pushed the Mississippi Lime horizontal play on to the Cherokee Platform with the drilling of their Ripley 1H-31 in 2008. With a completion that was registered in 2010, the well now shows a September 2008 initial potential of 94 BO + 1 MCF + 1009 BWPD and a retest one year later of 295 BO + 100 MCF + 785 BWPD. With still no reported production it is difficult to determine how good this well is, but it definitely set off a land rush in this part of the State. Pablo has since drilled additional wells: the Bruce 1H-32 one mile east (269 BO + 45 MCF + 1,238BWPD), and the Turkey Creek 1H-30 one mile north (145 BO + 167 MCF + 1,947 BWPD). Five miles west they are drilling the Gilbert 1H-32, which was spudded in November of last year, and one mile south the Larry 1H-6 has been permitted. Clearly the Ripley well gave Pablo a lot of encouragement. Produc-

ing 35 degree API crude, the Ripley was completed in a 4150-7054 ft lateral (TVD 3908 ft) and was treated with 1.4 million pounds of sand.

4) Sec. 27-19N-25W (Ellis County): In an area that is also being drilled horizontally for the Cleveland and the Marmaton, EOG Resources completed their 27-1H Max well in the Oswego flowing 730 BO (45 degree API) + 1,214 MCF + 179 BWPD. The well was completed in November last year and thus has no production history, but this IP makes it likely more such wells will be drilled in the future. Production is from an unfractured open-hole lateral extending from 9,410 – 13,354 ft at a TVD of 8,926 ft. Horizontal Oswego production has also been established by Unit Petroleum in the Oklahoma City Field, where multiple laterals are being drilled from the same pad within the city limits.

5) Sec. 22-19N-25W (Ellis County): In the same area EOG has expanded the width of the main horizontal Cleveland producing area by over five miles with the completion of their Wayland 22-1H. This well, the first horizontal well in the township, had an initial potential of 835 BO + 4.41 MMCF + 175 BWPD and in its first six months online has produced 48 MBO + 328 MMCF. In the last reported month the well was producing at a rate of 134 BOPD. Wells more distant from the main producing trend were drilled in 2010, but this one has sufficient production to confirm probable economic viability. The Wayland was completed in a lateral from 9,050-12,634 ft and treated with a single 1.5-million-pound fracture stimulation. TVD is 9,850 ft.

6) Sec. 23-16N-19W (Dewey County): Harding and Shelton expanded last year's satellite area of horizontal Cleveland production with the drilling of their Holcomb 1-14H. This well, which was completed in a lateral from 10,030 – 13,392 ft (TVD 9,585 ft), had an IP of 473 BO + 840 MCF + 404 BWPD. Average production in the first month was 1,069 BOPD. In its first six months online the Holcomb has produced 99 MBO and 98 MMCF with a rate in the last reported month of 293 BOPD. The Dewey/Custer County horizontal Cleveland area of production continues to expand, making it ever more likely that it will eventually continue through Roger Mills and Ellis Counties to link with the main play area. Based on current results production will not always be economic, but will probably consist of a series of WNW-trending linear 'sweet spots' that parallel sand deposition.

7) Sec. 4-17N-22W (Ellis County): Panther Energy completed the 2H-4 Pearlgirl as a horizontal Cottage Grove producer. A lateral from 8,915-12,156 ft (TVD 8,650 ft) was given a 14-stage fracture stimulation with 1.26 million pounds of sand and had an initial potential of 319 BO + 260 MCF + 33 BWPD. The well in seven months has produced 33 MBO + 10 MMCF at a rate in the last reported month of 120 BOPD. This is one of the many horizontal wells drilled in southern Ellis – northern Roger Mills Counties that have targeted the low-permeability sandstone/siltstone reservoirs

in this area. These include the Cherokee, Skinner, Marmaton, Cleveland, Cottage Grove and Tonkawa.

8) Sec. 31-12N-26W (Roger Mills County): In a major extension of the Desmoines horizontal Granite Wash play, Chesapeake has completed their Dowell 1-31H well on the Texas border. In yet another example of how initial potential tests can be misleading, its initial potential in May of last year, which was 3.231 MMCF + 4020 BWPD, is a third of its last reported rate of 9.8 MMCFPD. In less than two months it has produced 505 MMCF from a 12,949-17,565 ft (TVD 12,880 ft) lateral with no treatment reported. This well is about 50 miles west of the main producing area of the Desmoines Granite Wash located in north-central Washita County. With negligible condensate production, development in this area may now be put on hold, but there are clearly many more wells yet to be drilled before this wash play is fully developed.

9) Sec. 23-11N-23W (Beckham County): Another 'Granite Wash' completion was made by Apache with their Thetford 4-23H. Completed in a lateral from 11,380-15,501 ft (TVD 11,275 ft) and fractured with 1.9 million pounds of sand, the well had an initial potential of 2,043 barrels of 44 degree API oil + 3.87 MMCF + 210 BWPD. There is not yet any reported production. In another example of misleading nomenclature, the reservoir is called 'Hogshooter', making it likely a wash completion somewhere in the middle of the Missourian section. The Thetford lies in the center of an amalgamated horizontal granite wash play extending from eastern Washita County to the Texas border which includes reservoirs called Atoka, Skinner, Desmoines, Cherokee, Marmaton, Hoxbar, and now Hogshooter. Of note are two other Apache wells, the 1-5H Edler (Sec. 5-11N-20W), that had an initial potential from a Hoxbar Wash of 1,580 BO + 2,996 MCF + 574 BWPD and the Summers 3-24H (Sec. 13-11N-22W), which IPed for 10.1 MMCFPD from the Atoka (Wash). Like the Thetford, neither of these has reported production.

10) Sec. 20-1S-23W (Jackson County): GLB Exploration is building a natural gas pipeline in far southwestern Oklahoma in the Hollis Basin in order to begin production from their three new horizontal wells in the Duke Northeast Field. Pushing their infrastructure economics over the top is the Carol Sue 1-20 which was completed in late 2009. The second horizontal Atoka well in the Hollis Basin, this confirmation well is located two miles north of their horizontal Mitchell discovery in Section 32. From a TVD of 7,297ft and a productive lateral from 7,840-11,349 ft the well was fracture-stimulated with 525 thousand pounds of sand. It tested for 336 BC (50 Degree API) + 718 MCF + 345 BWPD. On an extended test the well produced about 14 MBC (gas was flared) and in the last full month produced at a rate of 214 BCPD. Combined with the Hatch, which was Oklahoma's first horizontal Barnett Shale well, the completion of this pipeline is expected to initiate a flurry of hori-

zontal drilling activity in this isolated and previously inactive part of the State.

**11)** Sec. 25-17N-16W (Dewey County): In a major (33-mile) northwestward extension of the horizontal Woodford play in the Anadarko Basin, Continental Resources completed the Doris 1-25H. Productive from a 13,269-16,827 ft lateral (TVD 12,740 ft) the well was fracture-stimulated with 2.1 million pounds of sand. After an initial potential of 4.64 MMCF + 1,193 BWP, it produced 294 MMCF and 1 MBC (57 degree API) in its first three months. It has produced at a flat 3.0 MMCFPD since going online. Other horizontal Woodford completions have been made on structural strike to the main Anadarko Basin productive area. These seem to be more liquids-rich, but none yet have any published production.

Continental reaped an indirect reward of deep Woodford drilling in this area (Sec. 4-16N-12W) when the vertical section of a horizontal well (1-4H Rother) ran into a Springer sand. This quickly led to its twinning with the 2-4 Rother, which was completed as a 3.1 MMCFPD vertical Springer well.

**12)** Sec. 19-5N-11E (Hughes County): An example of a Woodford Shale development technique being used by Newfield Exploration is the extended lateral. An excellent example is their David 1H-7E well, which is located in the center of the play in the Arkoma Basin and was completed in April 2010. On a drilling unit composed of two 'stand-up' 320-acre tracts, this well is producing from a lateral over 10,000 ft long (7,230-17,425 ft). Starting from a surface location located in Section 19, the lateral (TVD 7,160 ft) produces from Sections 18 and 7. The David was

fracture-stimulated in 18 stages with a total of 2.5 million pounds of sand (~140,000 pounds per stage). After an initial potential of 6,987 MCF + 3,335 BWP in its first five months it has produced 1,238 MMCF and continues at a rate of 6.2 MMCFPD in the last reported month.

**13)** Sec. 12-2N-11E (Coal County): In a demonstration that there is more to drill horizontally in the western Arkoma Basin than just the Woodford, Newfield Exploration completed their 7H-12 Ennis in the Cromwell. Completed in May 2010, it had an initial potential of 7,056 MCF + 719 BWP from a lateral at depths of 11,477-16,377 ft (TVD 10,750 ft). The well was fracture-stimulated with almost 3 million pounds of sand. A part of Ashland South Field, the Ennis in its first four months has produced 486 MMCF and continues in its last month at a rate of 3.75 MMCFPD. Thus far ten horizontal Cromwell wells have been drilled in the Arkoma Basin. These have combined cumulative production of 5.2 BCF at a rate of 7.1 MMCFPD.

**14)** Sec. 25-7N-16E (Pittsburg County): Petroquest Energy has helped push the Woodford Shale horizontal play east into the center of the Oklahoma part of the Arkoma Basin. With a surface location in Sec. 19-7N-17E and a bottom hole location in Sec. 25-7N-16E, their Carolyn 1-19H had an initial potential of 9,408 MMCF + 963 BWP. The well was completed from a lateral extending from 8,742-12,705 ft (TVD 8,229 ft) and fracture-stimulated using 3.1 million pounds of sand. In less than three months the well has produced 502 MMCF and continues at a rate of 6.8 MMCFPD. Clearly there is much room left to develop Woodford Shale gas.

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## ABOUT THE AUTHOR

Dan Boyd is a petroleum geologist with the Oklahoma Geological Survey, where he has been employed since 2001. Dan received his Master of Science degree in geology from the University of Arizona in 1978. He spent the first 22 years of his career as an exploration and development geologist in the petroleum industry in a variety of locations in the U.S. and overseas. Since joining the OGS staff Dan has presented and published several petroleum geological reports as well as a number on the history, status, and future outlook of the oil and gas industry in Oklahoma. He prepared and presented a workshop on the Booch gas play in southeastern Oklahoma and more recently performed a State-wide study of oil reservoirs and recovery efficiencies. This study demonstrates that large volumes of producible oil remain in the ground and that a major barrier to finding and producing this oil is shortcomings in State oil and gas data. Dan is an avid promoter of Energy Libraries Online (ELO) from a conviction that the long term success of the Oklahoma industry depends on improving both the completeness and accessibility of State oil and gas data.

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