Analysis of a Long Cane Creek Horizontal: New Insight into an Unconventional Tight Oil Resource Play, Paradox Basin, Utah*

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Abstract

A recent 5,600-ft Cane Creek horizontal well drilled by Whiting Oil & Gas provides new insight into the Cane Creek tight oil resource play in the northwestern Paradox Basin. The Threemile #43-18H well was drilled in early 2009, approximately 20 miles southeast of the Long Canyon, Bartlett Flat, and Big Flat producing fields. Sidewall cores from the vertical pilot hole showed good reservoir storage potential in dolomitic siltstone intervals with porosities of 8 to 13 percent, permeabilities between 10 and 50 microdarcies, and 20 to 35 percent water saturation. Interbedded mature source rocks sampled from this and the nearby Gibson Dome #1 well indicate a range of from nearly pure Type II kerogen to a mixture of Type II and Type III kerogen with up to 44 percent TOC.

Three hundred feet of salt overlying the Cane Creek and 80 plus feet of salt below provide the necessary top and bottom seals for the petroleum system and were viewed as potential hydraulic fracture barriers as well. Mud weights progressively increasing from 11.5 to 15 plus ppg were required during horizontal drilling, and a later DFIT analysis determined a formation pressure gradient of 0.938 psi/ft. Strong hydrocarbon shows during horizontal drilling included a steady flare up to 25 feet in length, oil over the shakers, and an overall 600 bbl pit gain. An uncedmented liner with swell packers was run in the horizontal wellbore and the Cane Creek was hydraulically fracture stimulated over eleven 500-foot stages, each with 110,000 pounds of proppant and 2,000 bbls of gel. Although the Threemile #43-18H well is producing oil and gas, it also produces a significant NaCl brine cut, an indication that the stimulation propagated into a nearby water-bearing zone. Several candidates for over-pressured water sources of unknown volumetrics were observed through cored salt sections in the Gibson Dome #1 well. Observations point to technological solutions as a key to the success of the Cane Creek tight oil resource play.
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ABSTRACT
A recent 5,600-foot Cane Creek horizontal drilled by Whiting Oil & Gas provides new insight to the Cane Creek tight oil resource play in the northwestern Paradox Basin. The Threemile # 43-18H was drilled in early 2009 approximately 20 miles southeast of the Long Canyon, Bartlett Flat and Big Flat producing fields.

Sidewall cores from the vertical pilot showed good reservoir storage potential in dolomitic siltstone intervals with porosities of 8 to 13 percent, permeabilities between 10 and 50 microdarcies, and to 35 percent water saturation. Analysis of interbedded mature source rocks sampled from this and a nearby well indicate a range from nearly pure Type II kerogen to a mixture of Type II and Type III kerogen with up to 44 percent TOC. Three hundred feet of salt overlying the Cane Creek and >80 feet of salt below provide the necessary top and bottom seals for the petroleum system and were viewed as potential hydraulic frac barriers as well. Mud weights progressively increasing from 11.5 to >15 ppg were required during drilling, and a later DFT analysis determined a formation pressure gradient of 0.938 psi/ft. Hydrocarbon shows during drilling included a steady flare up to 25 feet in length, oil over the shakers, and an overall 600 bbl pit gain.

An uncemented liner with swell packers was run in the horizontal wellbore and the Cane Creek was frac stimulated over eleven 500-foot stages, each with approximately 110,000 pounds of proppant and 2,000 barrels of water and acid. The stimulation resulted in a 107 bbl/ft of 50% 60/20 NPP oil and gas, it also produces a significant NaCl brine cut, an indication that the stimulation may have propagated into a nearby water-bearing zone. Several candidates for over-pressured water sources of unknown volumetrics were observed through salt sections in the continuously cored nearby Gibson Dome # 1 well. Observations from this core point to technological solutions as the key to success in the Cane Creek tight oil resource play.

CANE CREEK PLAY AREA
- The Cane Creek tight oil resource play area occurs along a 75 mi long, 10-20 mi wide NE-SW swath in the northern Paradox Basin (Grant & San Juan counties, UT) adjacent to the Deep Fold and Fault Belt (DFFB). The western limit of play area defined by maximum extent of salt beneath the Cane Creek. This is the basal seal of the hydrocarbon accumulation and, together with the top halite seal, is responsible for the near lithostatic overpressure in the reservoir.
- Eastern limit of play area defined by the western edge of the DFFB. This is a conventional limit, as the Cane Creek does occur within the DFFB, but in most sense it is either mixing in the salt with dissolved minerals or capped up in massive salt flowages in depths and anticlines.
- The Cane Creek "W" (cycle 220 siliciclastic) reservoir is present everywhere, ranging in thickness from 30 to >40 ft. It thins considerably to the NW and SE.
- The source is also present everywhere in the play area and is interbedded with reservoir siltstones.

SOURCE
- World-class source rocks – high TOC (up to 44%), pure Type II to mixed Type II-III kerogen, currently in the oil window.
- Source rocks interbedded with reservoir siltstones

RESERVOIR
- Dolomitic siltstones and silty dolomitic sandstones
- Porosities range from 8 to 13% and Permeabilities from 10 to 50 microdarcies.
- As good or better than the Middle Bakken or Thrusts.
- Good, even like to yellow UV fluorescence indicates good hydrocarbon saturation.
- Sur from 20-30% likely irreducible.
- Closely-spaced (110 to 1 cm) subvertical and additional subhorizontal fractures noted in several sidewall core samples; indicates brittle, fracture prone reservoir.
- Mineralogically, there are very low proportions of problematic minerals; calcite and dolomite are 1% or less; Illite is mostly detrital and the "Illite in mixed-layer Illite/smectite is very low, pyrite is ~1% to 5% or less.

SEAL & TRAP
- Salt above and below the Cane Creek interval forms an excellent seal.
- Low reservoir permeability results in progressive reservoir saturation with little opportunity for regional lateral migration.
**VERTICAL SECTION**

**DRILLING OVERVIEW**
- σ\(_1\)h determined from image logs in the Threemile vertical pilot and
- VERY unusual for Cane Creek producers which usually make < 10% water cut
- Steered at top of Cane Creek “B” siltstone with black carbonaceous mudstone above and 2’ anhydrite below as marker beds
- Stayed in 4-6” hole for 93% of horizontal
- Must weight continually reamed over length of horizontal from 11.54 (0.59 psi/ft) to 15.34 (0.98 psi/ft) to keep well from flowing
- Must gas continually increased over length of horizontal. Oil over shakers @ 0.300. Steady 20-25’ Flare and well attempting to flow during final 500’ of drilling
- A job gain of 800 Bbl was noted after drilling completed
- Horizontal TD @ 13,474' on 4/11/2009
- Max 5,600’ in Cane Creek
- Longest Cane Creek horizontal drilled to date by 2x
- Avoiding structurally complex areas and steering the horizontal
- Is it possible that the Cane Creek matrix is wet? Not likely
- Unlikely — A continuously cored interval from the nearby Gibson Dome #1 suggests that there is no interval in the Lower Hermosa capable of producing water and the large number of shales in the Lower Hermosa would be a major barrier to any fracture that might propagate into the underlying salt. The water appears to be on a linear decline (fracture drainage) and the oil on a hyperbolic decline (matrix drainage)
- One possibility is that this water is coming from the microfracture network within the Cane Creek. However, observed features appear to be healed and not wet

**WHAT ABOUT THE SALT?**
- Salt can be an excellent (perfect?) seal, but is it capable of producing large volumes of water? Is it a frac barrier, or will it frac?

**MEASURED DEPTH**

**TERMINAL SUMMARY**

**WHAT ARE THE TAKE AWAY POINTS / CONCLUSIONS**
- The Cane Creek petroleum system has all of the hallmarks of a pervasive tight oil accumulation
- The reservoir is overpressured, has low permeability, and is encountered with world-class type-closing source rocks that are currently in the oil window
- Excellent hydrocarbon shows while drilling the Threemile #43-18H indicate a HC saturated reservoir
- As horizontal length (>5x) increased, greater mud weight was required to hold back ever-increasing mud gas, well attempting to flow during final 500’ of drilling and overall 600 Bbl mud gain was noted post-drilling
- The Threemile #43-16H was successfully frac stimulated over 11 stages using plug & perf method with approximately 115,000 Bbl sand and 2,000 Bbl cross-link gel per stage
- A significant NaCl water cut unusual for the Cane Creek is currently being produced along with oil and gas
- Water production is on a linear decline and indicates fracture-like drainage, while oil appears to be on a hypothetic decline, indicating reservoir matrix drainage
- Salt 25-30’ above the horizontal target is a possible source of water.
- Numerous large, open vugs were observed in coarsely-crystalline salt in the nearby Gibson Dome #1; these were likely over-pressured and capable of producing an unknown volume of brine if connected to the production interval
- Future success of the Cane Creek tight oil resource play may involve a combination of long horizontals and a modified completion design; work on the Threemile #43-16H to minimize water production is ongoing