**ABSTRACT**

Tanos Exploration II, LLC (Tanox) along with partner Breitburn Energy Partners (Breitburn) conducted a microseismic survey in 2015 at Overton Field, Smith and Cherokee counties, Texas. The survey was acquired in two horizontal wells drilled in opposite directions (north and south) from the same surface pad. Both wellbores targeted the same stratigraphic interval within the Taylor sandstone of the Jurassic-aged Cotton Valley formation. Stimulation spacing, perforation clusters, pump rates and proppant concentrations were fairly consistent between wells. The McElroy-Swann #1H, the northern lateral, was drilled between twelve existing vertical wells that were completed with single stage fracture stimulations over the entire Taylor interval approximately 10 yr earlier. In contrast the southern lateral, the Wilkinson-McElroy A #1H was drilled within a relatively undrained area of the field. The survey was conducted to compare and contrast the fracture stimulation results for the two wells, one drilled within “partially-drained” versus one drilled within “undrained” areas of the field.

The McElroy-Swann #1H was drilled with a total displacement of 6640 ft and an effective lateral length (first perforation to last perforation) of 5803 ft along a 358° azimuth to a total depth of 17,999 ft. Completion design utilized 5½ in. P110 casing cemented in place and a “plug and perf” methodology with three or four perforation clusters sixty feet apart per stage. The existing vertical wells ranged from 410 to 1265 ft away from the horizontal wellbore. Cumulative production from the existing vertical wells totaled over 4.6 billion cubic ft (BCF) of gas and 98,650 barrels of condensate (BC) (5.2 BCFE [BCF gas equivalent]). The microseismic event mapping for the northern lateral indicated the original stress field of the Taylor sandstone reservoir had been significantly altered by the fracture stimulations and associated production from the vertical wells. Instead of “well-behaved,” predictable fracture propagation along a consistent orientation, results indicated a “random” orientation with different widths and half-lengths resulting in highly complex fracture patterns.

The Wilkinson-McElroy A #1H was drilled with a total displacement of 7253 ft and an effective lateral length of 6433 ft along a 169° azimuth to a total depth of 18,600 ft. Plug and perf methodology within 5½ in. casing was employed as above. In contrast to...
the McElroy-Swann #1H, the southern horizontal wellbore drilled through a relatively undrained area of the field. Three wells along the wellbore, all completed in 2004, had produced less than one BCFE of gas combined. The Wilkinson-McElroy A #1H results indicated a more predictable fracture propagation orientation consistent with an earlier 2005 study at Overton Field.
A MICROSEISMIC CASE STUDY: COTTON VALLEY TAYLOR SANDSTONES, OVERTON FIELD
- Haynesville Lime discovered in 1974
- Cotton Valley Taylor Sands discovered in 1978
- Field development accelerated after Southwestern acquisition- 388 wells drilled from 2001 to 2005
- Cumulative Production > 530 BCF & 4.7 MMBC from Taylor Sands
- Currently over 600 active wells still producing in the field
- Gross Taylor interval averages 350 ft. in thickness across the field
- Condensate yields range from < 5 BC/MM to > 50 BC/MM in the field
- 1st horizontal well drilled in 2005, study wells drilled in 2015
Williams, et al (2001) established a detailed sequence-stratigraphic interpretation of the Cotton Valley/Bossier depositional history. The Taylor sandstones are present in the BSB2 sequence, interpreted as part of a lowstand prograding complex that graded basinward into a predominantly shaly Bossier lithology.
STRUCTURE MAP
T/TAYLOR LIME

- Cotton Valley (Haynesville) Lime producers in blue
- Deepest Taylor production in the East TX Basin, produces at depths > 12,000
- Avg. porosity 8%, permeability 0.005 md & 27% Sw. Slightly overpressured @ 0.60 psi/ft
- First horizontal well drilled by J-W Operating in 2005 (red star), Mud Creek #2H (red triangle)
- Horizontal wells in this study identified by red laterals
Taylor sands generally perforated in L1-L3 + L4 when present and fracture stimulated in a single stage for most vertical wells in the field.

- Gross thickness ranges from 250 – 350 ft.
- L-4 generally present over the western half of the field and the best producing interval.
- Taylor Lime provides a good barrier inhibiting upward frac growth, however some of the 80 bbl/min. frac jobs broke through this barrier in the vertical wells.
- L-2 was target sand for both horizontal wells (red arrow).
Mayerhofer, et al. (2005) concluded symmetric fracture wing lengths of 1,550 ft. on each side of the wellbore in a N71°E azimuth, resulting in elongated “cigar-shaped” 27 acre drainage ellipses. Production interference was noted in wells as far as 2,450 ft. away along the fracture orientations.

Mud Creek #2H targeted the L-4 sand & mapping displayed more oval and egg-shaped stimulation areas encompassing ~10 acres. Stage 2 asymmetry infers a pressure sink around the producing Wilson #15.
McElroy-Swann #1H Horizontal Well

- McElroy-Swann #1H was drilled with an ELL of 5,803 ft. and completed with 20 frac stages utilizing plug and perf methodology in 5 ½” casing.
- The well was drilled between 12 vertical wells that had produced 4.6 BCF & 98,650 BC (5.2 BCFE) from the Taylor sands.
- Wells ranged from 410 to 1,265 ft. from horizontal lateral, M-G-W #1H drilled later.
- 12 vertical completions occurred from 2003 to 2006, with 9 wells completed during a 24 month span from 2005 to 2006.
- Pre-drill analysis calculated inefficient drainage from the existing vertical wells. Drainage ellipses were assumed to be oriented N71°E, consistent with the vertical microseismic study.
McElroy-Swann #1H (North Lateral) Microseismic Results

- Perfs and stimulated reservoir volume (SRV) for the 10 monitored stages are shown in alternating black and red colors. Lines through each stage indicate the mapped azimuth in comparison to the N71°E azimuth.

- Microseismic indicated the entire Taylor interval was stimulated.

- Results indicate the original stress field of the reservoir had been significantly altered by the fracture stimulations of the original vertical wells.

- The result is a highly complex fracture pattern characterized by frac azimuths that vary by 70°, varied widths and half lengths & overlapping stimulation areas.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Events</th>
<th>Azimuth (degrees)</th>
<th>Half Length East(ft)</th>
<th>West(ft)</th>
<th>Width (ft)</th>
<th>Avg Perf-Receiver Distance(ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>146</td>
<td>N100°E</td>
<td>671</td>
<td>591</td>
<td>470</td>
<td>1414</td>
</tr>
<tr>
<td>2</td>
<td>183</td>
<td>N95°E</td>
<td>460</td>
<td>477</td>
<td>647</td>
<td>1157</td>
</tr>
<tr>
<td>3</td>
<td>195</td>
<td>N90°E</td>
<td>455</td>
<td>465</td>
<td>577</td>
<td>1089</td>
</tr>
<tr>
<td>4</td>
<td>124</td>
<td>N60°E</td>
<td>513</td>
<td>425</td>
<td>614</td>
<td>1089</td>
</tr>
<tr>
<td>5</td>
<td>216</td>
<td>N45°E</td>
<td>392</td>
<td>182</td>
<td>499</td>
<td>982</td>
</tr>
<tr>
<td>6</td>
<td>173</td>
<td>N45°E</td>
<td>293</td>
<td>382</td>
<td>586</td>
<td>980</td>
</tr>
<tr>
<td>7</td>
<td>184</td>
<td>N30°E</td>
<td>575</td>
<td>550</td>
<td>597</td>
<td>1093</td>
</tr>
<tr>
<td>8</td>
<td>174</td>
<td>N60°E</td>
<td>576</td>
<td>571</td>
<td>475</td>
<td>1243</td>
</tr>
<tr>
<td>9</td>
<td>121</td>
<td>N50°E</td>
<td>460</td>
<td>393</td>
<td>426</td>
<td>1657</td>
</tr>
<tr>
<td>10</td>
<td>121</td>
<td>N65°E</td>
<td>579</td>
<td>574</td>
<td>542</td>
<td>1897</td>
</tr>
</tbody>
</table>
Wilkinson-McElroy-A- #1H Horizontal Well

SOUTHERN LATERAL

- Wilkinson-McElroy-A- #1H was drilled with an ELL of 6,433 ft. and completed with 24 frac stages utilizing plug and perf methodology in 5 ½” casing.

- In contrast to the McElroy-Swann #1H, the southern lateral was drilled in a relatively undrained section of Overton field.

- The 2 vertical wells near the mapped well path were drilled in 2004 and had produced less than 0.5 BCF combined. The 3 offsetting horizontal wells were drilled after the monitored well.

- Pre-drill analysis calculated insignificant drainage risk from the existing vertical wells. Drainage ellipses were again assumed to be oriented N71°E.
Perfs and stimulated reservoir volume (SRV) for the 11 monitored stages are shown in alternating black and red colors. Lines through each stage indicate the mapped azimuth in comparison to the N71°E azimuth.

Microseismic indicated the entire Taylor interval was stimulated.

Mapped azimuths more closely aligned to the Mayerhofer, et al. study.

Fracture mapping reflected complex stimulation results with overlapping stages and asymmetric wing lengths when completing in an undrained area of the field.
## Fracture Stimulation Stage Statistics

<table>
<thead>
<tr>
<th>McElroy-Swann #1H</th>
<th>Stage Interval (feet)</th>
<th>Prop. Pumped (lbs.)</th>
<th>Fluid pumped (Bbls.)</th>
<th>Avg. Rate (Bbl./min.)</th>
<th>Prop. Con. #/ft.</th>
<th>Clusters/stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>17750-17941</td>
<td>191</td>
<td>222960</td>
<td>7458</td>
<td>71</td>
<td>1167</td>
</tr>
<tr>
<td>2</td>
<td>17471-17697</td>
<td>226</td>
<td>228040</td>
<td>8520</td>
<td>71</td>
<td>1009</td>
</tr>
<tr>
<td>3</td>
<td>17218-17408</td>
<td>190</td>
<td>229000</td>
<td>7561</td>
<td>71</td>
<td>1205</td>
</tr>
<tr>
<td>4</td>
<td>16970-17150</td>
<td>180</td>
<td>227820</td>
<td>7710</td>
<td>71</td>
<td>1266</td>
</tr>
<tr>
<td>5</td>
<td>16700-16891</td>
<td>191</td>
<td>217060</td>
<td>7500</td>
<td>73</td>
<td>1136</td>
</tr>
<tr>
<td>6</td>
<td>16440-16598</td>
<td>158</td>
<td>258740</td>
<td>11277</td>
<td>80</td>
<td>1638</td>
</tr>
<tr>
<td>7</td>
<td>16150-16376</td>
<td>226</td>
<td>218200</td>
<td>7690</td>
<td>80</td>
<td>965</td>
</tr>
<tr>
<td>8</td>
<td>15806-16075</td>
<td>269</td>
<td>221900</td>
<td>7578</td>
<td>81</td>
<td>825</td>
</tr>
<tr>
<td>9</td>
<td>15381-15527</td>
<td>146</td>
<td>221240</td>
<td>7662</td>
<td>81</td>
<td>1515</td>
</tr>
<tr>
<td>10</td>
<td>15132-15319</td>
<td>187</td>
<td>218900</td>
<td>7459</td>
<td>81</td>
<td>1171</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Wilkinson-McElroy-A- #1H</th>
<th>Perf. Depths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage</td>
<td>Perf. Depths</td>
</tr>
<tr>
<td>1</td>
<td>18335-18543</td>
</tr>
<tr>
<td>2</td>
<td>18085-18263</td>
</tr>
<tr>
<td>3</td>
<td>17850-18024</td>
</tr>
<tr>
<td>4</td>
<td>17585-17768</td>
</tr>
<tr>
<td>5</td>
<td>17330-17520</td>
</tr>
<tr>
<td>6</td>
<td>16988-17251</td>
</tr>
<tr>
<td>7</td>
<td>16745-16931</td>
</tr>
<tr>
<td>8</td>
<td>16449-16623</td>
</tr>
<tr>
<td>9</td>
<td>16130-16303</td>
</tr>
<tr>
<td>10</td>
<td>15880-16068</td>
</tr>
<tr>
<td>11</td>
<td>15630-15748</td>
</tr>
</tbody>
</table>
HORIZONTAL PRODUCTION

- Lower reservoir pressure resulted in lower flush production of almost 1/2 the W-M-A #1H gas & 2.5X less oil
- IP is 1.22 MMCF/1000’ & EUR is 1.51 BCF/1,000’
- Shallower decline yields better EUR- 1.58 b factor
- Cum. Prod: 2.3 BCF & 51,600 BC- 22 BC/MM yield
- Current daily prod: 1.3 MMCF/D & 17 BC
- EUR: 8.2 BCF & 97,500 BC (8.8 BCFE)- 12 BC/MM yield

- First flush month of production almost 2X the M-S #1H gas & over 2.5X oil
- IP is 2.31 MMCFE/1000’ & EUR is 1.12 BCFE/1,000’
- Steeper decline yields lower EUR- 1.08 b factor
- Cum. Prod: 3.3 BCF & 114,300 BC- 34 BC/MM yield
- Current daily prod: 1 MMCF/D & 27 BC
- EUR: 6.2 BCF & 173,000 BC (7.24 BCFE)- 28 BC/MM yield
CONCLUSIONS

**McElroy-Swann #1H- Northern Lateral**

Microseismic mapping indicated the original reservoir stress field had been significantly altered by the earlier vertical completions, resulting in complex and more compact stimulations.

Drilled between 12 vertical wells drilled 9-10 years earlier completed with fracture stimulations in the same reservoir.

Pre-drill analysis indicated inefficient drainage from vertical wellbores, but with the risk of sufficient remaining reservoir pressures.

Maximum observed flowback pressures were ~1350# less than the southern lateral, indicating reservoir drawdown after 10 years of vertical production.

Partial depletion reduces IP rates, but drilling in a higher OGIP area yields a higher EUR.

**Wilkinson-McElroy-A- #1H- Southern Lateral**

Microseismic mapping indicated fracture azimuths consistent with the earlier vertical study, longer frac half lengths and wider stimulated areas.

Drilled in a relatively undrained area of the field- 3 vertical wells completed in the same reservoir 11 years prior with marginal results (<1 Bcf total cum.).

Pre-drill analysis indicated no depletion risk, but a deliverability risk associated with poor vertical production.

No reservoir pressure drawdown results in higher IP rates from the undrained area, but a lower EUR reflective of lower OGIP estimates.
Bonus Slide detailing upward & downward frac growth

Stage 1
Stage 2
Stage 3
Monitor Well
Stage 4
Stage 5
Stage 6
Stage 7
Stage 8
Stage 9
Stage 10

381’ Upward Growth

92’ Downward Growth

381' Upward Growth

92' Downward Growth
ACKNOWLEDGEMENTS

The authors would like to thank Tanos Exploration II and Breitburn Operating, now a subsidiary of Maverick Natural Resources, for permission to publish the proprietary microseismic results. Jeremy McLeod provided engineering expertise and a sounding board for EUR discussions. Jason Barfield supplied drafting expertise and help with the many graphic formats that constantly remind me that I am a geologist. I would be negligent if I did not give credit to Monty Merecka for initially proposing the microseismic surveys and championing the cause until the end.
REFERENCES


