Shallow Woodford Shale Gas Play in NE Oklahoma

Oklahoma Gas Shale Conference

Presented by

John Coates

October 22, 2008
Outline

- Area of activity
- Type log
- Geochemistry
- Production Data
- Drilling and completion
- Production practices
- Pipeline project
- Summary
Wagoner County Woodford Activity

Over 100 Wells Drilled

Mistletoe Pipeline

R-900 Pipeline
Woodford Shale – Type GR/Density Log

Caney/Fayetteville Shale

Woodford Shale

Arbuckle
Geochemistry

- Gas composition
- Isotope geochemistry
- Thermal maturity
- Total organic content (TOC)
Gas Composition

High CH₄, Some CO₂ and BTU~1,000
Similar to Antrim Gas

<table>
<thead>
<tr>
<th>HGS No.:</th>
<th>Well Name</th>
<th>Methane (C₁)</th>
<th>Ethane (C₂)</th>
<th>Propane (C₃)</th>
<th>Carbon Dioxide (CO₂)</th>
</tr>
</thead>
<tbody>
<tr>
<td>07-4726-200637</td>
<td>McCollough 17-1</td>
<td>95.7</td>
<td>0.9</td>
<td>0.0</td>
<td>2.74</td>
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<tr>
<td>07-4726-200639</td>
<td>McCollough 17-2</td>
<td>95.6</td>
<td>0.9</td>
<td>0.0</td>
<td>2.77</td>
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<tr>
<td>07-4726-200640</td>
<td>McCollough 17-2</td>
<td>95.7</td>
<td>0.9</td>
<td>0.0</td>
<td>2.68</td>
</tr>
</tbody>
</table>

Non-Hydrocarbon Gas Composition (%)

<table>
<thead>
<tr>
<th>Sample Id.</th>
<th>Gas units</th>
<th>He %</th>
<th>H₂ %</th>
<th>Ar %</th>
<th>O₂ %</th>
<th>N₂ %</th>
<th>CO %</th>
<th>Specific Gravity</th>
<th>BTU</th>
</tr>
</thead>
<tbody>
<tr>
<td>McCollough 17-1</td>
<td>50 PSIG</td>
<td>0.005</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.61</td>
<td>0</td>
<td>0.587</td>
<td>987</td>
</tr>
<tr>
<td>McCollough 17-2</td>
<td>50 PSIG</td>
<td>0.006</td>
<td>0.004</td>
<td>0.007</td>
<td>0.008</td>
<td>0.71</td>
<td>0</td>
<td>0.588</td>
<td>986</td>
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<td>McCollough 17-2</td>
<td>185 PSIG</td>
<td>0.007</td>
<td>0.000</td>
<td>0.006</td>
<td>0.005</td>
<td>0.69</td>
<td>0</td>
<td>0.588</td>
<td>987</td>
</tr>
</tbody>
</table>
Only Woodford Shale is “Dry Gas”

<table>
<thead>
<tr>
<th>Median Depth (ft)</th>
<th>SUM of C2, C3, i-C4, n-C4</th>
<th>C2 / C1</th>
<th>i-C4 / n-C4</th>
<th>C1 / C1-C4</th>
<th>GWR C2...C5 / C1...C5 x 100</th>
<th>LHR C1+C2 / C3+C4+C5</th>
<th>OCQ C4+C5 / C3</th>
</tr>
</thead>
<tbody>
<tr>
<td>923</td>
<td>67.0</td>
<td>0.934</td>
<td>0.2</td>
<td>0.279</td>
<td>73.38</td>
<td>1</td>
<td>0.7</td>
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<tr>
<td>953</td>
<td>66.5</td>
<td>0.961</td>
<td>0.2</td>
<td>0.279</td>
<td>73.43</td>
<td>1</td>
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<tr>
<td>985</td>
<td>65.0</td>
<td>0.917</td>
<td>0.2</td>
<td>0.307</td>
<td>70.36</td>
<td>1</td>
<td>0.6</td>
</tr>
<tr>
<td>995</td>
<td>60.1</td>
<td>0.807</td>
<td>0.2</td>
<td>0.377</td>
<td>63.13</td>
<td>2</td>
<td>0.5</td>
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<tr>
<td>1005</td>
<td>57.2</td>
<td>0.725</td>
<td>0.2</td>
<td>0.409</td>
<td>59.98</td>
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<td>0.5</td>
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<tr>
<td>1025</td>
<td>62.9</td>
<td>1.019</td>
<td>0.3</td>
<td>0.357</td>
<td>64.79</td>
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<tr>
<td>1035</td>
<td>53.8</td>
<td>0.725</td>
<td>0.2</td>
<td>0.452</td>
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<td>0.4</td>
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<tr>
<td>1173</td>
<td>34.7</td>
<td>0.209</td>
<td>0.2</td>
<td>0.645</td>
<td>36.35</td>
<td>3</td>
<td>0.4</td>
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<tr>
<td>1185</td>
<td>35.7</td>
<td>0.125</td>
<td>0.3</td>
<td>0.622</td>
<td>39.82</td>
<td>2</td>
<td>0.9</td>
</tr>
<tr>
<td>1195</td>
<td>24.9</td>
<td>0.069</td>
<td>0.3</td>
<td>0.734</td>
<td>29.47</td>
<td>3</td>
<td>1.4</td>
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<tr>
<td>1205</td>
<td>0.5</td>
<td>0.005</td>
<td>0.7</td>
<td>0.995</td>
<td>0.51</td>
<td>1623</td>
<td>1.3</td>
</tr>
<tr>
<td>1215</td>
<td>0.4</td>
<td>0.003</td>
<td>0.4</td>
<td>0.996</td>
<td>0.39</td>
<td>2413</td>
<td>1.1</td>
</tr>
<tr>
<td>1225</td>
<td>0.3</td>
<td>0.003</td>
<td>0.3</td>
<td>0.997</td>
<td>0.35</td>
<td>2346</td>
<td>1.7</td>
</tr>
</tbody>
</table>

GWR = gas wetness index  
LHR = light-to-heavy ratio  
OCQ = oil character qualifier

< 0.5 dry gas; 0.5-17.5 gas; 17.5-40 oil; > 40 residual oil  
LHR > 100 - dry gas; < 100 condensate/oil  
< 0.5 gas potential; > 0.5 gas/light oil potential
Isotope Geochemistry

Biogenic Component to Woodford Gas

- Bacterial Gas
- Mixed Bacterial-Thermogenic Gas
- Oil Associated Gas
- Post Mature Dry Gas
- Condensate Associated Gas
Characterization of Gases by Carbon Isotopic Ratios

- Modified after Schoell, 1983

Isotope Geochemistry
Thermal Maturity is in the Oil Zone
Production History

- 2 years of production is now available for some wells

- Observed well production is consistent with a desorption driven reservoir (e.g. Antrim Shale)
  - Good initial gas and water rates
  - Gas inclines as dewatering progresses
  - Flattening followed by gradual decline in gas rate
### 3rd Party Well – Over 1 Year Production History

<table>
<thead>
<tr>
<th>Field</th>
<th>Operator</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lease Name</td>
<td>PUN</td>
<td>Reporting Entity</td>
</tr>
<tr>
<td></td>
<td>14511971300000</td>
<td>OTC</td>
</tr>
<tr>
<td>Wells</td>
<td>Cumulative (since 1979)</td>
<td></td>
</tr>
<tr>
<td>35-145-2966(19-4C)</td>
<td>44 MMCF</td>
<td></td>
</tr>
</tbody>
</table>

**Gas Production**

Monthly Production Volume (Logarithmic) vs. Time

**PUN:** 14511971300000 - Wagoner County, Oklahoma

- **Peak Production:** 110 Mcfd

© 2006 Drillinginfo, Inc.
3rd Party Wells

Field: UNKNOWN (UNION VALLEY-CROMWELL, WOODFORD)
Operator: Wagoner County, Oklahoma
Location: PUN 14511865500000
Reporting Entity: OTC
Cumulative (since 1979): 91 MMCF; 133 BO


Monthly Production in a Table or download DRI Version 2 Format (PHDWin users) or, for compatibility with older programs, you can download Older DRI Version 1 Format or give me help on downloading files.

Gas and Condensate Production

Monthly Production Volume (Logarithmic) vs. Time
PUN: 14511865500000 - Wagoner County, Oklahoma

3 Wells @ 90 Mcfd/well
## Coronado’s Production Test Summary

<table>
<thead>
<tr>
<th>Well Name</th>
<th>Well Cost ($)</th>
<th>Peak Rate (Mcfd)</th>
<th>Water (BWPD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>McCollough 17-2</td>
<td>173,170</td>
<td>422</td>
<td>188</td>
</tr>
<tr>
<td>McCollough 17-1</td>
<td>184,921</td>
<td>400</td>
<td>332</td>
</tr>
<tr>
<td>Coronado 18-3</td>
<td>158,050</td>
<td>353</td>
<td>391</td>
</tr>
<tr>
<td>Showman 17-2</td>
<td>125,206</td>
<td>347</td>
<td>308</td>
</tr>
<tr>
<td>Essary 7-1</td>
<td>136,394</td>
<td>342</td>
<td>319</td>
</tr>
<tr>
<td>Gaither 7-1</td>
<td>160,557</td>
<td>313</td>
<td>237</td>
</tr>
<tr>
<td>Johnson 8-2</td>
<td>137,722</td>
<td>308</td>
<td>203</td>
</tr>
<tr>
<td>Chase 8-2</td>
<td>243,276</td>
<td>280</td>
<td>245</td>
</tr>
<tr>
<td>George 17-1</td>
<td>199,243</td>
<td>275</td>
<td>217</td>
</tr>
<tr>
<td>Coronado 18-5</td>
<td>210,703</td>
<td>260</td>
<td>272</td>
</tr>
<tr>
<td>Coronado 18-4</td>
<td>154,218</td>
<td>224</td>
<td>257</td>
</tr>
<tr>
<td>Showman 17-1</td>
<td>160,889</td>
<td>222</td>
<td>179</td>
</tr>
<tr>
<td>Chase 8-1</td>
<td>140,367</td>
<td>214</td>
<td>264</td>
</tr>
<tr>
<td>Tibbs 7-1</td>
<td>178,807</td>
<td>186</td>
<td>225</td>
</tr>
<tr>
<td>Miller 17-3</td>
<td>161,600</td>
<td>178</td>
<td>227</td>
</tr>
</tbody>
</table>
## Coronado’s Production Test Summary

<table>
<thead>
<tr>
<th>Well Name</th>
<th>Well Cost ($)</th>
<th>Peak Rate (Mcf/24h)</th>
<th>Water (BWP/Day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Edwards 8-1</td>
<td>141,116</td>
<td>150</td>
<td>97</td>
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<tr>
<td>McCollough 17-3</td>
<td>537,110</td>
<td>146</td>
<td>156</td>
</tr>
<tr>
<td>Tracy 20-1</td>
<td>187,271</td>
<td>142</td>
<td>255</td>
</tr>
<tr>
<td>Coronado 18-2</td>
<td>170,747</td>
<td>112</td>
<td>263</td>
</tr>
<tr>
<td>Methvin 7-1</td>
<td>143,941</td>
<td>82</td>
<td>89</td>
</tr>
<tr>
<td>Johnson 7-1</td>
<td>195,822</td>
<td>70</td>
<td>142</td>
</tr>
<tr>
<td>Chrisman 21-1</td>
<td>177,860</td>
<td>61</td>
<td>640</td>
</tr>
<tr>
<td>Coronado 18-7</td>
<td>139,641</td>
<td>39</td>
<td>230</td>
</tr>
<tr>
<td>Ternes 8-2</td>
<td>168,413</td>
<td>32</td>
<td>58</td>
</tr>
<tr>
<td>Coronado 18-6</td>
<td>174,069</td>
<td>32</td>
<td>256</td>
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<tr>
<td>Thompson 12-1</td>
<td>154,729</td>
<td>29</td>
<td>11</td>
</tr>
<tr>
<td>Edwards 8-2</td>
<td>162,622</td>
<td>29</td>
<td>199</td>
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<tr>
<td>Berry 13-1</td>
<td>186,699</td>
<td>26</td>
<td>246</td>
</tr>
<tr>
<td>Gillin 20-2</td>
<td>489,494</td>
<td>21</td>
<td>250</td>
</tr>
<tr>
<td>Johnson 8-1</td>
<td>191,263</td>
<td>11</td>
<td>146</td>
</tr>
<tr>
<td>Staner 29-1</td>
<td>198,972</td>
<td>11</td>
<td>35</td>
</tr>
<tr>
<td><strong>Average w/ all Wells</strong></td>
<td><strong>191,771</strong></td>
<td><strong>172</strong></td>
<td><strong>224</strong></td>
</tr>
</tbody>
</table>
Woodford Shale Dewatering

Initial
- Fluid level – high
- Water rate - high
- Gas rate – zero/minimal
- Casing psi – low pressure

Dewatering
- Fluid level – dropping
- Water rate – steady
- Gas rate – increasing
- Casing psi – increasing

Pumped Down
- Fluid level – at perfs
- Water rate – dropping
- Gas rate – maximum
- Casing psi – maximum
McCollough 17-2

422 Mcfd

From 10/08/2007 00:00 To 02/15/2008 00:00
Edwards 8-1

From 10/01/2007 00:00 To 02/15/2008 00:00

150 Mcfd

Date

MCF, PSI

BBLs

Water (BWPD)  Gas (MCF)  CP (PSI)
McCollough 17-1

From 10/15/2007 00:00 To 01/15/2008 00:00

401 Mcfd

Date

0 1 10 100

0 1 10 100

MCF, PSI

BBLs

Water (BWPD)  Gas (MCF)  Oil (BOFD)  CP (PSI)
Chase 8-2

280 Mcfd
Chrisman 21-1

From 12/15/2007 00:00 To 03/15/2008 00:00

640 Bpd
61 Mcfd
Reserve Potential

The Antrim Shale is the analog to assess reserve potential in the play.
Antrim Shale Decline Curves

- High Permeability
- Early Peak Rates

2008 Cum = 12 Bcf: ~0.5 Bcf/Well

- 24,000 Mcf/Mo
- 32 Mcfd/Well
- 1,000 B/Mo
Antrim Shale Decline Curves

- Lower Permeability

2008 Cum 21.5 Bcf: ~0.3 Bcf/well

94,500 Mcf/mo

8,000 B/mo

51 Mcfd/well
Drilling

- Air rigs
- 2 days per well
- 120 feet of surface pipe
- 7 7/8” hole to TD
- Cement 5 1/2” casing to surface
- TD with 200 feet of rat hole
Completion

- Cased, perforated and fracture stimulated
  - 15% HCL
  - Resin coated sand
  - N₂ 70/30 quality foam

- 2 open hole horizontal wells drilled
  - Promising results – no horizontal fracs to date
Production Practices

- Utilize electric submersible pumps (ESP) with surface controllers
- Lowering and monitoring fluid level important
- Lifting water efficiently is key
- Dispose of water in Arbuckle injection wells
Well Location
Water Disposal Facility
Gas Transportation

Built a 26 mile pipeline connected to R-900
Gas Transportation

Pipe is 12” Steel (900 psi) and 16” Poly (90psi)
Gas Transportation

Compressor Station Takes 90 psi Line to 900 psi - Amine Unit for CO₂
Summary

- Appears to be a desorption driven system – dewatering results in inclining gas rates
- Average observed well rates (>150 Mcfd) are highly economic at current well costs
- Biogenic component to gas
- Convenient water disposal in the Arbuckle
- Large pipeline project completed
- Antrim Shale analog - Typical Reserves (0.3-0.5 Bcf/well)