SPE DISTINGUISHED LECTURER SERIES

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SPE DL Talks 2006

- Sep 11  Tomsk Section, Russia
- Sep 12  Moscow Section, Russia
- Sep 13  Nizhnevartovsk Section, Russia
- Sep 14  Western Siberia, Noyabrsk, Russia
- Sep 18  Volga Section, Almetyevsk, Russia
- Sep 21  Aktau Section, Kazakhstan
- Sep 22  BP Baku, Azerbaijan
- Oct 18  Midland Texas
SPE DL Talks 2007

- Jan 10  Houston, SPE Drilling Study Group
- Feb 21  Denver, Colorado
- Feb 22  Billings, Montana
- Mar 11  Dubai, UAE
- Mar 12  Abu Dhabi, UAE
- Mar 14  Cairo, Egypt
- Mar 16  Tunis, Tunisia
SPE DL Talks 2007

- Apr 9  Michigan Section, Lansing, Michigan
- Apr 11 Bridgeport, West Virginia
- Apr 12 Charleston, West Virginia
- May 14 Trans-Pecos Section, Odessa Texas
- May 15 Arkansas Section, Fort Smith Arkansas
- May 16 Mid Continent Section, Tulsa, Oklahoma
- May 17 Oklahoma City Section, Oklahoma, City

22 Talks Total
Formation Pressure Testing in the Dynamic Drilling Environment

- Formation Testing While Drilling (FTWD) tools were introduced in 2002 and this new service has raised fundamental questions.

- How does the drilling environment affect the measurement?

- How do FTWD and Wireline Formation Testers (WFT) compare?

- What new applications can FTWD address?
Formation Pressure Testing

- Evolution of Formation Testing Technology
  - Wireline Formation Testing
  - Formation Testing While Drilling (FTWD)
- FTWD Deployment & Challenges
- FTWD Applications and Examples
- Summary
Formation Testing
like a Hypodermic

Pressure Transient

\( VC_f \)
Formation Testing like a Hypodermic

Total Flow = - Storage

\[ M = \frac{k}{\mu} \left( \frac{md}{cp} \right) \]

Pressure Transient

+ Formation
Typical Pressure Test > 1md/cp

- Hydrostatic
- Drawdown
- Steady State Drawdown
- Buildup

Pressure (psi)

Time (sec)

Q

\[ t_{s\_dd} \quad t_{e\_dd} \quad t_{stop} \]
Early Formation Testers

Chambers 1947

Hyde 1963
Early Formation Testers

Chambers 1954

Hyde 1963
Wireline Testers

RFT 1974
SFTT 1986
MDT 1989
RDT 1998
Wireline Testers

RFT 1974

SFTT 1986

Focused Probe

Oval Probe
Formation Testing While Drilling
FTWD Sensors

DFT Pathfinder 2001
GeoTap Halliburton 2002
TestTrack Baker INTEQ 2003
StethoScope Schlumberger 2005
Probe Based Testers FTWD Sensors

- Proven Pad/Probe design
- Bidirectional communications
- 0.01 psi Quartz Gauge Precision
- 1 – 3 drawdowns per set
- 5000 - 7000 psi drawdown
- 0.5 – 50 cc drawdown volumes
- 0.1 – 8 cc/sec selectable rates
- 100+ pressure tests per trip
- 7 - 15 Minutes, Typical Test Time
- 4 ¾”, 6 ¾”, 8” and 9 ½” Tool sizes currently available
Advantages of FTWD

- Less invasion – formation damage
- Reduced sticking – no fishing
- Faster testing – less rig time
- While drilling data – pressures & gradients
- Geo Steering – horizontal drilling
- Well control – mud optimization
Challenges for FTWD

- High accuracy real-time formation pressures
- Verify pressure test quality in Real-time
- ECD & dynamic invasion effect pressure?
- FTWD pressures repeatable & reliable?
- FTWD pressures & gradients compare with WL?
FTWD Real-time Data Transmission
Pressures & Quality Factors

\[
P_{bu}(t') = P_f - \beta e^{-\frac{t'}{\alpha}}
\]

- \(P_{hydr1}\)
- \(P_{hydr2}\)
- \(P_{start}\)
- \(P_{stop}\)
- \(P_{dd}\)
- \(3\alpha\)
- \(t' = t - t_{dd}\)
- \(\beta\) - buildup psi
- \(\alpha\) - buildup time
- \(\sigma\) - std. dev. ± psi
- Drawdown
- Pressure (psi)

\(t=0\)
\(t_{dd}\)
\(t_{stop}\)
Real-Time Data Modes & Summary

Test Summary
MD 12,452
TVD 7,683

Pressures:
- $P_{\text{stop1}}$ 3,521.1
- $P_{\text{stop2}}$ 3,521.4
- $P_{\text{stop3}}$ 3,522.2
- $P_{\text{hyd1}}$ 6,432
- $P_{\text{hyd2}}$ 6,445
- $P_{\text{dd\_start}}$ 6,509
- $P_{\text{dd\_end}}$ 3,421

Quality Factors:
- $\beta$ (psi) 98.0
- $\alpha$ (sec) 1.0
- $\sigma$ (±psi) 0.2

Results:
Good Stable Test
Mobility 148md/cp
# Real-Time Data Summary

## FTWD Real-Time Report

<table>
<thead>
<tr>
<th>Sample No</th>
<th>Depth (ft)</th>
<th>FTWD MD (ft)</th>
<th>FTWD TVD (ft)</th>
<th>Date</th>
<th>Time</th>
<th>Hyd 1 Pres (psi)</th>
<th>Hyd 2 Pres (psi)</th>
<th>Start DD Time (Sec)</th>
<th>End DD Pres (psi)</th>
<th>End DD Time (Sec)</th>
<th>Stop DD Pres (psi)</th>
<th>Alpha</th>
<th>Beta</th>
<th>Std. Dev.</th>
<th>Survey Temp (deg F)</th>
<th>FTWD TF</th>
<th>Comments</th>
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<td>Sand - B</td>
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</tr>
</tbody>
</table>

- Good Stable Test - Good RT to Rec Match
- Somewhat Stable Test
- Unstable test - Bed RT to Rec Match
Real-Time Data & Gradients

\[ y = 0.3209x + 2534.5 \]
\[ R^2 = 0.7955 \]

\[ y = 0.3735x + 2366.8 \]
\[ R^2 = 0.9859 \]
Post Processing Downloaded Data

EXACT PRESSURE / TIME  Depth: 18206.94 ft

Legend
- Pressure Data
- Exact Curve
- Hydrostatic 1
- Start DD
- End DD
- Stop
- Hydrostatic 2
- Velocity (fps)
- Stability Curve

P*ex (psia) 8544.36; P*ex ± (psia) 0.27; Ms ex (md/cp) 28.951; Ms ±% 1.3
Post Processing Downloaded Data

EXACT PRESSURE / TIME  Depth: 18206.94 ft

Legend
- Pressure Data
- Exact Curve
- Hydrostatic 1
- Start DD
- End DD
- Stop
- Hydrostatic 2
- Velocity (fps)
- Stability Curve

P*ex (psia) 8543.53; P*ex ± (psia) 0.16; Ms ex (md/ctp) 27.583; Ms ±% 1.0
Pressure Gradients

Gradients (psia/ft)
- Zone 1 - 1.110
- Zone 2 - 1.012
- Zone 3 - 1.051
- Zone 4 - 1.460
- Zone 5 - 0.288
- Zone 6 - 0.229
- Phyd Gradient 2.231

<table>
<thead>
<tr>
<th>Gradient Group</th>
<th>Gradient psia/m</th>
<th>Equivalent Fluid Density #/gal</th>
<th>g/cc</th>
</tr>
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<tbody>
<tr>
<td>Zone 1</td>
<td>1.1113</td>
<td>6.5138</td>
<td>0.7805</td>
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<td>Zone 2</td>
<td>1.0117</td>
<td>5.9302</td>
<td>0.7106</td>
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<tr>
<td>Zone 3</td>
<td>1.0510</td>
<td>6.1604</td>
<td>0.7382</td>
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<tr>
<td>Zone 4</td>
<td>1.4602</td>
<td>8.5591</td>
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<td>Zone 5</td>
<td>0.2885</td>
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<tr>
<td>Zone 6</td>
<td>0.2293</td>
<td>1.3439</td>
<td>0.1610</td>
</tr>
</tbody>
</table>

Disclaimer: All equivalent fluid densities are calculated from TVD pressure gradients.
Dynamic Wellbore Conditions

Packer element directs mud filtrate flow around probe

$P_{bu} \approx P_{ss}$ sandface pressure

$P_{ss}$ - actual sandface supercharge pressure

$P_{mh}$ - mud hydrostatic pressure
Dynamic Drilling Environment Models
From 2005 SPE and SPWLA Papers

\[ P_m \] 

\[ P_f \]
Dynamic Drilling Environment Models
From 2005 SPE and SPWLA Papers
Supercharge Simulation (1 md/cp)
Supercharge Sensitivity to Permeability
1000 psi Overbalance

![Graph showing sensitivity of supercharge pressure to invasion time with permeability as a parameter.](image-url)
Supercharge Events – Pipe Rotations
1000 psi Overbalance 10 md/cp

- Invasion Model (psi)
- Static Mudcake Model (psi)
- Mudcake Growth (cm)
FTWD Experience in Caspian Development
(SPE 96719 Joseph Finneran, Clive Green, Haavard Reed, BP)
Table 2--GeoTap history, Caspian Region

<table>
<thead>
<tr>
<th>Well</th>
<th>Tool Size (in.)</th>
<th>Hole Size (in.)</th>
<th>Date</th>
<th>Good Tests</th>
<th>Tight Tests</th>
<th>No Seal</th>
<th>Total Tests</th>
<th>Success Rate (%)</th>
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<tbody>
<tr>
<td>1</td>
<td>6 ¾</td>
<td>8 ½</td>
<td>Dec-03</td>
<td>19</td>
<td>0</td>
<td>0</td>
<td>19</td>
<td>100</td>
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<td>2</td>
<td>6 ¾</td>
<td>8 ½</td>
<td>Jun-04</td>
<td>16</td>
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<td>0</td>
<td>16</td>
<td>100</td>
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<td>3</td>
<td>8</td>
<td>12 ¼</td>
<td>Oct-04</td>
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<td>35</td>
<td>89</td>
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<td>4</td>
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<td>8 ½</td>
<td>Nov-04</td>
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<td>31</td>
<td>100</td>
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<tr>
<td>5</td>
<td>6 ¾</td>
<td>8 ½</td>
<td>Dec-04</td>
<td>28</td>
<td>0</td>
<td>0</td>
<td>29</td>
<td>100</td>
</tr>
<tr>
<td>6</td>
<td>6 ¾</td>
<td>8 ½</td>
<td>Apr-05</td>
<td>34</td>
<td>4</td>
<td>3</td>
<td>41</td>
<td>93</td>
</tr>
<tr>
<td>7</td>
<td>8</td>
<td>12 ¼</td>
<td>Apr-05</td>
<td>22</td>
<td>8</td>
<td>8</td>
<td>38</td>
<td>79</td>
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<td>6 ¾</td>
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<td>May-05</td>
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<td>20</td>
<td>100</td>
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<tr>
<td>9</td>
<td>6 ¾</td>
<td>8 ½</td>
<td>Jun-05</td>
<td>18</td>
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<td>18</td>
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<td>Jun-05</td>
<td>23</td>
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<td>239</td>
<td>17</td>
<td>15</td>
<td>271</td>
<td>95</td>
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Stable Pressure Test
Low Supercharge Effect
FTWD and Wireline Pressures

![Graph showing FTWD and Wireline Pressures with TVD (meters) on the y-axis and Pressure (psi) on the x-axis. The graph includes data points for FTWD and Wireline pressures at various TVD and Pressure values.](Image)
FTWD and Wireline Pressures

<table>
<thead>
<tr>
<th>TVD (meters)</th>
<th>FTWD 20 Kpsi Gauge</th>
<th>± 4 psi</th>
<th>Wireline 15 Kpsi Gauge</th>
<th>± 2.5 psi</th>
<th>Gauge Position</th>
<th>± 3 psi</th>
<th>Depth accuracy (± 2 ft)</th>
<th>± 1 psi</th>
<th>Maximum difference:</th>
<th>± 10.5 psi</th>
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<td></td>
<td>± 5 psi</td>
<td>461 md/cp</td>
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<td>XX 600</td>
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<td>± 243 md/cp</td>
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<td>508 md/cp</td>
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<td>± 317 md/cp</td>
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</table>

- FTWD 20 Kpsi Gauge: ± 4 psi
- Wireline 15 Kpsi Gauge: ± 2.5 psi
- Gauge Position: ± 3 psi
- Depth accuracy (± 2 ft): ± 1 psi
- Maximum difference: ± 10.5 psi
FTWD and Wireline Pressure Gradients
FTWD and Wireline Pressure Gradients

\[
y = 1982.6 + 0.96028x \quad R = 0.99949 \quad 0.293 \text{ psi/ft (~0.67 g/cc)}
\]

\[
y = 1826 + 1.014x \quad R = 0.99947 \quad 0.309 \text{ psi/ft (~0.71 g/cc)}
\]
## Wireline Gradient Statistics

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<th>Units</th>
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<td>0.5</td>
<td>± psi</td>
<td>Press repeatability, 95% Confidence</td>
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<tr>
<td>5.0%</td>
<td>± %</td>
<td>Depth repeatability, 95% Confidence</td>
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<tr>
<td>16.74</td>
<td>± ft</td>
<td>Depth repeatability, 95% Confidence</td>
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<tr>
<td>334.8097</td>
<td>ft</td>
<td>Interval vertical length</td>
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<tr>
<td>11</td>
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<td>Number of pressure test points</td>
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<tr>
<td>0.293</td>
<td>psi/ft</td>
<td>Gradient</td>
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### Results

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<td>33.48 ft</td>
<td>ft</td>
<td>Average Point spacing</td>
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<td>909</td>
<td>#</td>
<td>Number of tests analyzed</td>
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### Expected Deviations (95% Confidence)

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<td>Gradient max dev</td>
</tr>
<tr>
<td>4.7%</td>
<td>± %</td>
<td>Gradient max dev</td>
</tr>
<tr>
<td>0.306</td>
<td>psi/ft</td>
<td>max Gradient</td>
</tr>
<tr>
<td>0.279</td>
<td>psi/ft</td>
<td>min Gradient</td>
</tr>
<tr>
<td>+/- Pexp</td>
<td></td>
<td>Expected point scatter range (95% Confidence)</td>
</tr>
</tbody>
</table>

### Actual Pressure Deviations (95% Confidence)

<table>
<thead>
<tr>
<th></th>
<th>Units</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.006</td>
<td>± psi/ft</td>
<td>Gradient max dev</td>
</tr>
<tr>
<td>2.1%</td>
<td>± %</td>
<td>Gradient max dev</td>
</tr>
<tr>
<td>0.299</td>
<td>psi/ft</td>
<td>max Gradient</td>
</tr>
<tr>
<td>0.287</td>
<td>psi/ft</td>
<td>min Gradient</td>
</tr>
<tr>
<td>+/- Pact</td>
<td></td>
<td>Actual point scatter range (95% Confidence)</td>
</tr>
</tbody>
</table>

**Gradient Analysis Input Data**
Wireline Gradient Statistics

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Units</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>± psi</td>
<td>Press repeatability, 95% Confidence</td>
</tr>
<tr>
<td>2.3%</td>
<td>± %</td>
<td>Depth repeatability, 95% Confidence</td>
</tr>
<tr>
<td>7.70</td>
<td>± ft</td>
<td>Depth repeatability, 95% Confidence</td>
</tr>
<tr>
<td>334.8097</td>
<td>ft</td>
<td>Interval vertical length</td>
</tr>
<tr>
<td>11</td>
<td>#</td>
<td>Number of pressure test points</td>
</tr>
<tr>
<td>0.293</td>
<td>psi/ft</td>
<td>Gradient</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>33.48 ft</td>
</tr>
<tr>
<td>909</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Expected Deviations (95% Confidence)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.007 ± psi/ft Gradient max dev</td>
</tr>
<tr>
<td>2.3% ± % Gradient max dev</td>
</tr>
<tr>
<td>0.299 psi/ft max Gradient</td>
</tr>
<tr>
<td>0.286 psi/ft min Gradient</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Actual Pressure Deviations (95% Confidence)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.006 ± psi/ft Gradient max dev</td>
</tr>
<tr>
<td>2.1% ± % Gradient max dev</td>
</tr>
<tr>
<td>0.299 psi/ft max Gradient</td>
</tr>
<tr>
<td>0.287 psi/ft min Gradient</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>+/- Pexp</th>
<th>Expected point scatter range (95% Confidence)</th>
</tr>
</thead>
</table>

Gradient Analysis Input Data
## FTWD Gradient Statistics

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Units</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>± psi</td>
<td>Press repeatability, 95% Confidence</td>
</tr>
<tr>
<td>2.8%</td>
<td>± %</td>
<td>Depth repeatability, 95% Confidence</td>
</tr>
<tr>
<td>7.00</td>
<td>± ft</td>
<td>Depth repeatability, 95% Confidence</td>
</tr>
<tr>
<td>250</td>
<td>ft</td>
<td>Interval vertical length</td>
</tr>
<tr>
<td>6</td>
<td>#</td>
<td>Number of pressure test points</td>
</tr>
<tr>
<td>0.309</td>
<td>psi/ft</td>
<td>Gradient</td>
</tr>
</tbody>
</table>

**Results**

<table>
<thead>
<tr>
<th>50.00 ft</th>
<th>Average Point spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1666 #</td>
<td>Number of tests analyzed</td>
</tr>
</tbody>
</table>

**Expected Deviations (95% Confidence)**

| 0.011 ± psi/ft | Gradient max dev        |
| 3.4% ± %      | Gradient max dev        |
| 0.320 psi/ft  | max Gradient            |
| 0.299 psi/ft  | min Gradient            |
| +/- Pexp      | Expected point scatter range (95% Confidence) |

**Actual Pressure Deviations (95% Confidence)**

| 0.010 ± psi/ft | Gradient max dev        |
| 3.2% ± %      | Gradient max dev        |
| 0.319 psi/ft  | max Gradient            |
| 0.299 psi/ft  | min Gradient            |
| +/- Pact      | Actual point scatter range (95% Confidence) |

**Gradient Analysis Input Data**

![Graph showing pressure vs. relative deviation]
FTWD vs. Wireline Gradients

### Wireline Gradients

<table>
<thead>
<tr>
<th>Gauge</th>
<th>Analysis</th>
<th>Interval TVD ft</th>
<th>Gradient psi/ft</th>
<th>Gradient ± psi/ft</th>
<th>Gradient ± %</th>
<th>Depth ± ft</th>
<th>Depth ± %</th>
</tr>
</thead>
<tbody>
<tr>
<td>QP1</td>
<td>QP1-1 Main</td>
<td>8515.95 - 8559.76</td>
<td>43.81</td>
<td>0.262</td>
<td>0.008</td>
<td>3.21%</td>
<td>1.45</td>
</tr>
<tr>
<td>QP1</td>
<td>QP1-2 Sidetrack</td>
<td>8794.00 - 8862.39</td>
<td>68.39</td>
<td>0.268</td>
<td>0.005</td>
<td>1.99%</td>
<td>1.65</td>
</tr>
<tr>
<td>QP2</td>
<td>QP2-3 Main</td>
<td>8516.27 - 8658.89</td>
<td>142.62</td>
<td>0.282</td>
<td>0.002</td>
<td>0.75%</td>
<td>1.3</td>
</tr>
<tr>
<td>QP2</td>
<td>QP2-2 Sidetrack</td>
<td>8792.79 - 8843.77</td>
<td>50.98</td>
<td>0.272</td>
<td>0.007</td>
<td>2.76%</td>
<td>1.6</td>
</tr>
<tr>
<td>QP3</td>
<td>QP3-1 Main</td>
<td>8517.58 - 8561.36</td>
<td>43.78</td>
<td>0.260</td>
<td>0.007</td>
<td>2.67%</td>
<td>1.25</td>
</tr>
<tr>
<td>QP3</td>
<td>QP3-2 Sidetrack</td>
<td>8796.10 - 8860.86</td>
<td>64.76</td>
<td>0.273</td>
<td>0.006</td>
<td>2.33%</td>
<td>1.9</td>
</tr>
<tr>
<td>SP1</td>
<td>SP1-1 Main</td>
<td>8517.58 - 8561.36</td>
<td>43.78</td>
<td>0.262</td>
<td>0.008</td>
<td>3.20%</td>
<td>1.4</td>
</tr>
<tr>
<td>SP1</td>
<td>SP1-2 Sidetrack</td>
<td>8796.100 - 8864.490</td>
<td>68.39</td>
<td>0.273</td>
<td>0.004</td>
<td>2.37%</td>
<td>1.250</td>
</tr>
<tr>
<td>Averages</td>
<td></td>
<td></td>
<td>0.269</td>
<td>0.006</td>
<td>2.41%</td>
<td></td>
<td>2.57%</td>
</tr>
</tbody>
</table>

### FTWD Vs. Wireline

<table>
<thead>
<tr>
<th>Gauge</th>
<th>Analysis</th>
<th>Interval TVD ft</th>
<th>Gradient psi/ft</th>
<th>Gradient ± psi/ft</th>
<th>Gradient ± %</th>
<th>Depth ± ft</th>
<th>Depth ± %</th>
</tr>
</thead>
<tbody>
<tr>
<td>QG</td>
<td>GeoTap</td>
<td>9340.55 - 9590.55</td>
<td>250.00</td>
<td>0.309</td>
<td>0.010</td>
<td>3.18%</td>
<td>7.3</td>
</tr>
<tr>
<td>QG</td>
<td>MDT</td>
<td>9340.55 - 9675.36</td>
<td>334.81</td>
<td>0.293</td>
<td>0.006</td>
<td>2.08%</td>
<td>7.8</td>
</tr>
<tr>
<td>Averages</td>
<td></td>
<td></td>
<td></td>
<td>0.008</td>
<td>2.63%</td>
<td></td>
<td>2.62%</td>
</tr>
</tbody>
</table>
Qatif Field
Eastern Province of Saudi Arabia
Using Supercharge to ID Tar

Pressure Gradient Plot

- BASE TAR
- Supercharged
- Water Gradient 0.483 ps/ft
- Repeat Point

FINAL BUILD-UP PRESSURE (PSIA)
Optimizing Drilling & Completions
(SPE/IADC 92712 - 25 February 2005)

N14 MW+GEOTAP+PERF PRESSURES+GAS

- Pre Drill Pore Low Estimate
- Pre Drill Pore High Estimate
- Pre Drill Pore Base Estimate
- Mud weight
- Geotap Good
- Geotap poss S/charged
- Geotap no seal
- Perf Pore
- Final Pore Pressure
- Drill Gas
- Connection gas

Pressure PSI vs. Meters md graph.
Drilling Challenges
Well Control and Optimization

FTWD offers additional opportunities for well control, optimized drilling and completions that wireline can’t.
Pre Drill Pressure Predictions

At the Wellsite

Wellsite Engineer monitors drilling, collects data, LWD, mud, updates prediction and sends information to Pore Pressure Team.

At the Remote Support Center

Pore Pressure Team receives information from the Wellsite Engineer, updates the pore pressure prediction, and sends results to the rig.

LWD
Resistivity While Drilling
MWD
FPWD
Sonic While Drilling
Pre Drill Pressure Predictions

Formation Pressure Measured In Real Time

Real Time Pressure Predictions

Formation Pressure Measured In Permeable Formations

Reducing Cone Of Uncertainty

Denser Measurements Yield Higher Quality Look Ahead

Final Pore Pressure Profile

SPE 103936 Ted Tollefsen
Optimize Drilling Using Remote Real-Time Monitoring

At the Wellsite

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Resistivity While Drilling
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Pore Pressure Team receives information from the Wellsite Engineer, updates the pore pressure prediction, and sends results to the rig.
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Optimize Drilling Using Remote Real-Time Monitoring

Well Economics

Value to Client

- 6 NPT Days Eliminated $900k
- Wireline Delayed Until EOW $150k
- Eliminated 5” Casing $500k
- Slimhole Drilling Costs Savings $500k
- Less Additional LWD Costs (360k)

Savings to client $1.7M

Drilling well for less cost without intermediate casing
FTWD Summary

- Introduced in 2001-2003
- Initially used where WFT could not test
- Has replaced WFT for pressures in many cases
- Pressures and gradients are equivalent to WFT
- In conditions where WFT perform well FTWD pressures and gradients are comparable
- Concerns still exist about pressure stability
- Drilling applications now driving adaptation
- Will sampling be next?