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And special thanks to The American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME) for their contribution to the program.
“Lessons Learned from Integrated Analysis of GOM Drilling Performance”

Presented by Robert A. Meize, WWDWO Drilling Manager
Anadarko Petroleum Corporation
Presentation Summary

• Company Overview
• Drilling Data Analysis Implications
• Conventional Drilling Data Analysis
• “New-and-improved” Analysis
• Actual Results
• Conclusions
2004 GOM Rig Count – Max 7; Min 2

- GC 518 (K2 North)
- GC 562 (K2)
- GC 608 (Marco Polo)
- GC 652 (Genghis Khan)

EGOM

1000m

LOUISIANA

TEXAS

Houston

New Orleans
2004 Onshore Rig Count;
Max. 62, Min. 42
Study Objectives

• Stimulate industry discussion
• Present summary data to management and industry peers
• Benefits of *state-of-the-art* drilling analysis
  – efficiency
  – knowledge retention and transfer
  – problem identification
Drilling Analysis …

• On par with other disciplines?

• What resources committed to collecting and storing data?

• How much analysis needed for improvement?
Drilling Challenges and Opportunities

- Wellbore Designs for Different Areas
- Project Management – All Disciplines
- Implementation
- Technology Development & Transfer
- Lowering Cost / ft
Motivation and Justification

- Industry spends $MM’s collecting/storing data
- 35% + corporate capex spent on drilling
- Individual well costs often determine economics
- Cost/benefit of drilling studies
- Trained personnel necessary for maximum benefit.
- Drilling Data Mgmt ≤ $1MM/yr
Percentages of Total and Non-Trouble Drilling Costs
SPUD Through Evaluation
APC 1999 – 2004

- **Non-Trouble Cost**: 73%
  - 620 MM

- **Trouble**: 27%
  - 232 MM
1999 - 2004 APC
Drilling Trouble Cost

Trouble Type

Cost ($MM)

Cementing, Well Control, Loss Circ., Tool Failure, Tight Hole, Rig Repair, BOP, Other

Distinguished Lecturer Series,
2005 - 2006
Trouble Time Percent

Distinguished Lecturer Series, 2005 - 2006

Year

Percent of Time

Trouble Time
Non-Trouble Time

Distinguished Lecturer Series, 2005 - 2006
Trouble Time Analysis
Lessons Learned

- Drilled too far, took kick
- Weak formation or close tolerance to frac gradient
- Lost circulation
- Tight hole/packing-off
- Casing/cementing problems
Lessons Learned Number One

“Enemy of Good is Perfect”

• Don’t “push” casing points
• Casing point selection & pore pressure interpretation is critical
• Add 1 or 2 contingency strings
• Once wellbore starts losing mud, set pipe.
AnadarkoWells
Max Depth

Year

Distinguished Lecturer Series,
2005 - 2006
CONTINUOUS DRILLING IMPROVEMENT …

BEST COMPOSITE COST-BCC
BEST COMPOSITE TIME-BCT

(Combined best cost & time from existing wells in a field)
<table>
<thead>
<tr>
<th>17&quot; HOLE SECTION</th>
<th>EXAMPLE BCT ACTIVITIES</th>
<th>Best Hrs.</th>
<th>FROM WELL(S)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Make Up BHA &amp; TIH</td>
<td>5.5</td>
<td>GOM Wells 2&amp;5</td>
</tr>
<tr>
<td></td>
<td>Drill out</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Shoe/Cement</td>
<td>2.5</td>
<td>GOM Well 4</td>
</tr>
<tr>
<td></td>
<td>Leak off Test</td>
<td>1</td>
<td>GOM Wells 5&amp;6</td>
</tr>
<tr>
<td></td>
<td>Drilling Ahead</td>
<td>43</td>
<td>GOM Well 3</td>
</tr>
<tr>
<td></td>
<td>Circ/Condition Mud</td>
<td>7.5</td>
<td>GOM Well 2</td>
</tr>
<tr>
<td></td>
<td>Short Trip</td>
<td>0</td>
<td>GOM Wells 1&amp;2</td>
</tr>
<tr>
<td></td>
<td>Rig Service</td>
<td>0.5</td>
<td>GOM Well 4</td>
</tr>
<tr>
<td></td>
<td>Trip out of Hole</td>
<td>6</td>
<td>GOM Well 5</td>
</tr>
<tr>
<td></td>
<td>Run 13-3/8&quot; Casing</td>
<td>16.5</td>
<td>GOM Wells 1,3,6</td>
</tr>
<tr>
<td></td>
<td>Circ.&amp; Cmt. Casing</td>
<td>5.0</td>
<td>GOM Wells 3&amp;4</td>
</tr>
</tbody>
</table>
Deepwater Well Times, 18-23 days with the BCT (pink curve ~15 days)

Time vs Depth

- Measured Depth (ft)
- Time (day)

- Best no Trouble
- Input Data
Deepwater Drilling Costs with BCC - Uppermost (Pink) Curve

PHASE SEQUENCE

PreSpud  Conductor  26" Phase 17.5" Phase  12.25"  Post-TD

CUMULATIVE WELL COST

(12,000,000)
(10,000,000)
(8,000,000)
(6,000,000)
(4,000,000)
(2,000,000)

0
The Drilling Learning Curve

Time

Well Sequence Number

1 2 3 4

Learning Potential (C1)

Learning Rate (C2)

Operational Limit (C3)
Learning Curve Analysis

\[ t_n = C_3 + C_1 \times \exp \left[(1-n)C_2\right]; \quad \ldots \ldots \ (\text{Eq.1}) \]

\( t_n \) is time to drill the \( n \)th well; \( C_1, C_2, C_3 \) are defined in the literature as the learning potential, learning rate & operational limit.

BCT (~15 days) < C3 (~20 days); \( C_2 \) from 0.4 to 0.8 shows “good performance” and \( C_2 > 0.8 \) indicates excellent performance;

Note: \( C_2=0.7 \) results in 50\% \( C_1 \) in 2nd well.
Lessons Learned Number Two

“Measure twice, cut once”

• Review all available data
• Seek best performance in all phases of operations
• Repeat things that work well
Cajun Express
Deepwater Drilling Economics - Improved C1 Level ➔ $5.96MM
Lessons & Solutions from ~4000 ft WD to Ultra-deepwater, 9000 ft WD WD

Days (Norm. footage = 8541.5 ft)

- Wells 1-6; Deepwater; 4,000' ft WD
- Ultra deepwater; 9,000' ft WD

Graph showing the days required for different stages of drilling and casing for wells 1 to 9.
ULTRA-DEEPWATER LEARNING; Curves Separated by Drilling Operation

Days (Norm. footage = 9902.5 ft)

- Atwater Valley 349 #1: 14.2 days for Drilling, 7.01 days for Casing, 6.58 days for Evaluation, 4.79 days for Trouble
- Lloyd Ridge 360 #1: 11.83 days for Drilling, 5.6 days for Casing, 5.75 days for Trouble
- Lloyd Ridge 50 #1: 10.45 days for Drilling, 4.77 days for Casing, 2.16 days for Trouble
Subsalt S. Timbalier; AFE estimate for Well #3 based on previous performance

- Drilling
- Casing
- Evaluation
- Trouble
- Rig Pos
- BOP
- Post-Drill

5 days (Norm footabe = 9018.4 ft)

- South Timbalier 308 #1: 164.95
- South Timbalier 308 #2: 121.04
- South Timbalier 308 #3: 70.76
- South Timbalier 308 #3 (Planned): 102.43
- South Timbalier 308 #4: 60.26
S. Timbalier Learning Analysis; C2 = 0.8 ⇒ Excellent Learning

Days (Norm footage = 18590.1 ft)

- Drilling
- Casing
- Evaluation
- Trouble
- Rig Pos
- BOP
- Post-Drill
Top Five Time & Money Savers

1. Marker beads on surface casing cementing
2. BOP test against 20” & 13-5/8” casing
3. Bit run retrievable wear bushing
4. Use cement stinger on 9-5/8” production to set TA plugs
5. Utilize same rig & crew on consecutive wells
Leveraging Technology / Transfer

- Alaska
- Algeria
- East Texas
- Gulf of Mexico
Traditional Analysis
The Future
Summary and Conclusions

• There are computer-assisted tools available for drilling data analysis
• Proper utilization can set new benchmarks for drilling performance
• Facilitate lessons learned, problem identification and areas for improvement
• Requires technical skills to interpret and utilize the data
• Senior management support is essential.
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