Proposal to Develop an Improved Methodology for Wellbore Stability Prediction

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Knowledge systems Inc.

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Constructing a Stable Wellbore

Low Wellbore Pressure Differential → High

Major Kick or Blowout → Oriented Shear Failure → Non-Oriented Splintering → Stable Wellbore → Hole Ballooning → Hydraulic Fracturing

- Major Kick or Blowout: May produce angular caving visible in surface returns
- Oriented Shear Failure: Pore pressure "pops" chips into Wellbore
- Non-Oriented Splintering: Well "breathes", alternately producing and taking fluids
- Stable Wellbore: Major fluid losses
- Hole Ballooning: Alternate production and taking fluids
- Hydraulic Fracturing: Major fluid losses

MORE KNOWLEDGE. FEWER SURPRISES.
Wellbore Stability Prediction
Current Practice

• Not widely practiced, despite the cost of instability problems
• No industry consensus regarding methodologies
• Hard to select which methods to use under varying geologic conditions
• Lack of training

Different Approaches to WBS Modeling
10 Years of GOM Performance Data

- **Drilling Environment**: 27%
- **Pore Pressure Prediction**: 17%
- **Wellbore Instability**: 14%
- **Weather**: 9%
- **Other**: 7%
- **Service Company Equipment**: 7%
- **Rig Contractor Equipment**: 8%
- **Procedures & Training**: 11%
- **Risk Management**: 7%

Lost Opportunity

What’s the value of annular pressure planning?

- PP pre-planning from offset MW
- No WBS pre-planning
- GOM shelf well
- High deviation
Lost Opportunity

Drilling Events
- Tight Hole
- Tight Hole
- Backream
- Pack Off
- Stuck
- Tight Hole
- Pack Off

Pore Pressure

Shear Failure Pressure

Fracture Pressure

Overburden Pressure

FATAL KICK

MORE KNOWLEDGE. FEWER SURPRISES.
Lost Opportunity Summary

• Until the kick, the MW’s were adequate to avoid influx

• MW was inadequate to prevent borehole collapse

• KSI contacted to conduct post-mortem
  – Limited data, coarse defaults, calibration inexact but results
    used to plan new well – successfully!
The Impact of Complacency

• What is the value of that effort?
  – $5,000,000 to re-drill
  – <1% investment to prevent
What’s Needed

Better methods for drilling engineers to plan for wellbore stability:

– Reduced well construction time and cost
– Reduced casing related costs
– Reduced mud costs
– Reduced dependence on contingency casing designs
– Improve quality of formation evaluation data
– Maintain hole integrity for maximum production
Proposed Wellbore Stability Joint Industry Project (WBS JIP)

Objective
Identify and develop best practices for wellbore stability analysis

Sponsor
Marathon Oil Company

Participants
Firms actively engaged in drilling or providing drilling services
15 participants minimum

JIP Structure
Patterned after prior KSI-managed JIP initiatives
(DEA 119 Deepwater Pore Pressure Prediction, Sub-Salt)
Five Major Project Phases

1. Research of Current Practices
2. Data Gathering, Quality Control and Validation
3. Determination of in-situ stress and rock strength
   a) Need: better earth stress inputs to WBS model
4. Wellbore Stability Analysis
5. Documentation and Communication of Findings
Project Scope

• Analyze five areas globally
  – North Sea, Australia, GoM Shelf, GoM deepwater, Western Canada

• Review current practices

• Technical panel selects most promising methods for further testing

• Data obtained by KSI from available sources
  – Participant data not required
  – ~50 wells per geographic region
Project Scope cont’d

• Identify best methods for in-situ stress and rock strength estimation

• Test wellbore stability models with data to determine most effective modeling approaches
  – Pre-Drill
  – Real-Time
  – All five regions

Analytical or numeric methods, or both?

• Identify new and enhanced methods, where possible

• Best methods documented and communicated to participants
Project Workflow

1. **Research current WBS analytical prediction practices**
   - Acquire data from multiple wells in five basins for model testing
   - Research in-situ stress and rock strength estimation methods

2. **Select most promising methods**
   - In-situ stress & rock strength parameters for model testing
   - Select most promising methods

3. **Analytical Modeling**
   - **Pre-Drill**
     - Theoretical prediction based on data available pre-drill
   - **While Drilling**
     - Theoretical prediction based on pre-drill + data available while drilling
   - **Definitive**
     - Determine the wellbore instability mechanism best honoring actual post-well data

4. **Numerical Modeling**
   - **Pre-Drill Modeling**
   - **Definitive analyses**
     - Correlated to core data and wellbore instability events

5. **Compare definitive vs. predicted stability under varying conditions**
   - Select best methods

6. **Document and Communicate Results**
   - Manuals
   - Training Programs
   - Expert Systems
   - Workshops
   - Website

**Data Needs**
- In-situ stress & rock strength parameters for model testing
**Project Timeline**

Commences Jan 1 2007
18 month Duration

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<th>Research of Current Practice</th>
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<th>2008</th>
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<td>Data Gathering and Quality Control</td>
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<td>Determination of In Situ Rock Stress and Strength</td>
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<td>Documentation and Communication of Results</td>
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Project Resources

• William Standifird Officer in charge
• AJ Rizvi Project Manager
• Dr. Jon Zhang Chief Project Geoscientist
• Dr. Xinpu Shen Geomechanics Specialist
• Dr. Joel Gevirtz Modeling Specialist
• Dr. Martin D. Matthews Modeling Specialist
• Other consultants As required to perform work under supervision
• **Modeling Software:** KSI and 3rd party applications

Participants provide oversight through Technical Committees.
## Estimated Participation Cost

### Project Cost:

- **Labor**: $1,071,900 (72.3%)
- **Software**: $220,500 (14.9%)
- **Hardware**: $29,400 (2.0%)
- **Travel**: $147,000 (9.9%)
- **Production Costs & Incidentals**: $14,700 (1.0%)

**TOTAL**: $1,483,500

Cost per participant: $98,900
Project Deliverables

• Monthly project status reports, semiannual project progress reports
• Improved methods, models and procedures for the prognosis of wellbore stability
• Wellbore Stability Prognosis Manual, printed & electronic
• A Wellbore Stability School for drilling engineers, held in each of the project’s geographic areas
• Database for future research and study to include testing new models and methods.
• Wellbore Stability website
WBS JIP Status

Currently accepting participants

Details in information package

Further information:
- Technical: Will Standifird
- Participation: Kevin Brady