Wellbore Stability and Real Time Drilling Optimisation: Delivered Worldwide from Cornwall

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GeoScience Limited

Experienced Specialist Services company with multi-disciplinary staffing

- Independent SME, UK based, providing services world-wide
- Background in mining and tunnelling from 1970
- Formed in 1985 for the oil & gas, and geothermal sectors
- Work in oil & gas, geothermal and deep engineering
- Main areas of speciality: structural geology (fracture characterisation), wellbore rock mechanics (in situ stress), fluid flow
- Studies have been carried out in the North Sea, Africa, Russia, America and beyond
GeoScience Around the World
Borehole Rock Mechanics Group

- Wellbore Instability Studies
- Fracture / Injection Assessment
- Sand Production Assessment
- *In Situ* Stress Assessment
- Cuttings and Produced Water Re-Injection
- Casing Integrity

- Junction Modeling
- Compaction / Subsidence
- Coupled Reservoir Behaviour during Production
- Gas Cavern Storage
- Gas Reservoir Storage (Natural Gas and CO2)
- Depleted Reservoirs
What is Wellbore Instability?

Purpose and Benefits

GeoScience Method for Avoiding Wellbore Instability

What is Real Time Support?

Real Time Support Examples
WELLBORE INSTABILITY
Wellbore Failure - Example: Wellbore Instabilities

Hole Instability Defined

FORMATION BREAKDOWN
- Lost Circulation

COMPRESSION FAILURE
- Hole Collapse
- Hole Closure

Tensile Failure
- Drilling Induced Fracture

Compressive Failure
- Breakout
It Also Happens in Mines

AECL’s Mine-by tunnel in Granite: splinters, slabbing
PURPOSE AND BENEFITS
Purpose and Benefits

• Reduce Drilling Risk
  – Reduce uncertainty
  – Increase understanding
  – Promote confidence
  – Enhance safety

• Reduce Costs
  – Reduce outrun costs
  – Reduce non productive time (NPT)
  – Potentially enhance production / recovery
The Cost of Unstable Wells

- $600-$1000 million worldwide (Exxon, 1991)
- Cost to Shell in 1997, $250 million
- 6% of all drilling costs in Indonesia
- Cost to Mobil, Gulf Coast, 8-12% AFE
- +20% in South America (BP)
- 19%->4% in 12 months, Nigeria Mobil
- Zeng of BHI suggested a figure of $6000 million pa!
- SPE NPT Forum 2009 - 20%>25% all NPT
AVOIDING WELLBORE INSTABILITY
How to Manage Wellbore Instability?

- Balancing the *in situ* stresses and rock strength with mud weights AND drilling practices

- Understanding that geology defines the way the rock responds, and the borehole has disturbed the natural state

- Remembering that all natural systems are variable and lead to uncertainty; we manage these inherent risks
Borehole Rock Mechanics Method

- Field Data
  - Parameters
    - Formation Properties
    - In Situ Stress
    - Pore Pressure
  - Geomechanical Model
    - Prediction / Recommendations
    - Field Application
- Improved Understanding
  - Test Point Dataset
    - Calibration Comparison
      - Improved Understanding
- Comparison
  - Field Data

GeoScience
REAL TIME SUPPORT
What is ‘Real Time Support’ (RTS)

• RTS is the phase of support which occurs while the wellbore is being drilled - typically after stability predictions have been supplied

• Current technology means having people on site is not necessary

• Daily assessment of the drilling conditions, normally via a combination of report reviewing, real time online viewing, and daily rig calls, can mean quick forward planning based on current wellbore conditions
RTS Benefits

- Avoids the ‘fire fight’ of analysis after an incident, when (sometimes) not all the facts are known

- Multiple jobs can be run from one office, with several staff involved

- Working with both offshore and onshore staff and access to real time online operations means everyone knows what is happening offshore, wherever the project is located
Typical Data Received Daily from the Rig

- Daily Drilling (operations), Geological, Mudlogging and Mud Reports
- Daily LWD (Logging While Drilling) & MWD (Measurement While Drilling) data & daily reports. Which includes rock property data and caliper data
- Daily PWD (Pressure While Drilling) data & daily reports. This includes rig operation data (hook position, hookload, weight on bit, ROP, torque etc), actual downhole mud weight and annulus pressure data
- Well survey data
Real Time Support Method

- This new well information is input back into the existing geomechanical model.
- The model is run to check the model consistency between what is happening offshore and what was anticipated.
- If drilling conditions are not matched, additional calibration of the model may be necessary.
Real Time Support Method

- Well information is used to build a Well Time Summary (WTS).
- The WTS and logging data can be used to estimate if problems could be anticipated which will affect future drilling operations.
- This becomes an ongoing record of the drilling progress and is one of the core daily deliverables of RTS.

Losses observed
- Pumped LCM pill and drilled ahead with surface losses only.
- Cavings reported 40klbs overpull.
- Tabular cavings observed at shakers.
- Decreasing cavings volume as circulation continued.
- Losses 1-4bph.

Stringers
- 6,800
- 7,300
- 7,800
- 8,300
- 8,800
- 9,300
- 9,800
- 10,300
- 10,800

- 16 Apr 18 Apr 20 Apr 22 Apr 24 Apr 26 Apr 28 Apr 30 Apr 02 May
- Depth (ft) MD
- Stringers
- Eocene Fan
- Mid Eocene
- Lwr Eocene
- Balder

Running in hole with 17½" Mill BHA. Clean out run.
- Work casing down, no progress. 50 klbs set down.
- 0.25x0.25" blocky cavings observed at shakers.
- Decreasing cavings volume as circulation continued.
- Losses 1-4bph.
Some (of the many) factors to consider

- Mud weight
- Mud Chemistry
- Geology
- Actual Drilling Operations
- Bottom Hole Assembly Type
- Well Path
- Time
REAL TIME SUPPORT EXAMPLES
<table>
<thead>
<tr>
<th>Action</th>
<th>Color</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>Normal RIH / POOH</td>
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<tr>
<td>Drill Ahead</td>
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<td>Logging</td>
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<td>Coring</td>
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<tr>
<td>Pump Out Of Hole</td>
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<td>Circulate</td>
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<tr>
<td>Cavings</td>
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<tr>
<td>Pack Off</td>
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<tr>
<td>Minor Tight Spot</td>
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<td>Significant Tight Spot</td>
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<td>Tight Section</td>
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<tr>
<td>Fill (volume shown in green text)</td>
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<tr>
<td>1/1/WT/A/X.. Bit Grading</td>
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<td>NPT / Surface Operations</td>
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<td>Flowcheck - static</td>
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<tr>
<td>Mud Weight - OBM</td>
<td>1.35</td>
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<tr>
<td>Mud Weight - WBM</td>
<td>1.35</td>
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<tr>
<td>ECD</td>
<td>1.35</td>
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<td>Fish In Hole</td>
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<tr>
<td>Pump Cement Plug</td>
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<td>LOT (EMW shown in green text)</td>
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<td>FIT (EMW shown in green text)</td>
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<tr>
<td>Wash</td>
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<tr>
<td>Wash &amp; Ream</td>
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<tr>
<td>Wash / Ream / Backream, Hole Packing Off</td>
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<td>Loss Rate (separate Y-axis)</td>
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<tr>
<td>Pump LCM Pill</td>
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<td>Well Flowing / Connection Gas</td>
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<td>Well Swabbing</td>
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<td>Run Casing</td>
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<td>SCRs</td>
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<tr>
<td>Set Packer</td>
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Real Time Support Deliverable Example 1

**WELL TIME SUMMARY**
- Losses observed pumped LCM pill and drilled ahead with surface losses only.
- Cavings reported.
- 40kls overpull.
- Work casing down, no progress. 50kls set down.
- 0.25x0.25" blocky cavings observed at shakers. Decreasing cavings volume as circulation continued. Losses 1-6bph.

**MUD WEIGHT PROFILE**
- Stringers
- Eocene Fan
- Mid Eocene
- Lower Eocene
- Balder

**REAL TIME LOGGING DATA**
- 0° Breakout
- $\sigma_{v}$
- $\sigma_{Hmax}$
- $\sigma_{Hmin}$
- Pore Pressure
- Fracture Initiation
- Static MW Used
- ACTECDX.ppg

**Mud Weight (ppg)**
- 9.2
- 9.4
- 9.5
- 9.6
- 9.8
- 10.0
- 10.2

**Cumulative Losses (bbl)**
- 0
- 30
- 60
- 90
- 120
- 150
- 180
- 210

**Depth (ft) MD**
- 6,800
- 7,300
- 7,800
- 8,300
- 8,800
- 9,300
- 9,800
- 10,300
- 10,800
Real Time Support Deliverable Example 2
Summary

- Wellbore instability is a risk, but with proper planning, and care while drilling, unnecessary time and expense can be avoided

- RTS can be used to help drillers maintain an overview of wellbore conditions

- Quick intervention resulting from RTS recommendations can prevent potential problems, saving time and money
ANY QUESTIONS?