Realtime Geopressure and Wellbore Stability Monitoring while Drilling

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Main points

1. Why bother with PPwD? Isn’t the prognosis good enough?
2. Can it be justified?
3. PPwD as part of the Drilling process
4. Make the most of your valuable data and knowledge
5. Some case histories
6. Summary / Conclusions
Why bother with PPwD?

Any Pore Pressure Prognosis inherently involves uncertainty

- Offset Well Data Uncertainty
  - Distance / Geologic complexity
  - Offset MW don’t necessarily reflect PP
  - May be no relevant offset data available

- Seismic Data Uncertainty
  - Low resolution, 500’-2000’
  - Not always suitable for PP Prediction

- Geological Uncertainty
  - Formation properties
  - Formation depth / thickness
Why bother with PPwD?

In 2004* geopressure and wellbore stability related problems were estimated to be costing the industry $8\text{billion/year}$

- Stuck Pipe
- Kicks
- Lost Circulation
- Sloughing Shale
- Flows
- Wellbore Instability

$= 41\%$ of total NPT

* Offshore Magazine – Dodson Jan 2004
Why bother with PPwD?

In 2009 an update of this study * showed similar statistics and an average of $2.5m Non-Productive Time cost per well

* Eliminating Non-Productive Time Associated with Drilling Trouble Zones, OTC 20220
PPwD can = $$$ saved

1 hr NPT = $42k

Well operation 100 days @ $1m/day

PPwD

$ Saving
Savings – at all levels

Financial savings can be made at all levels in the well process. Not just the big-ticket items:
• Kick / Blowout
• Lost circulation
• Stuck pipe / Twist off / Sidetrack
• Correct casing shoe depth

But also the ‘smaller’ stuff:
• Avoid Circulating time
• Avoid trip in HPHT conditions for LWD failure
• Reduce need for 10-10-10 tests
• Help diagnose ballooning/breathing = avoid MW increases
Any PP Prognosis involves uncertainty.

A picture says a 1000 words…
PPwD as part of Drilling Process

Pore pressure work at the planning and drilling stages is critical to the well’s success.

Prognosis
- Seismic
- Regional Studies
- Offset Wells

Drilling
- Mitigate Pre-drill Uncertainties
- Safe & Efficient Drilling
- Optimise MW & Casing Plans
- Proper use of offset well data
- Document lessons learned
- Good quality borehole

Post-well
- QC’d final data set
The PPwD process

- Independence
- Expertise
- Experience
- Processes
- All relevant data
The PPwD process

**Purpose**

**Mud Logging**
- DXC, TEMP, RPM, ROP, TORQ, MFI, MWI, MWO, GAS, MTI, MTO, Gas Peaks, Cavings, Drag, Fill, Swab, Surge, Shale Dens, Shale Factor, Reports

**LWD**
- DIR, GR, RES, DT, POR, DENS, ANNP, ESD, DWOB, DTORQ, TEMP

**Wireline**
- CALI, GR, SP, RES, DT, POR, RHOB, RFT, TEMP, POISS

**Depth-based & Time-based**

**Real-Time Drilling Data**

**Pre-drill Model**

**Basin Model**

**Geomechanics Model**

**Wellsite / Office Team**

**Frequent updates of PP/CP/FP**

**Purpose-built Software**

**Pro-active changes to Well Plan**
Several WITSML streams incoming simultaneously, at user-defined intervals.
Make the most of your data

Display and analyse ALL data in relation to each other
Start with the calibrated regional parameters as guides for monitoring while drilling
Make the most of your data

Time-based data can be imported via WITSML
High resolution for detailed events analysis
Some Case Histories

1. Norske Shell, 1998 – Deepwater well, Norwegian North Sea
   • Shell estimated savings of $7,000,000 due to pore pressure work on well

2. Shell Brunei, 1999 - Deepwater well, S. China Sea
   • “Prevented at least one kick and reduced drilling time”
   • Internal Shell Magazine article, then published in OFFSHORE Magazine – “Real-time pore pressure calculations from MWD: Successful application in the South China Sea” – Doyle, Kuyken and de Lange

3. BP Norge, 2002 - Deepwater well, Norway
   • Saved a contingency casing string; helped define well TD
   • SPE Paper 79848, Amsterdam 2003 – “Plan for Surprises: Pore Pressure Challenges during the drilling of a Deepwater Exploration Well in mid-winter in Norway” - Doyle, Berry and McCormack

4. Norsk Hydro, 1996 – HPHT well, Viking Graben, Norway
   • First use in N. Sea of Seismic While Drilling, combined with Basin PP Modelling
   • Saved contingency 16” liner and set 13 3/8” casing 500m deeper than planned
   • PP Workshop, Pau 1998 – “Case study - Comprehensive approach to formation pressure prediction and evaluation on a Norwegian HPHT well “ - Doyle
Summary

From drillingcontractor.org – “Real-time data offers critical tool to redefine well control, safety” by Pritchard

• All well control events are predictable and avoidable
• The more complex the geological environment, the more uncertain the PP and FG… Effective monitoring helps ensure the successful navigation of the drilling margin
• Monitoring must evolve to be proactive. Multiple specialists should be involved
Summary, contd

- Real-time data can not only improve process safety but can also improve decision quality around management of change and risk management.
- Data systems must use intelligent agents to ensure process safety before the event occurs.
- Industry leaders are challenged in their ability to effectively monitor key drilling parameters....For those who may be old enough to remember what Well Listening means, they are challenged not only with drilling the well but also mentoring a younger generation unfamiliar with the art and science of rotary drilling.
Conclusion

Real-time Pore Pressure Surveillance while Drilling reduces:

• Uncertainty
• Risk
• Cost
Thank you – Any Questions?

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Norway, North Sea 1995-1998

Viking Graben – Real-Time drilling support of Geopressure prediction ahead of the bit

/Norsk Hydro ASA/

Actual Fm tops and PP estimate at bit are fed into Basin Model to update ahead of bit prognosis and reduce uncertainty