Hole Cleaning in Complex Wells

Optimization to Address Specific Drilling Challeneges

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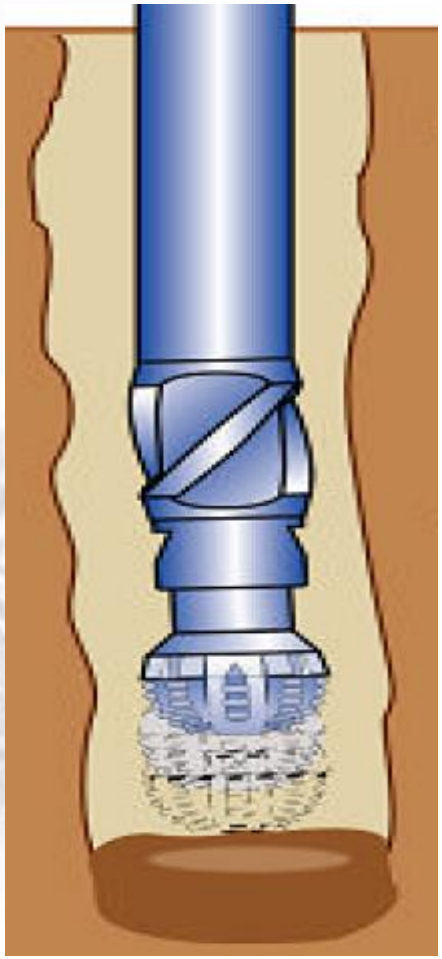
Agenda – What are the Challenges?

High angle and ERD wells present specific challenges

Hydraulics

- What's the endgame?
- Temperature profile ……
- New PVT data & new tools ……



Hole Cleaning

- How hard can it be, right??
- Poor hole cleaning or wellbore instability?
- Monitoring

Hydraulics

Interrelated Problems

- Narrow drilling windows
- Excessive ECDs (drilling, tripping, running casing)
- Temperature and pressure effects on density and rheology
- Mud weight required for wellbore stability
- Depleted zones
- Excessive sliding or inclination/azimuth changes for directional control
- Over-aggressive drill rates
- Inadequate planning
- People.....training, understanding & communicating

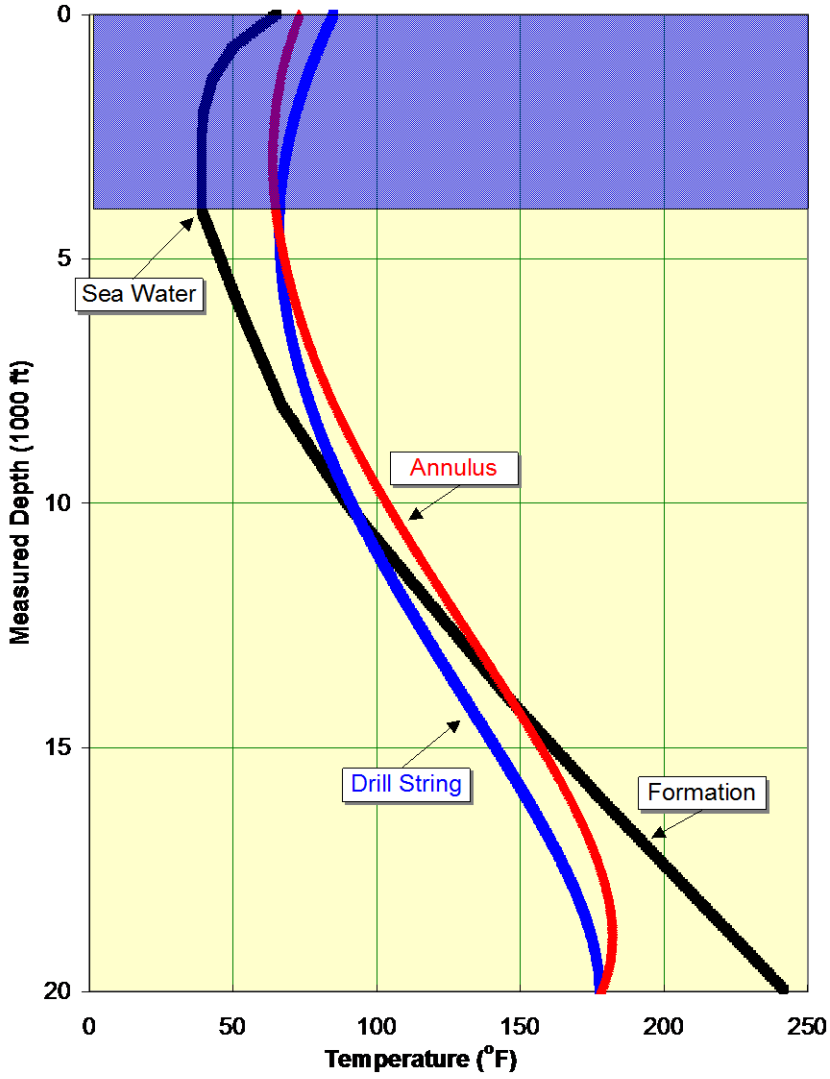
"Hydrostatic Pressure is equal to 0.052 x Mud Weight x TVD" True or False?

How do we drive this thing?

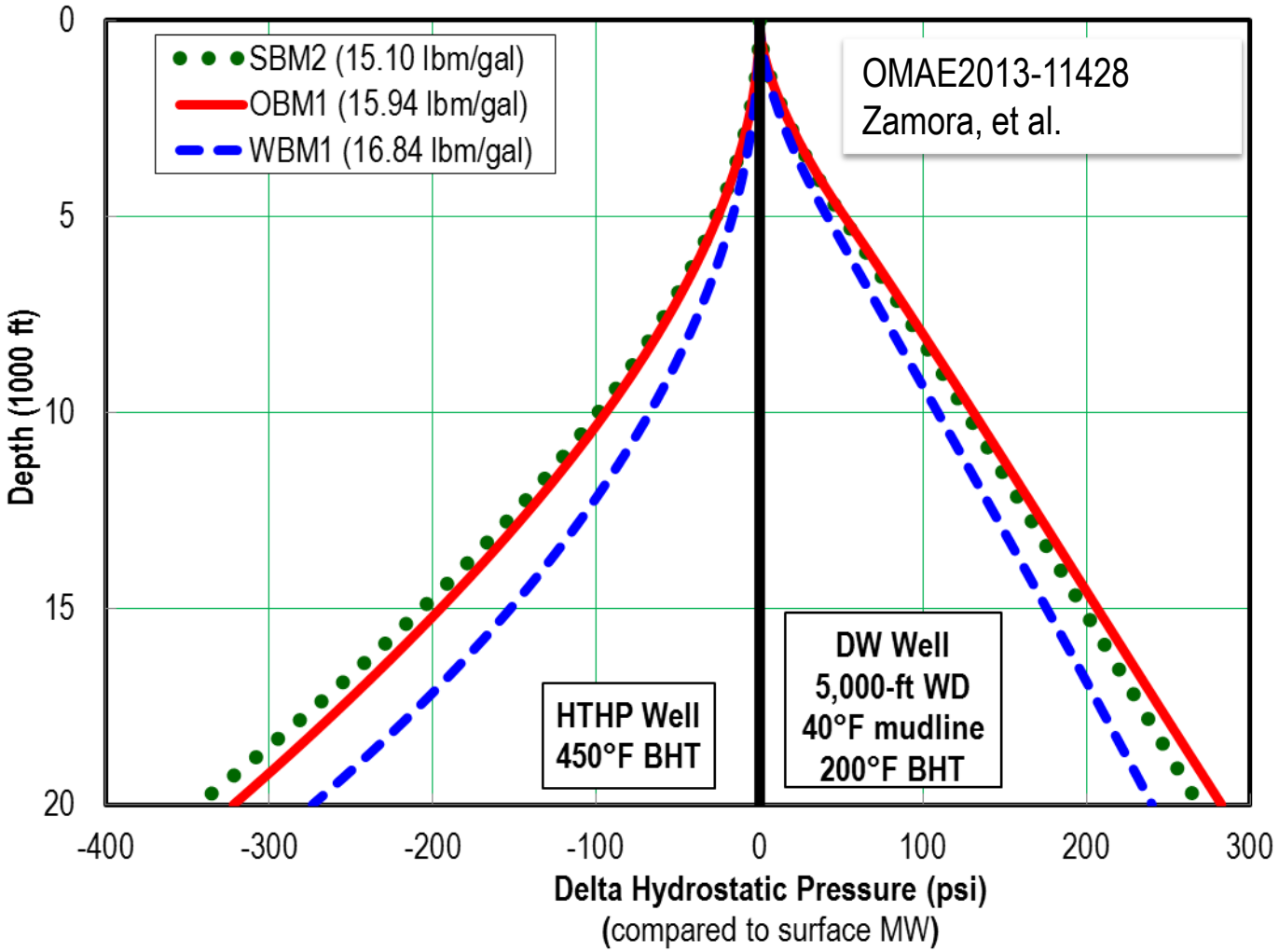
Temperature Profile Very Critical

Effects

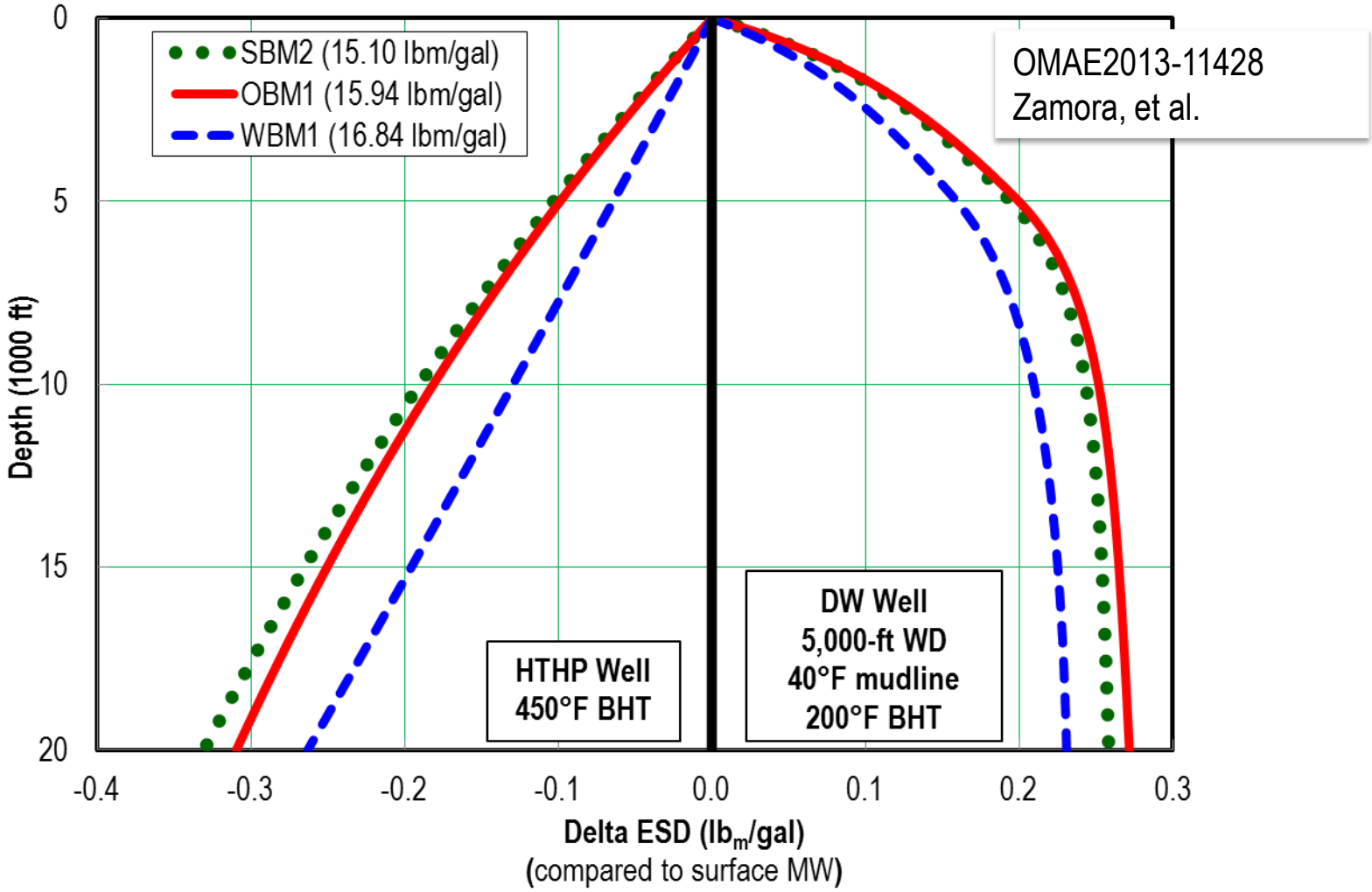
- Temperature affects mud weight, viscosity, gels, and hydrostatic pressure.
- Deepwater, HTHP, and Artic applications are affected the most.
- Temperature profiles are too often ignored or over simplified.
- However, a temperature model or profile is critical to a good simulation.



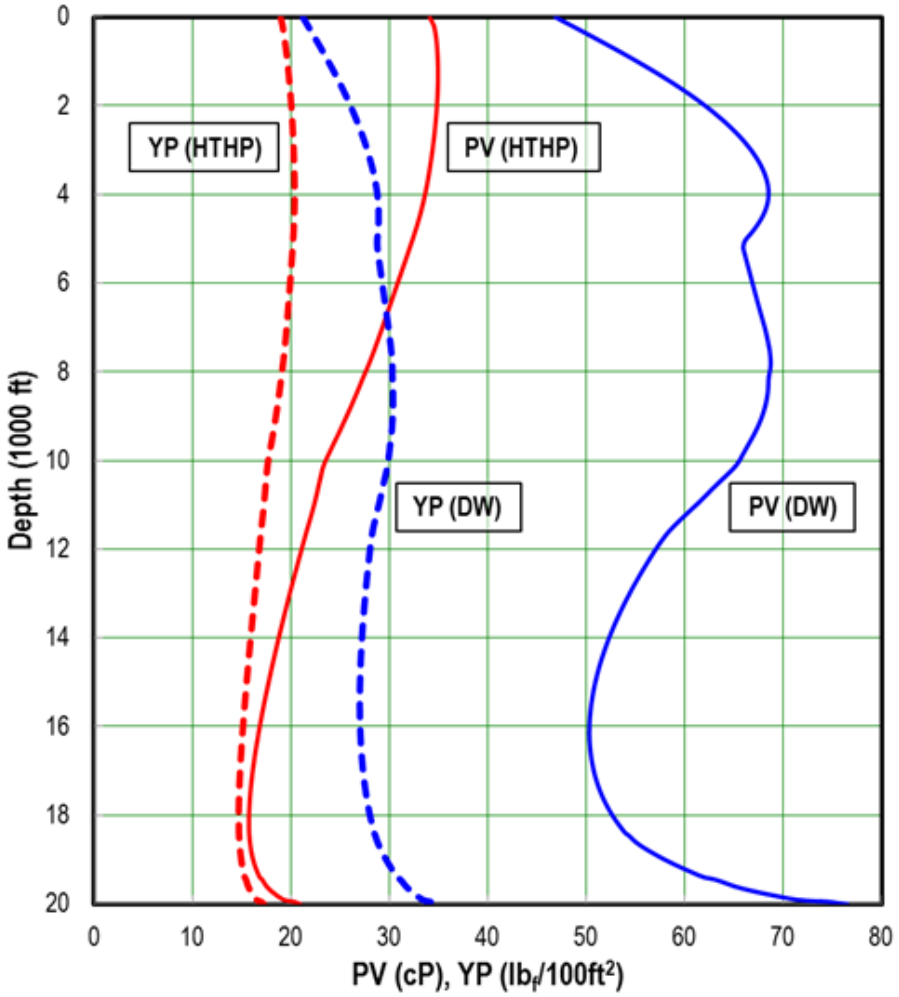
Comparing True Hydrostatic Pressure



Comparing ESD Profiles

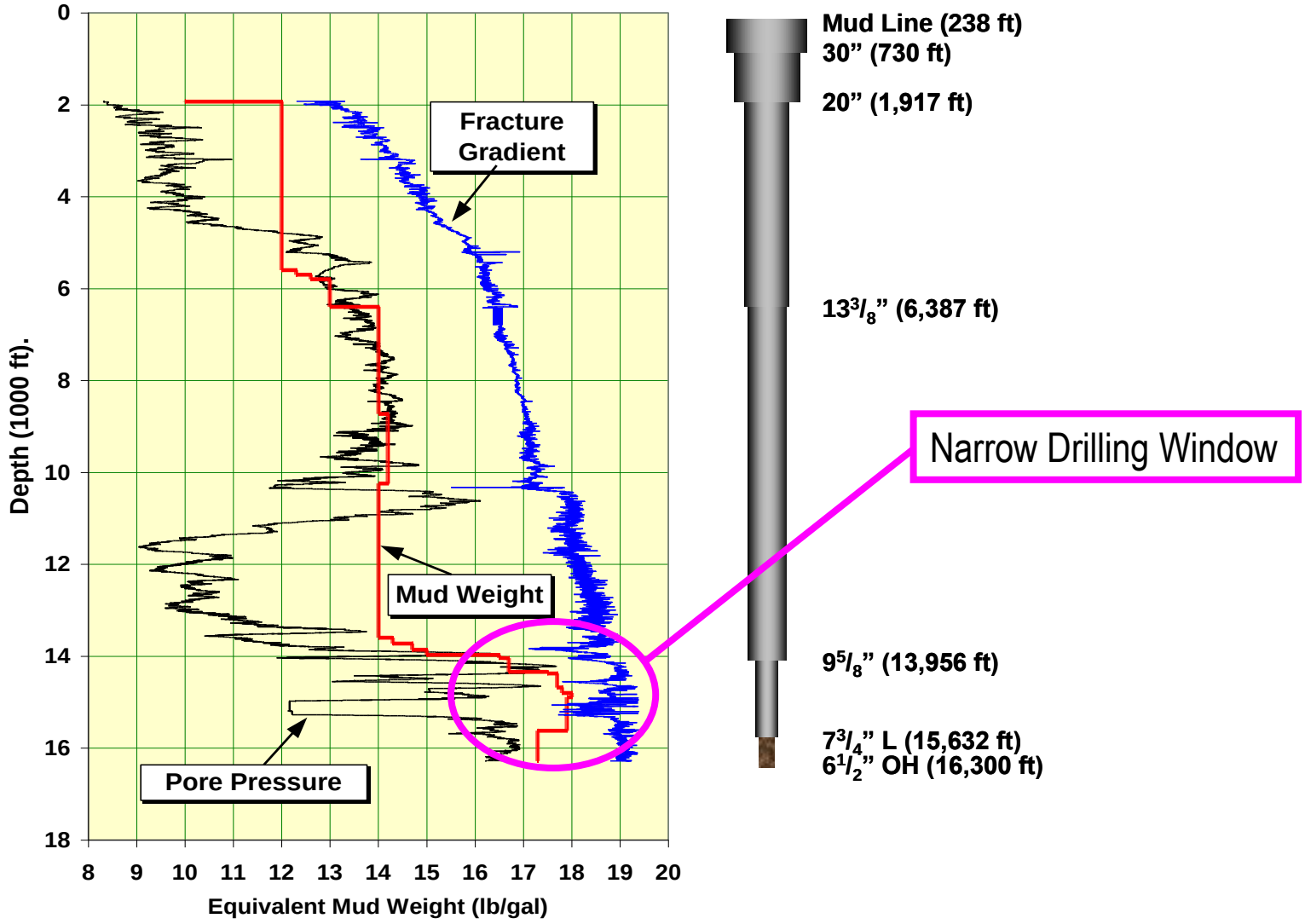


Predicted Values vs. Measured Depth

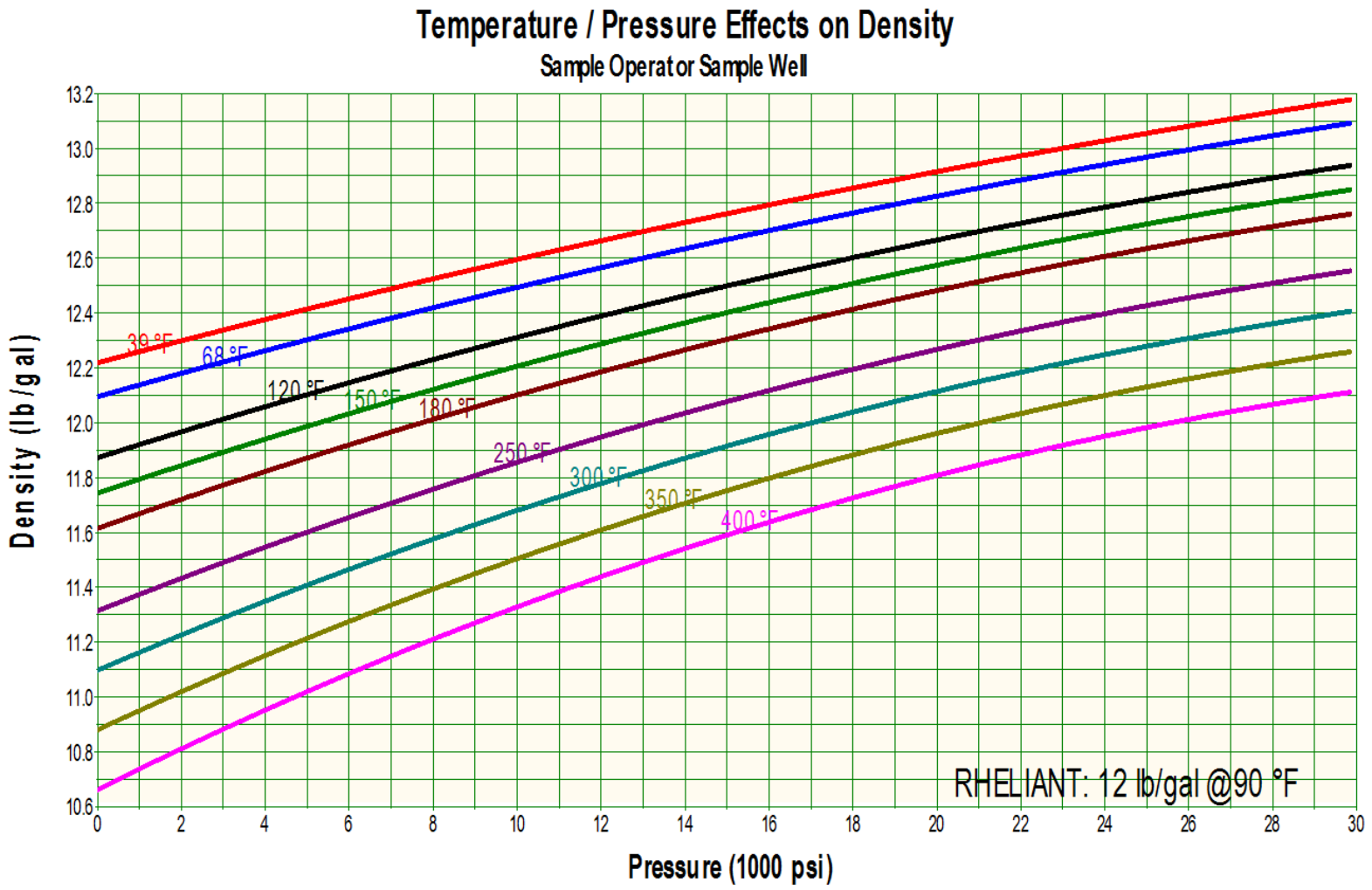


OMAE2013-11428
Zamora, et al.

ECD Management is all about windows!!!



New Tools to Work With …..



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Drilling Fluid Hydraulic Issues

"Hydrostatic Pressure is NOT equal to 0.052 x Mud Weight x TVD"

Mud Weight should be forever linked to the temperature at which it was measured

Hydrostatic pressure should be based on Equivalent Static Density **(ESD)**

ΔMW, because of Temperature and Pressure effects, can exceed calculated ΔPa for ECD calculations!

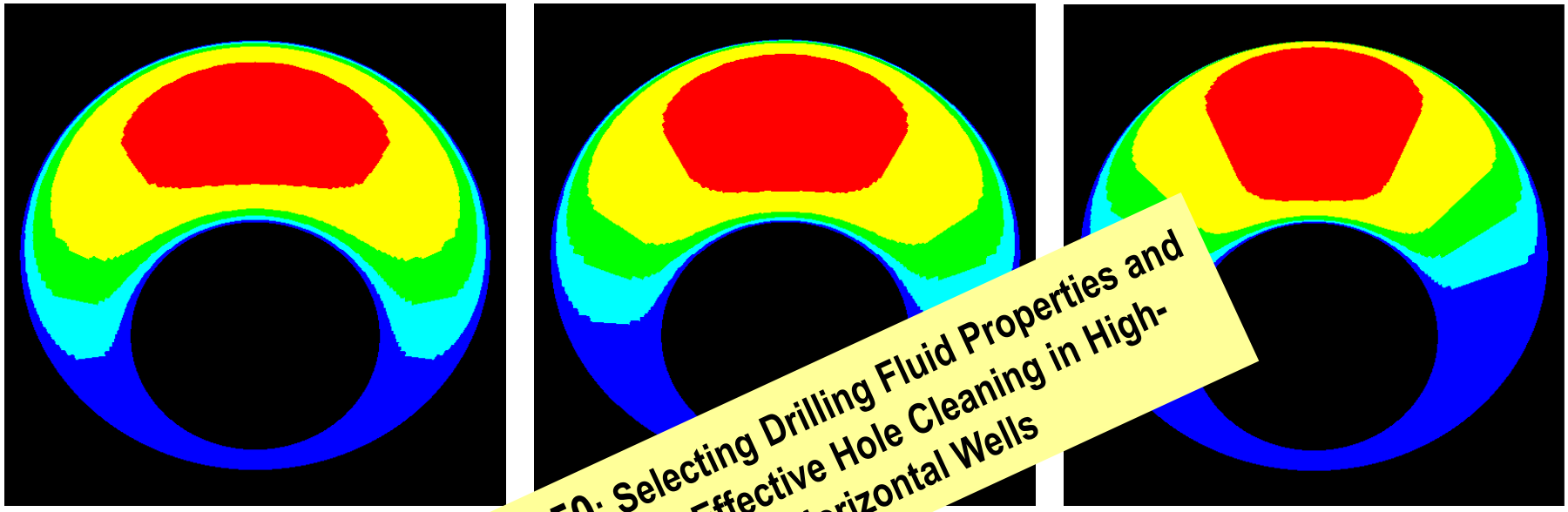
Downhole Densities (ESD/ECD) for Wellbore Stability

Velocity Profile: 8.5” Hole - 4.5” OD DP - 500 gpm - 12 ppg MW

“Right “ Rheology

“Thick “ Rheology

“Thicker “ Rheology



SPE 63050: Selecting Drilling Fluid Properties and Flow Rates For Effective Hole Cleaning in High-Angle and Horizontal Wells

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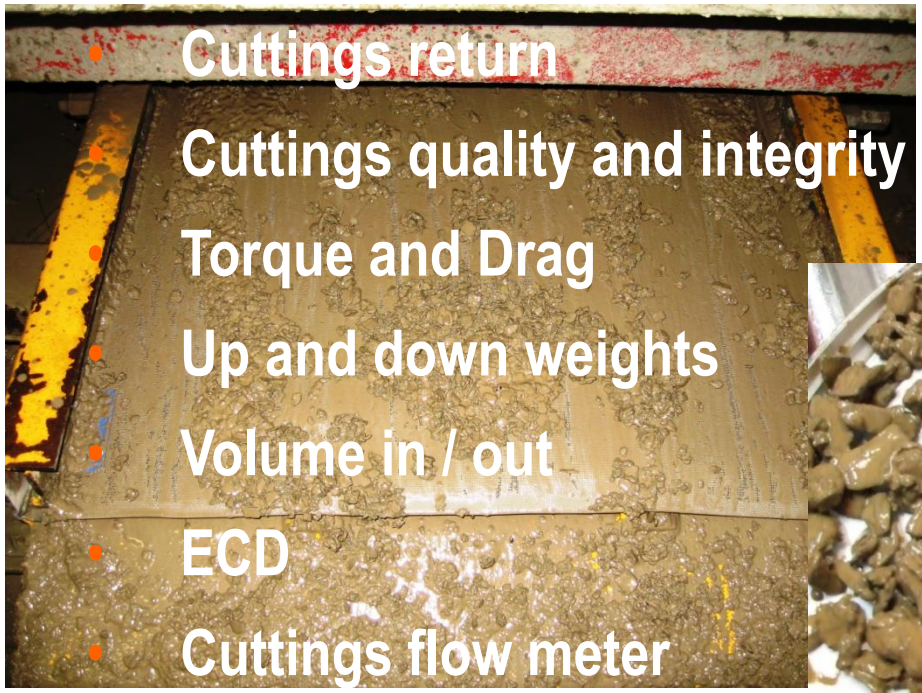
Optimization Efforts ……

Key Elements

- Drilling fluids viscosity should be an ***output*** not an ***input***
- Optimization scheme:
  - Temperature profile
  - Temperature and pressure effects on downhole density and rheology
  - Complex hole cleaning analysis.....
- Biggest challenge is prioritizing the boundary conditions when everything cannot be met simultaneously
  - What if we are pump pressure limited and must reduce the flow rate, should we just raise the viscosity or pump more sweeps?

Monitoring Hole Cleaning

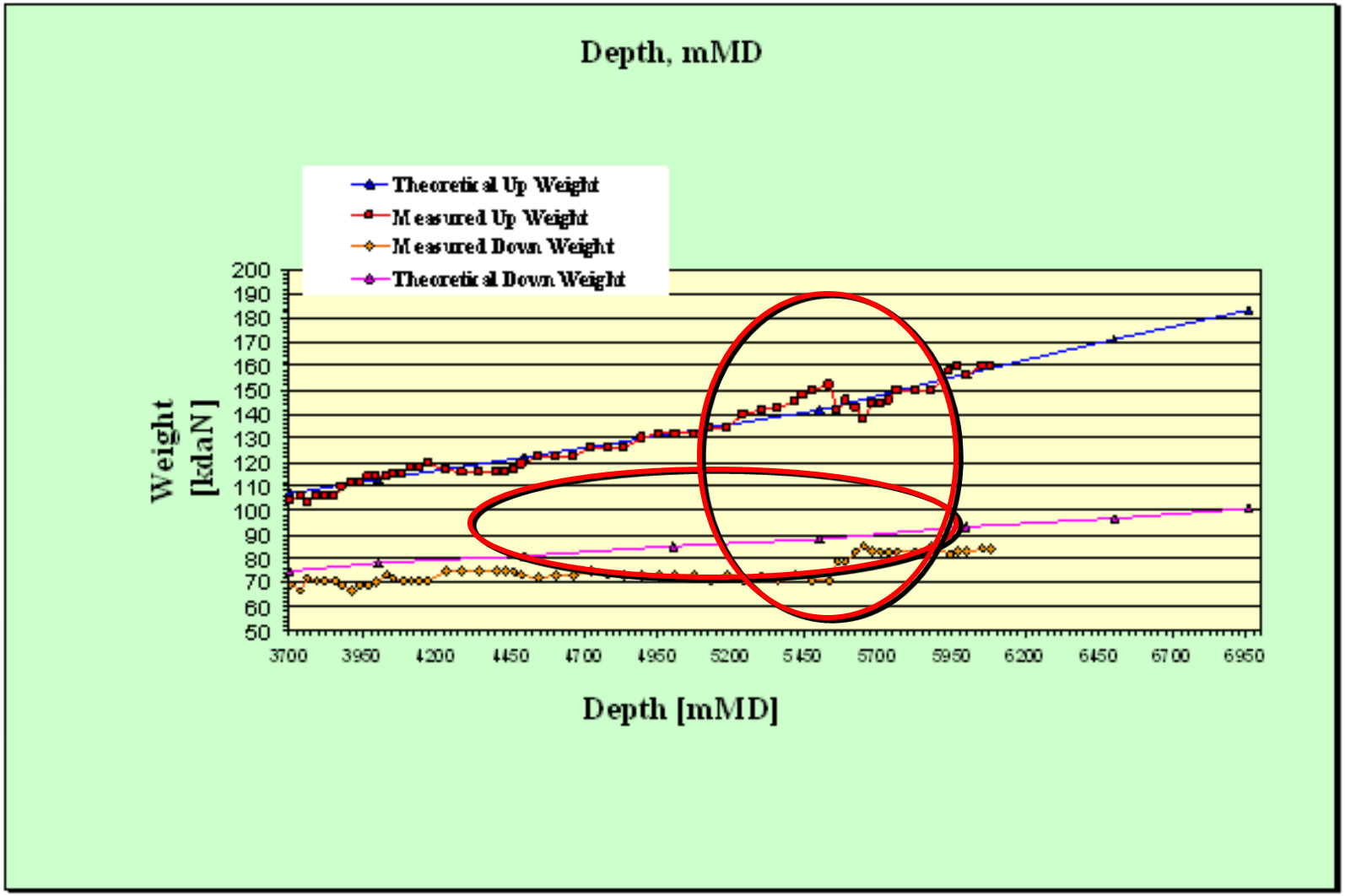
How to monitor hole cleaning – but not limited to:



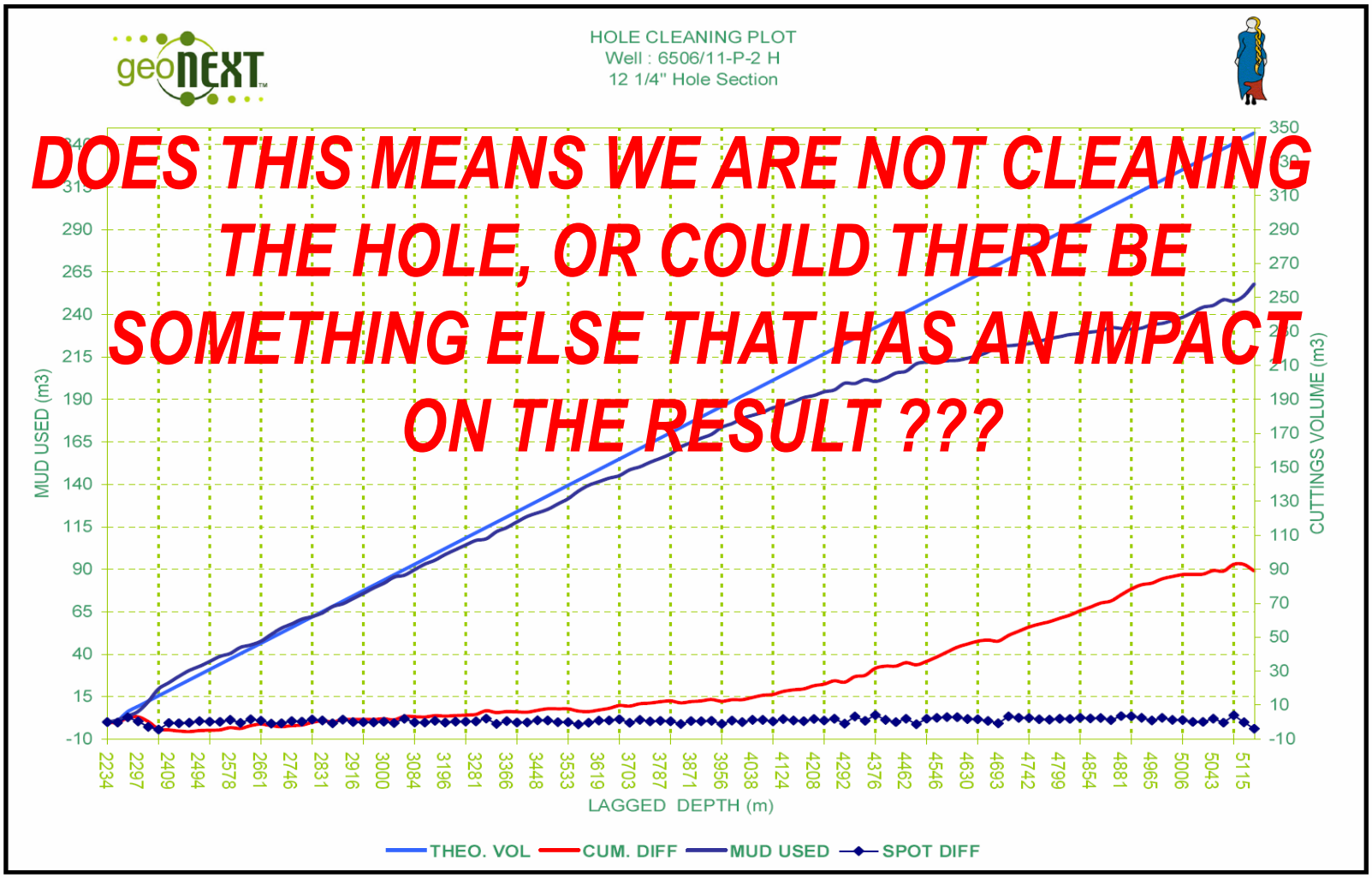
- Cuttings return
- Cuttings quality and integrity
- Torque and Drag
- Up and down weights
- Volume in / out
- ECD
- Cuttings flow meter

- APWD or RT caliper
- Drilling fluid properties
- ROC (Retention on Cuttings)

Up and Down Weights (Pick-up / Slack-Off Wt)



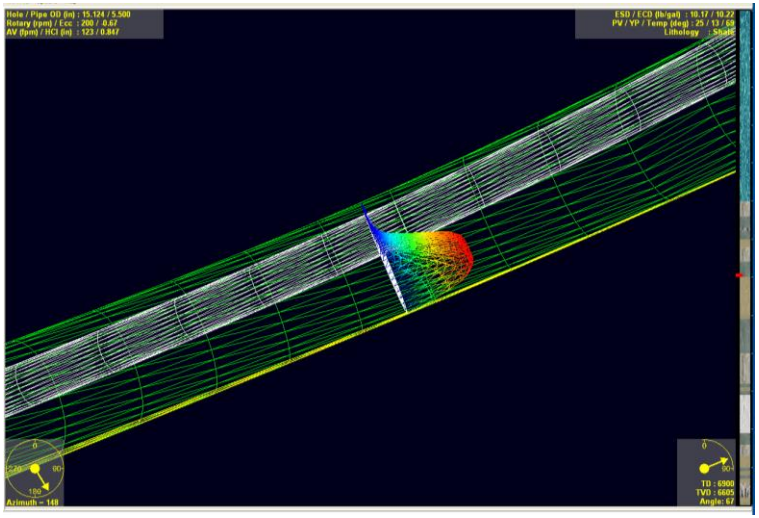
Hole Cleaning Plot



Hole-Cleaning Best Practices

Physical indicators of inadequate cleaning

- No cuttings over shakers
- Low volume of cuttings at surface compared to hole drilled (measured?)
- Hole fill in vertical wells
- Cuttings beds in directional wells
- Rapid ECD increase when starting drill string rotation
- Increasing torque
- Pick-Up & Slack-Off weights
- Increased drag after connections
- Bridges, tight hole and/or packoffs
- Stuck pipe



When is the Hole Clean?

- ”*Hole cleaning is adequate if no operational problems are encountered*”
- A clean hole can be defined as ”*a wellbore with a cuttings bed height and distribution such that operations are trouble free*”.
- A ”clean” hole does not mean the same for drilling and tripping, due to differences in:
  - Annular clearances and
  - Tripping pipe through cuttings beds

Decisions, Decisions !!!!

Do we know what we need?

Do we understand what we want?

Thank you

The floor is open …..