The SPE Distinguished Lecturer Program is funded principally through a grant from the SPE Foundation.

The society gratefully acknowledges the companies that support this program by allowing their professionals to participate as lecturers.

Special thanks to the American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME) for its contribution to the program.
Well Construction Hydraulics in Challenging Environments

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Outline

• Introduction
• Offshore/onshore challenges
• Hydraulic concerns
  – Drilling
  – Fluid displacement
  – Completion
• Relevant field results
• Final remarks / future trends
Challenging Environments

- Offshore:
  - Deep and ultra deep waters

- Reservoir related issues
  - Salt drilling
  - Non-consolidated sands
  - Heavy oil reservoirs
  - Heterogeneous carbonates

- Low cost on-shore drilling
Offshore Challenges – Well Trajectory

Water Depth 500~3000m

- Vertical exploratory wells

TVD ~3000m
Offshore Challenges – Well Trajectory

Water Depth 500~3000m

- Inclined and horizontal development wells

$L = 500-700$ m
Offshore Challenges – Well Trajectory

Water Depth 500~3000m

- Challenge: long horizontal sections (heavy oil fields)

$L \geq 1200 \text{ m}$
Challenge: ERW (dry completion, UDW)

\[
\frac{LD}{TVD} \geq 2
\]
Offshore Challenges

New Offshore Frontiers
- Deep and Ultra Deepwaters
  - Short sediment layers
  - Rocks w/ low fracture resistance

New Discovered Fields
- Heavy oil w/ high viscosity
  - Long horizontal sections
  - High friction losses

Narrow operational window
(drilling, fl displacement, gravel packing)
Onshore Challenges - Trajectory

- Slant rig drilling – short radius horizontal wells to exploit shallow water reservoirs
- ERW in environmentally delicate area to exploit shallow water reservoirs
Onshore Challenges

- Low cost projects
- Depleted reservoirs
- Limited rig equipment
Hydraulic Concerns in Well Construction

- Drilling
- Fluid Substitution
- Completion
Work Strategy

- Multidisciplinary teams
- In house R&D group
- External Cooperation
  - Universities and research institutes
  - Service companies
  - Partner operators
Drilling Hydraulics - Goals

- Achieve proper hole cleaning, maintaining pressures inside operational window
- Real time monitoring of downhole pressures
Well Construction

- Optimized Design
- Real Time Data Collection
- Risk Assessment
- Well Quality Assurance
- Rock Fluid Integration
- Lubricity and Drag Reduction
- Stuck Pipe Prevention
- Wellbore Stability
- Cuttings Transport
Hole Cleaning

- Reliable mechanistic model
- Experimental validation
- Transient effects
- User friendly in house developed software
- Operational procedures
Hydraulics Optimization

- Combine minimum hole cleaning criteria within operational window constraints
- Sensitive Formations – hole enlargement issues
  - Heavy Oil
  - Salt
Real time Monitoring of downhole pressures

- Dynamic modeling
- Interpretation Methodology
- Software for rig and decision support centers use

Interpretation modulus
Fluid Displacement - Focus

- Synthetic fluids by water based fluids – Minimizing contamination in the riser
- Drill in fluid by completion fluid in Horizontal wells
- CFD Simulation + experiments
Open Hole Gravel Pack

- Major sand control strategy for offshore wells
  - Conventional operation: alpha/beta wave placement
  - Hydraulic concerns: excessive pressure during beta wave placement in long horizontal sections
OHGP

- Reliable mechanistic model (borrowed from cuttings transport predictions)
- Experimental validation
- User friendly in house developed software
- Extending hydraulic limits
OHGP – Operational Window

Variable Pump rate schedule
Relevant Field Results

- 230+ OHGP in sections as long as 3600 ft
- Exploratory drilling in sub-salt / UDW environments
- Offshore ERW(LD/VD=1.73, WD=1217 m)
- 2000 m horizontal section in shallow water carbonate reservoirs
Relevant Field Results

- Managed pressure drilling onshore experiences

- Extended reach onshore wells for offshore reservoir exploitation (LD/VD=3.3), 23 wells drilled

- Slant rig drilling ERW - (LD/VD=10)

- Open hole gravel packing with synthetic low viscosity fluids
Final Remarks

- Long Horizontal wells in non consolidated sands – technology is ready to build longer sections

- Real time monitoring and data interpretation – key for reducing well costs and increasing operational safety
Future - Challenges

- Naturally fractured reservoirs – loss control
- Inclined, horizontal and ERW in sub-salt environments
- Offshore Multilaterals
Future – Technological Drives Related to Hydraulics

- Smart fluids
- Drag reducing additives and tools
- Downhole measurements
- Real time data analysis and control
- Advanced Simulation
- Offshore MPD
Thanks