What Limits Reach in Deep Water?

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Introduction

• Upcoming projects exceed industry ER experience
  – Technical limitations can be solved with existing technology
    • Limitations are different for deep vs. shallow BML
  – Fear often trumps legitimate technical rationale
    • Due to bad experiences in the past with ER wells
    • Or perception that vertical is faster, cheaper, and easier

• ERD Wells in Deep Water are more challenging
  – Compared to vertical deep water
  – Compared to shallow-water or land based ERD

• However, the challenges can be met
  – With fundamental engineering
  – Then application of appropriate technology
Only Wells in >3000’ Water Depth (98 Wells)

Worldwide Reach Record: ±38,000’

>1,000’ Water Depth Reach Record = ±30,000’

>3,000’ Water Depth Reach Record = ±20,000’
Several ER Projects Studied Recently
- Various regions and local constraints
- All wells deemed feasible
- Common themes in most wells

Realistically Possible Future Extension
1. Application of fundamental engineering
2. Appropriate use of technology
What Limits Deep Water Reach?

Depends on the “Type”:

- **Shallow** (<7,000’) below Mudline
  1. ECD – Rapid growth relative to fracture gradient
  2. Drag / Buckling - Running casing and completions

- **Deep** (>15,000’) below Mudline
  1. Tension – Drives exotic drillstring and hoisting equipment
  2. Side Forces – Generally quite high (depends on KOP and DLS)
    - Creates high torque
    - Elevates risk of casing & drillpipe wear
  3. Hydraulics - Deep “big hole” drives rig hydraulics package and drillstring (which then complicates tension and side force)
“Shallow” BML Example

- Offshore Egypt
- TLP Based ERD Development Opportunity
- ±3,500’ Water Depth, ±7,000’ TVD (±3,500’ BML)
- Up to 11,000’ Departure Required
- Narrow Pore Pressure / Fracture Gradient Margin
  - Mud Weight Driven by Wellbore Stability
  - ±1.0 ppg EMW Window in reservoir
- Base Case uses vertical design from offsets
  - 13\(\frac{3}{8}\)”, 9\(\frac{5}{8}\)”,” 6\(\frac{5}{8}\)” screens
  - “Standard” design to simplify logistics
“Shallow” BML Example

Base Case:
- Drill riserless and set 13\(\frac{3}{8}\)” @ ±5,100’
- Install 13\(\frac{5}{8}\)” riser and drill to TD
- 9\(\frac{5}{8}\)” set near top reservoir

ERD Design:
- Set 20” @ ±4,800’ (due to MW for stability)
- Set 16” @ ±5,800’ TVD (due to MW for stability)
- 10\(\frac{3}{4}\)” set near top reservoir (required for ECD management)

Key challenges are ECD and Drag management…
Pore / Frac / Collapse Gradients

- For S-Path Trajectory
- Mud Weights for Stability + Swab

8½” Drilling ECD with 5⅜” drillpipe through 9⅜” casing is unmanageable

5” drillpipe is unmanageable too

5”x4½” drillpipe is marginal

Drilling 9½” hole through 10¾” intermediate with 5” drillpipe provides adequate margin

ECD when circulating 10¾” in 13½” hole exceeds FG – unacceptable risk for cement job – High Rate Gas Well!

Upsizing to 14¾” (through 16” casing / riser) reduced ECD to acceptable levels

Application for Managed Pressure Drilling (MPD)

- Optimization for wells of this departure
- A requirement for longer wells
10\(\frac{3}{4}\)” Conventional Casing Run

Casing stops 1,000-2,000’ off bottom if conventional running methods are used.
- Why?
- Helical buckling of the landing string in the riser
10¾” Floated Casing Run

Solution:
- Run casing completely evacuated (flotation technique)
- Step change improvement in drag / buckling
- Other solutions possible (run as long string or on HWDP)
Conclusions

• **ECD and Drag the key limitations**
  – Solutions affect entire well design
  – Casing, Riser, Wellhead, and Drillstring

• **Vertical well design logic would have lead to failure**

• **Logistical convenience would have lead to failure**
  – 12-18 month lead time to procure appropriate materials

“Shallow” BML Example
Summary

• Solutions are available to exceed current industry ERD Envelope in Deep Water

• Pushing past perceived limits requires;
  – Fit-For-Purpose well design and equipment
  – Finesse to solve ECD and Drag (Shallow TVD BML wells)
  – Brute force rig equipment (Deep TVD BML wells)
Where is the Future?

- **Emerging Technology Opportunities**
  - Managed Pressure Drilling
  - Lightweight material (Al, Ti, HSS, Composite)
  - Sag resistant low-rheology fluids
  - Expandable Casing/Liner
    - Planned (as opposed to contingency)
    - Set shallow (as opposed to deep)
  - Telemetry solutions