

# Deepwater: Drilling Trouble Zones and Well Integrity

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# What is Drilling Trouble Zones?

**“Hole Problems” - Hole related NPT (non-productive time) that slows or interrupts drilling & increases rig days to planned depths**

## ❖ **Most costly hole problems**

- **Lost circulation to formations in narrow PP/FG profiles**
- **Stuck pipe mainly across low pressure zones**
- **Kicks and flows by high pressure zones**

## ❖ **Other hole problems**

- **Excessive drag: tight spots, tar, ledges, keyseats, etc.**
- **Rock problems: hard rock, bit balling, gumbo, rubble, swelling, etc.**
- **Poor hole cleaning: spiraling or irregular hole shapes/sizes, etc.**
- **High ECD limits pump rates: non-drilled rock solids in mud, bridging, etc.**
- **Poor directional control: washouts, breakouts, etc.**
- **Poor shoe tests: most caused by unexpectedly weak rocks**
- **Deformed holes or casing damage: high temperature rock movement**
- **Etc.**

# Wells with Trouble Zones?

Highest Cost in GoM Deepwater & Ultra-deepwater Wells

(Figure below from MMS 2006-022 OCS report)

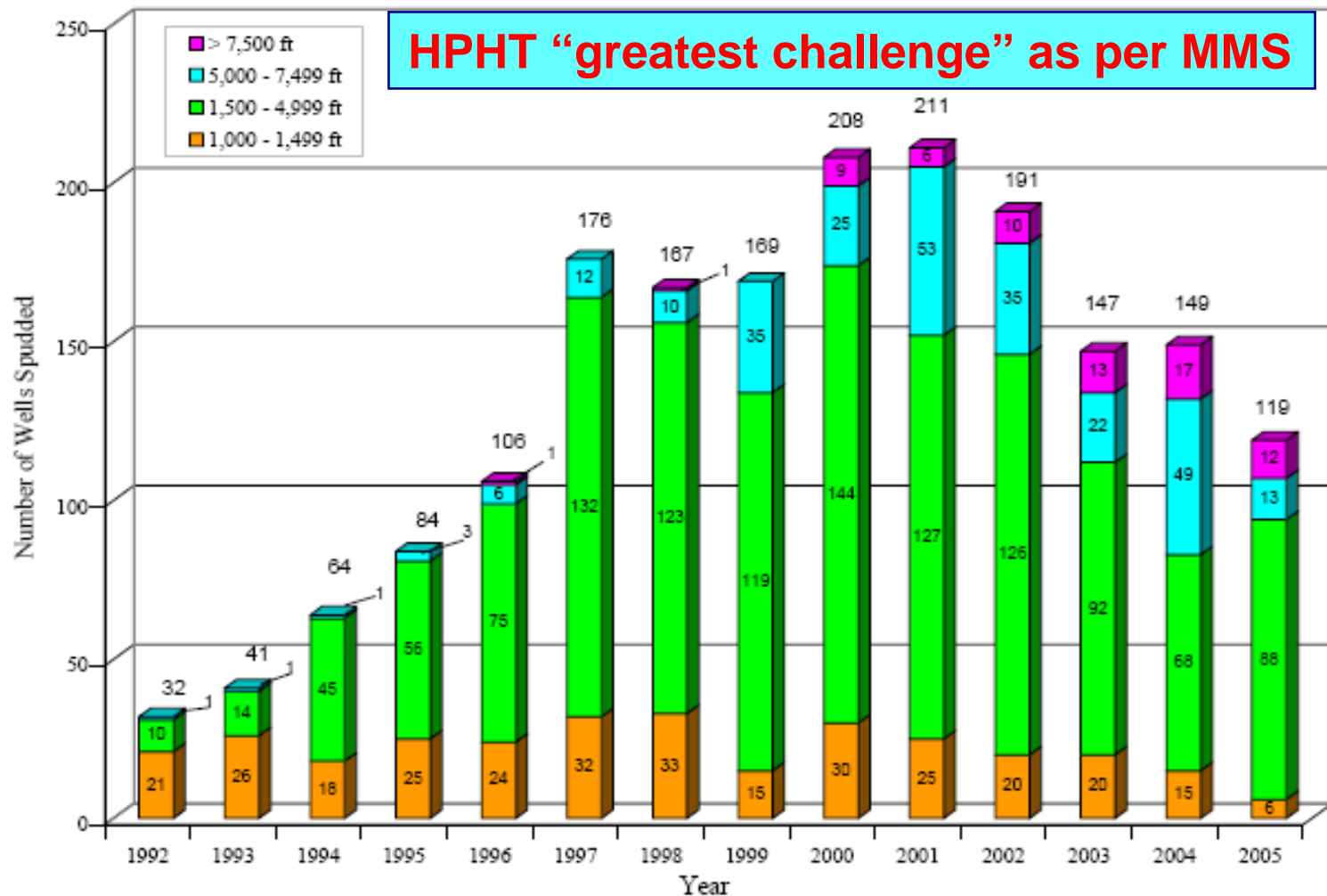
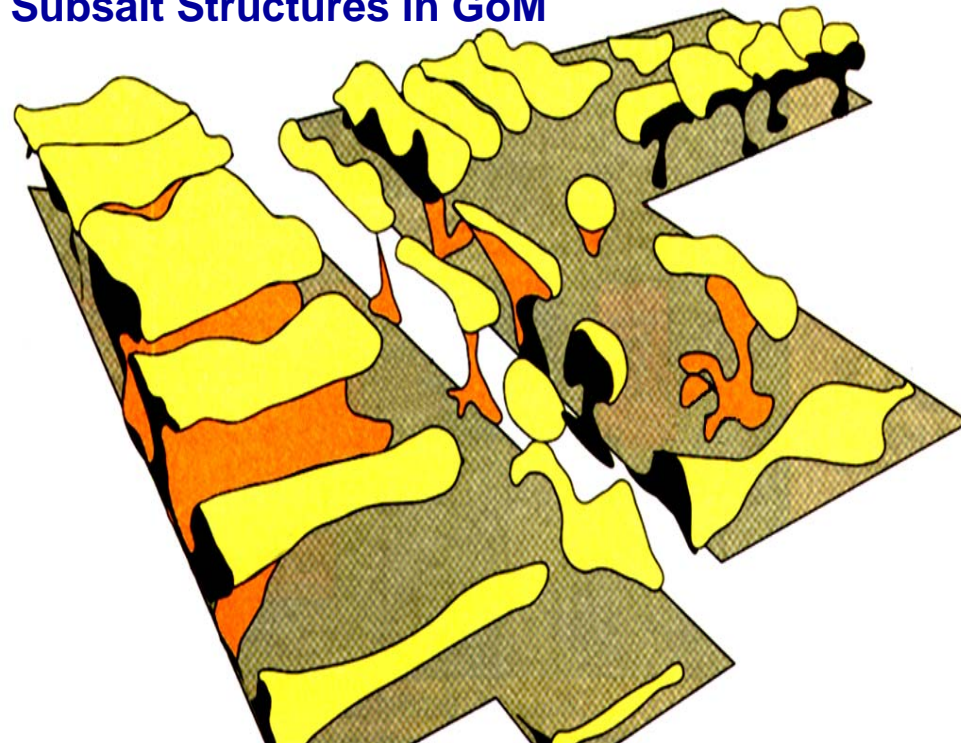


Figure 29. All deepwater wells drilled in the Gulf of Mexico, subdivided by water depth.

# Subsalt Wells Have Severe Trouble Zones

- ✓ Lost Circulation: Rubble Zones, Weak Shales, etc.
- ✓ Kicks & Crossflows: High Pressure Zones
- ✓ Formation Solids Influx: Gumbo, breakouts, sloughing shales
- ✓ Casing deformation: Moving salt zones at high temperatures

## Subsalt Structures in GoM



From University of Texas Bureau of Economic Geology,  
Offshore, January 1994



Subsalt: blue shaded area (MMS website)

# Trouble Zone HPHT Conditions?

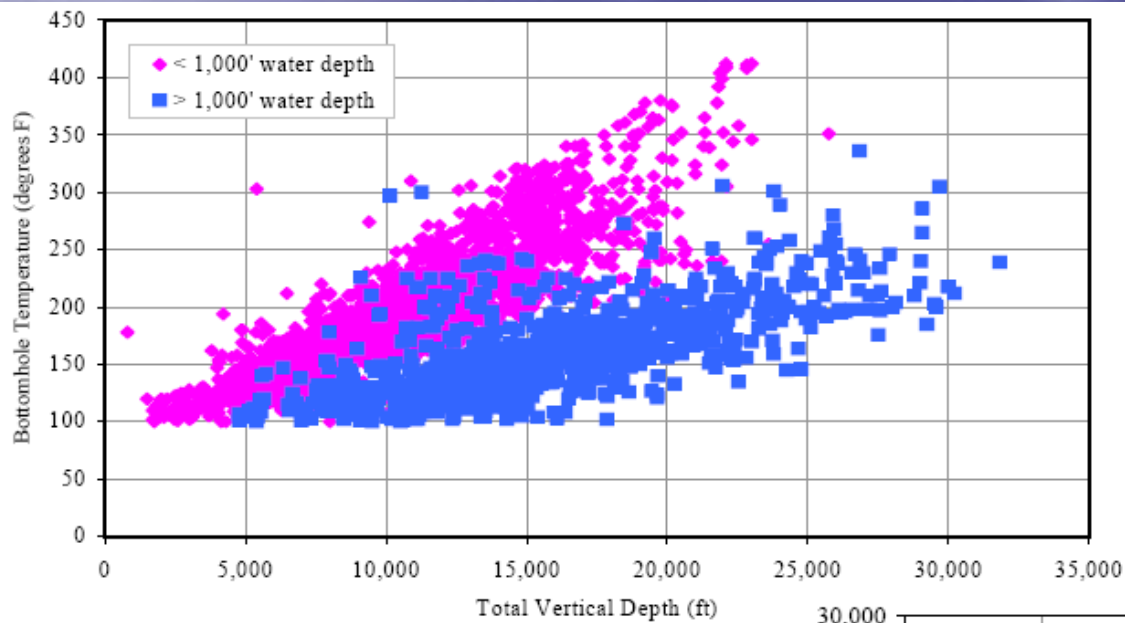


Figure 38. Bottomhole temperature (°F) versus total vertical depth.

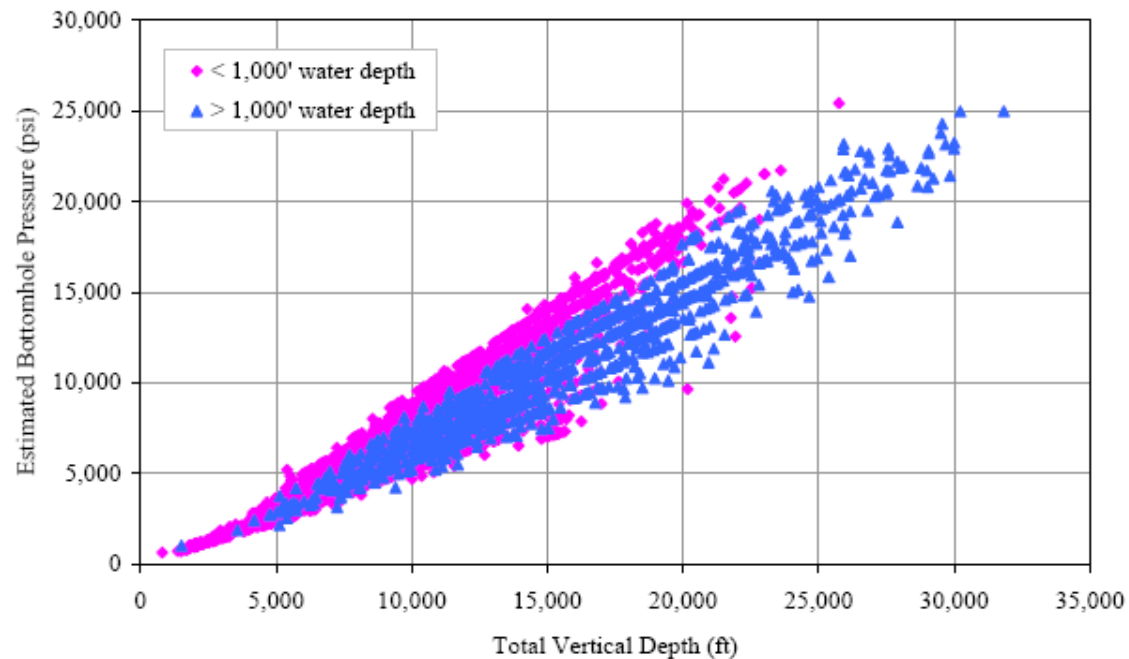


Figure 37. Estimated bottomhole pressure (psi) versus total vertical depth.

Figures from MMS 2006-022  
OCS report

# Industry's Hole Problem Costs in the Past?

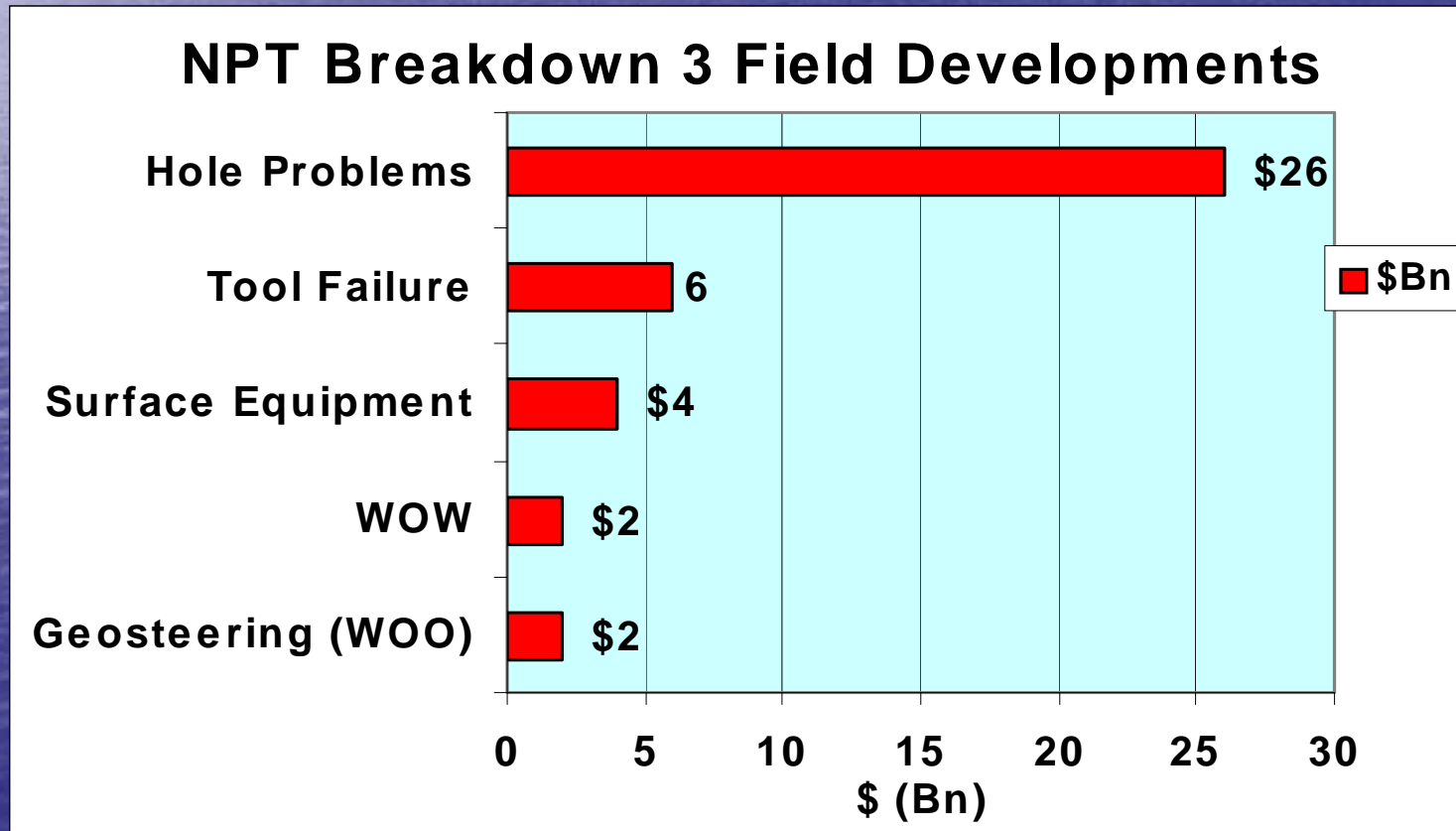
## 1998 Review (1985-1997 Data)

<u>Source</u>	<u>Estimate of costs for all industry wells</u>
✓ AMOCO:	\$600 Million to \$1 Billion per Year
✓ ARCO:	17% of Total Cost of Wells
✓ MOBIL:	Min. 10% of Total Cost of Wells
✓ Western-Atlas:	>\$6.4 Billion per Year
✓ HAL & Shell:	~\$8 Billion/1996 or ~30% of Total Cost of Wells
✓ Soloman Bros:	15% of Total Drilling Cost in 1996
✓ API Survey:	High Mud Losses in 19-24% of all Hole Sections
✓ GRI & OGS:	\$500-750 Million/year for Unstable Shales
✓ SHELL:	>\$500 Million/year in Unstable Shales
✓ BP (DeepStar):	\$167.6 Million/1985-97 SWF (123 deepwater wells)

# Hole Problem Costs Now!

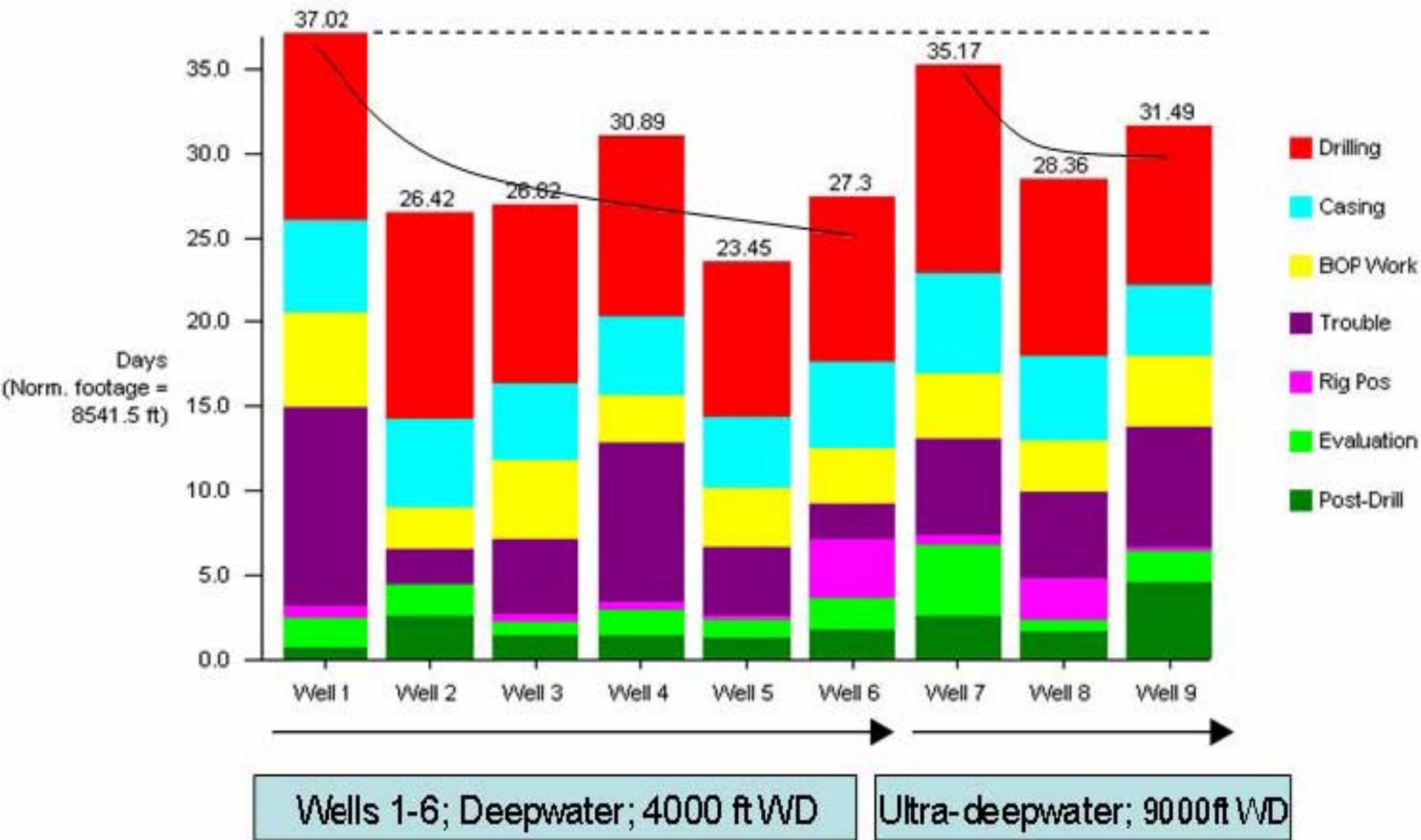
## 2006 Review with Updated Industry Data

- ❖ A deepwater squeeze job can cost \$1 million (mostly rig time)
- ❖ Recent study found 44% of NPT caused by “geopressure & wellbore instability related delays in well construction” (Standifird & Keaney)
- ❖ Hole problem estimated costs in all deepwater wells based on three fields:



# Example Deepwater Hole Trouble NPT

Most Trouble Days (OTC paper 16290 Figure 9 Purple) by Lost Circulation, Stuck Tools, Well Control, Tight Holes, & Hole Cleaning



# Research to Reduce Hole Problem Costs?

## Greatest Priorities:

- **Better pore- and frac-pressure prediction methods**
- **Measurements that “look ahead” of the bit to update predictions:**
  - Pore- and frac-pressures
  - Geomechanical stress
  - Correlating static Young’s modulus with dynamic values
  - Dimensional characterization of lost circulation out-flow paths
  - Improved methods to optimize drilling via real-time geomechanical analysis
- **Borehole integrity enhancement methods & materials:**
  - Integrated process to know when & what to apply
  - Drilling fluids that increase borehole integrity in shales while drilling
  - Same for other trouble zones such as unconsolidated sands & caverns

## **Other Priorities:**

- **Low cost “dual-gradient” method without multi-million\$ equipment**
- **Lower cost metallurgy to:**
  - Resist corrosive fluids
  - Overcome pressure integrity limitations in expandable casing & liners
- **How to drill from surface casing to total well depth in “one trip”**

# Deepwater Well integrity Issues

## TOP ISSUES:

- MMS says 40% of GoM deepwater wells have casing pressure
- Well failures reported by thermally induced annular pressure
- HPHT corrosive formation fluids & production effects on:
  - Tubular integrity
  - Pressure barrier sealing performance
    - Wellhead seals
    - Downhole mechanical seals in packers, etc.
    - Cement sealing & structural integrity

## Other Issues:

- Need for 20K rated well equipment
- High temperature elastomers are damaged in cold risers
- No way to monitor well integrity in un-accessible annuli:
  - Pressure containment
  - Structural integrity
  - During production
  - After well abandonment

# Research for Deepwater Well integrity

## TOP Priorities:

- How to mitigate casing pressure in deepwater wells
- Materials that resist HPHT corrosive formation fluids
  - Pressure barriers
  - Tubulars

## Other Priorities:

- High temperature elastomeric seals that resist cold temperatures
- Lower cost 20K rated well equipment
- Lower cost metallurgy to:
  - Resist corrosive fluids
  - Increase pressure integrity in expandable casing & liners
- Methods to monitor well integrity in inaccessible areas:
  - Cemented & non-cemented annuli
  - Liner laps
  - Annuli below packers
  - Multiple depths

A background image showing a vast blue ocean under a blue sky with light, wispy clouds. The sun is visible on the left side, creating a bright reflection on the water's surface.

**Thank you.....any questions or  
comments?**