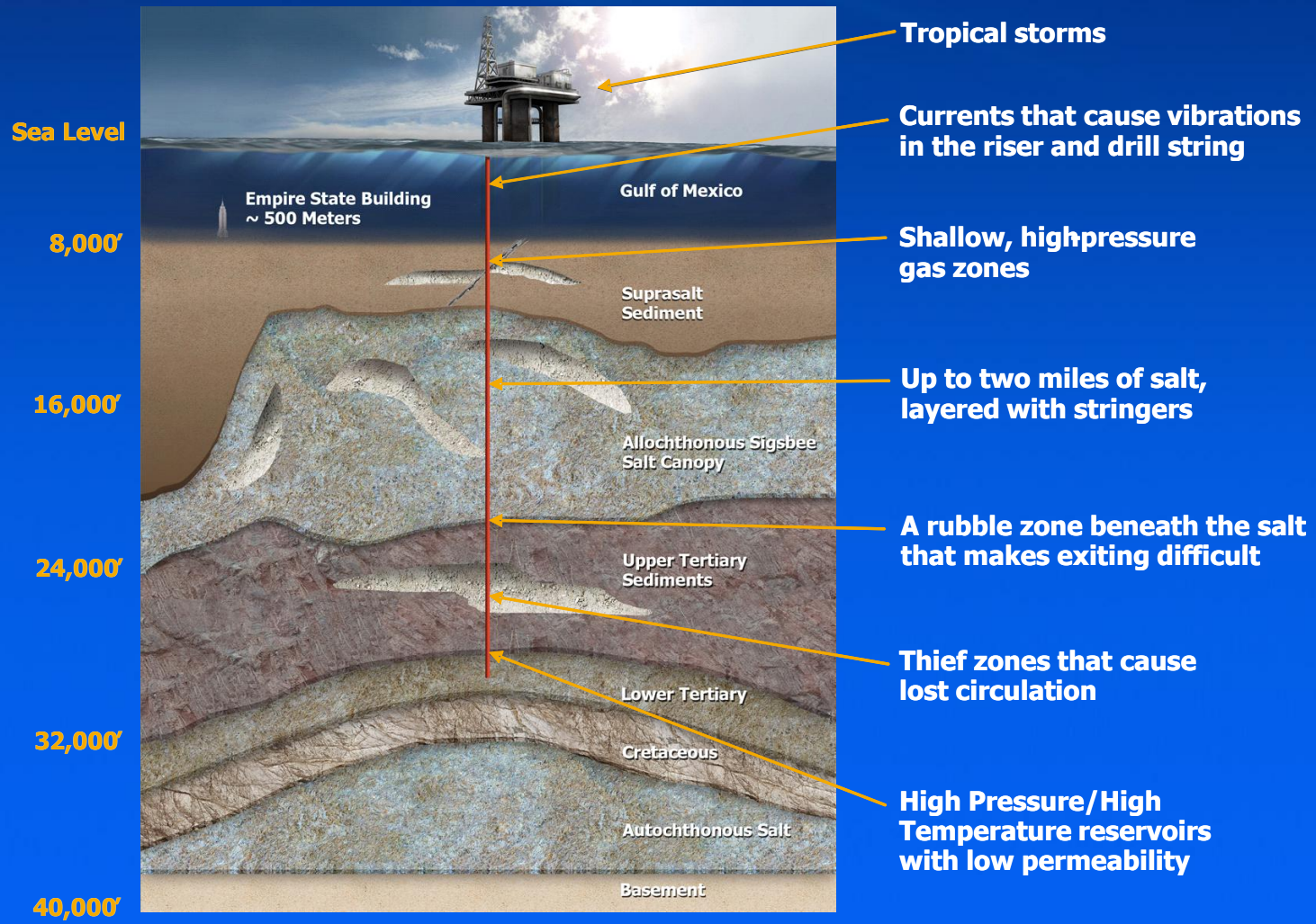


# AADE/Fluids Management Group: Advances in Deepwater Fluids

Best Available Technology & Practices for Successful  
Delivery of GoM Ultra-Deepwater Wells

Jeff Chaapel  
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# Deepwater Drilling Technical Challenges



# Ultra-Deepwater Case Wells

<b>Location</b>	<b>Water Depth</b>	<b>Salt Drilled</b>	<b>Total Depth</b>	<b>Mud Line Temp</b>	<b>Bottom Hole Static Temp</b>
<b>Walker Ridge</b>	<b>6,179'</b>	<b>19,475'</b>	<b>33,277'</b>	<b>35 F</b>	<b>275 F</b>
<b>Mississippi Canyon</b>	<b>5,656'</b>	<b>5,074'</b>	<b>29,821'</b>	<b>36 F</b>	<b>264 F</b>
<b>Walker Ridge</b>	<b>7,016'</b>	<b>11,078'</b>	<b>28,200'</b>	<b>37 F</b>	<b>196 F</b>
<b>Walker Ridge</b>	<b>7,201'</b>	<b>10,340'</b>	<b>30,955'</b>	<b>38 F</b>	<b>278 F</b>

# Dynamic Kill Drilling ( DKD™)



- What is DKD?
  - A riser-less drilling application
  - Dual gradient procedure - seawater gradient above the seabed & weighted mud gradient below the seabed
  - Provides precise management of hydrostatic pressure with increasing depth
- Process
  - Pre-well planning - fluid density, logistics, etc.
  - Computerized blending equipment - up to 3 streams
  - Weighted WBM - (16 lb/gal or 1.92 g/cc)
  - Blends heavy fluid on-the-fly composed of:
    - Seawater + weighted WBM slurry + heavy brine + polymers for fluids loss & viscosity control
  - Continuous circulation while drilling with returns to the seabed

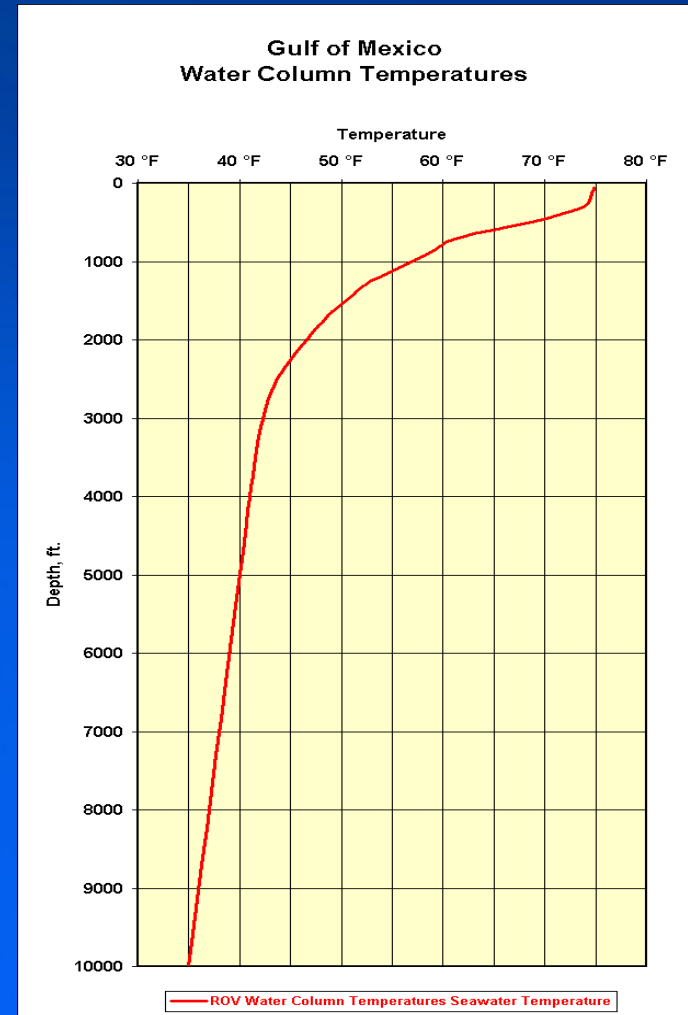
# Dynamic Kill Drilling (DKD) Considerations

- Capabilities & distance of shore base
- Shallow hazard analysis – evaluate the risk, but plan for the worst
- Key in ultra-deepwater: Required Leak Off Test (LOT) requires deepest shoe placement



# Synthetic-Based Mud Design Considerations

- Synthetics are fluid of choice
  - Compliant use for cuttings discharge in GoM
  - Highly reactive shale inhibition
  - Hole cleaning capability over wide range of temperature and pressure
  - High rates of penetration
  - Easy to maintain



# SBM Design Considerations

Synthetic fluid properties, concentrations and viscosity profile for the Bottom Interval (22,500'+)

MUD PROPERTIES	PLANNED	ACTUAL
Density (lb/gal)	10.4 – 11.5	10.2 – 11.8
PV (cP)	50 – 60	36 – 45
YP (lb/100 ft. <sup>2</sup> )	10 – 15	12 – 16
Synthetic-Water-Ratio	75:25 – 80:20	72:28 – 74:26
Water Phase Salinity (mg/L)	300 K	235 – 275
HTHP @ 250 <sup>0</sup> F (cc/30min)	< 2	3.6 – 4.2
PPA @ 250 <sup>0</sup> F (cc/ 30 min)	< 5	8.8 – 2.6
<b>MATERIAL CONCENTRATIONS</b>		
	<b>lb/bbl</b>	<b>lb/bbl</b>
Barite	As Needed	180
Compliant Synthetic Fluid	As Needed	
Organophilic Clay	2 – 4	2.7 – 3.6
CaCl 2 (% by weight)	30	22 – 25
Emulsifier	1.5 – 2.5 gal/bbl	1.3 – 1.5 gal/bbl
Bridging Agent A	15	6 – 6.6
Bridging Agent B	4	2.1 – 3.0
Bridging Agent C	4	4.1 – 6.6

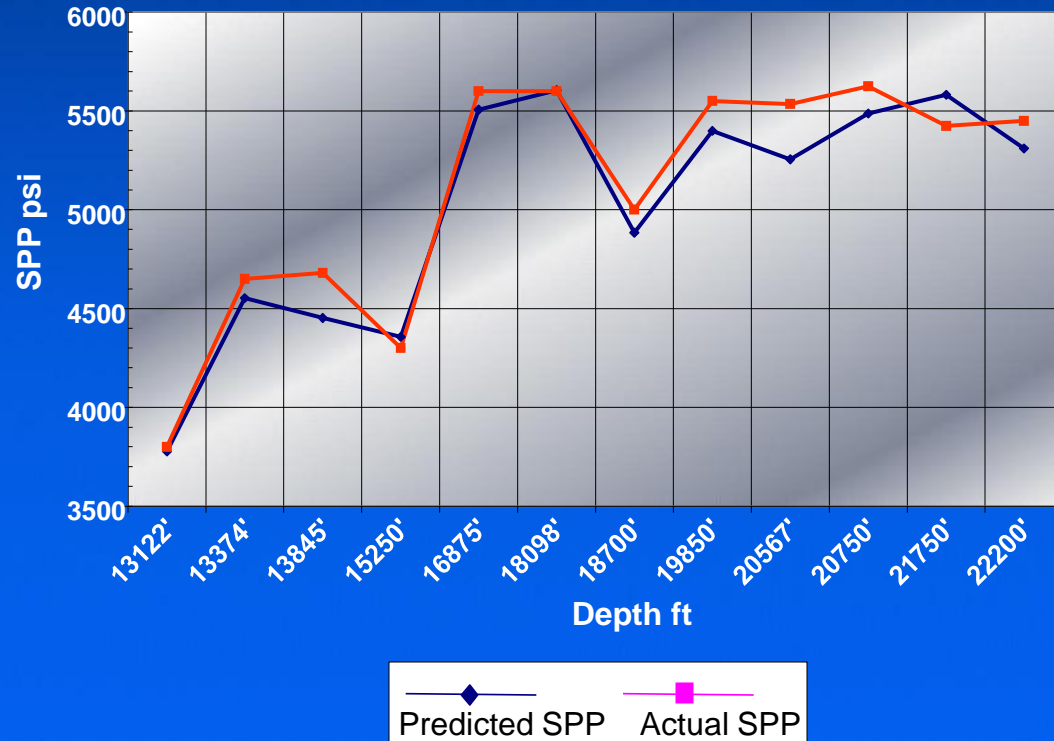
# Hydraulics Modeling

- Equivalent Circulating Density (ECD) Management:
  - Compressibility
  - Viscosity
  - Hole cleaning
- Evaluation of an array of fluid compositions:
  - Pressure
  - Volume
  - Temperature
- Other dependent factors:
  - ROP
  - Cuttings (density, size)
  - Drilling practices



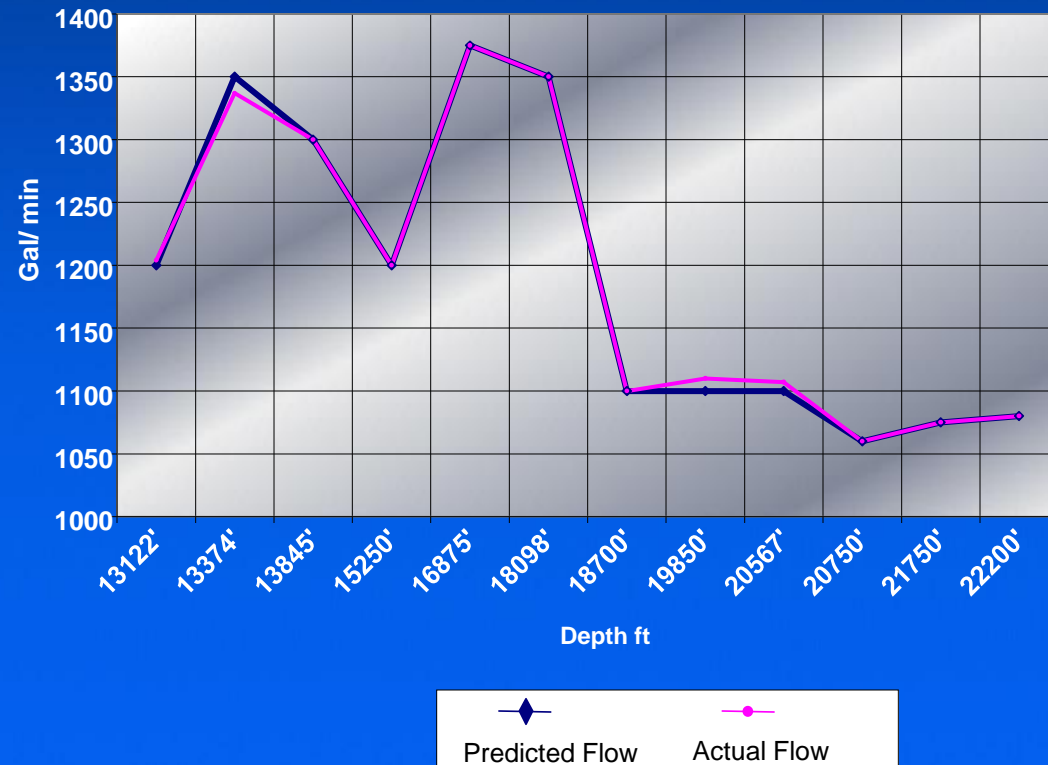
# Hydraulics Modeling

- Effects on Stand Pipe Pressure (SPP)
  - Flow rates
  - Drillstring config.
  - Temperature
- Viscosity profiles adjusted to deliver max hole cleaning with available flow rates
- Because of many variables, SPP most difficult parameter to predict, model



# Hole Cleaning Considerations

- Cuttings overload
- Viscous weighted sweeps prove most beneficial
- Light initial mud weights require special attention
- Sweep simulations reduced cuttings conc. from 3% to 1.7% while maintaining ROP of 50-75 ft/hr



# Lost Circulation Avoidance and Management



Select bridging rule

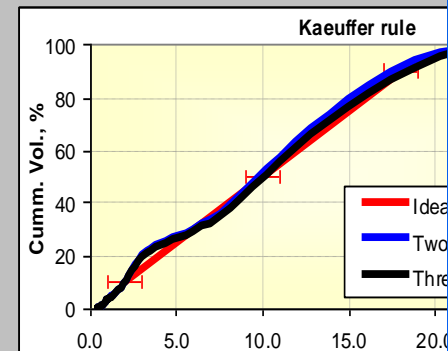
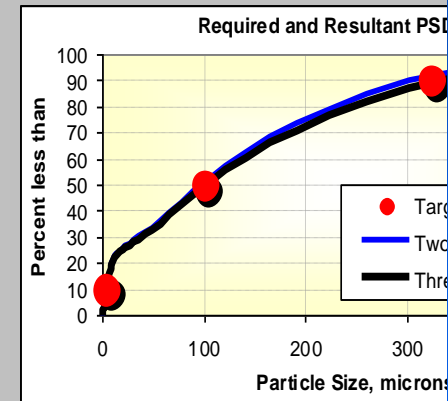
Select what information is known

Max. Pore Size or Fracture width  microns

Bridging material concentration:

Code	Products	D-90	D-50	D-10
1	MILCARB 5	21	7	1
2	MILCARB	121	15	2
3	MILCARB 50	124	44	4
4	SOLUFLAKE SF	216	55	6
5	CHEK-LOSS	192	74	17
6	SOLUFLAKE F	432	174	14
7	MILCARB 150	384	178	22
8	LC LUBE	483	326	165
9	MILCARB 450	536	451	15

Enter Product Code below to select products to be used



# Lessons Learned – Above Salt

- Communication – review all planned activities for hole section with DS, DE, Drilling Foremen, Mud Engineers and Transportation Personnel
- If a new boat is being used, once the boat has 1,000 bbl on board, have the boat pump back to the Liquid Mud Plant to time how fast it can pump
- Once rig is full of DKD mud, plan on using the boat with the slowest pump time first
- Survey the rig a week prior to rigging up the DKD manifold to make sure all required parts are shipped
- Before converting from seawater to DKD mud, make sure the bit is off bottom
- Calculate U-Pressure and know what flow rate will achieve full drill string engagement (Positive SPP)
- Use PHPA sweeps while jetting 36" casing to reduce skin friction

# Lessons Learned – Through Salt

- SBM  $\neq$  /  $<$  than planned displacement mud weight
- Keep 1,500 bbl of heavier SBM on board for slugs
- While drilling salt plan on a SRE of 95-97%
- Keep mud weight while drilling salt at 90-93% of overburden gradient
- Maximum ROP should be based on ECD and SCE
- No more than 2 sweeps in the hole at one time
- Plan on ROP's of 100-125 fph
- It is common to experience 5-12 bph SBM losses while drilling salt – maintain LCM concentrations

# Lessons Learned – Sub Salt

- Have a salt-exit strategy and stick to it
- Begin monitoring for Tar and follow Tar mitigation plan
- Pore pressure mitigation is common below salt. Have a pit mgmt plan in place in case reduction in MW is required
- Plan on SRE of 90-94%
- Model hydraulics with ADVANTAGE and compare to actual PWD
- Use coarse barite in sweeps to keep from weighting up the system
- Baseline PPT filtration control on a 35 micron disk @ 250F and 2500 psi, maintaining with 10-12 ppb MILCARB, 3-5 ppb LC LUBE and 4-6 ppb CHEK-LOSS PLUS. Target a spurt of 2.0 cc's and a total fluid loss of <5.0 cc's. Lower the spurt and total fluid loss as the hole gets deeper

# Deepwater Drilling Technical Challenges

