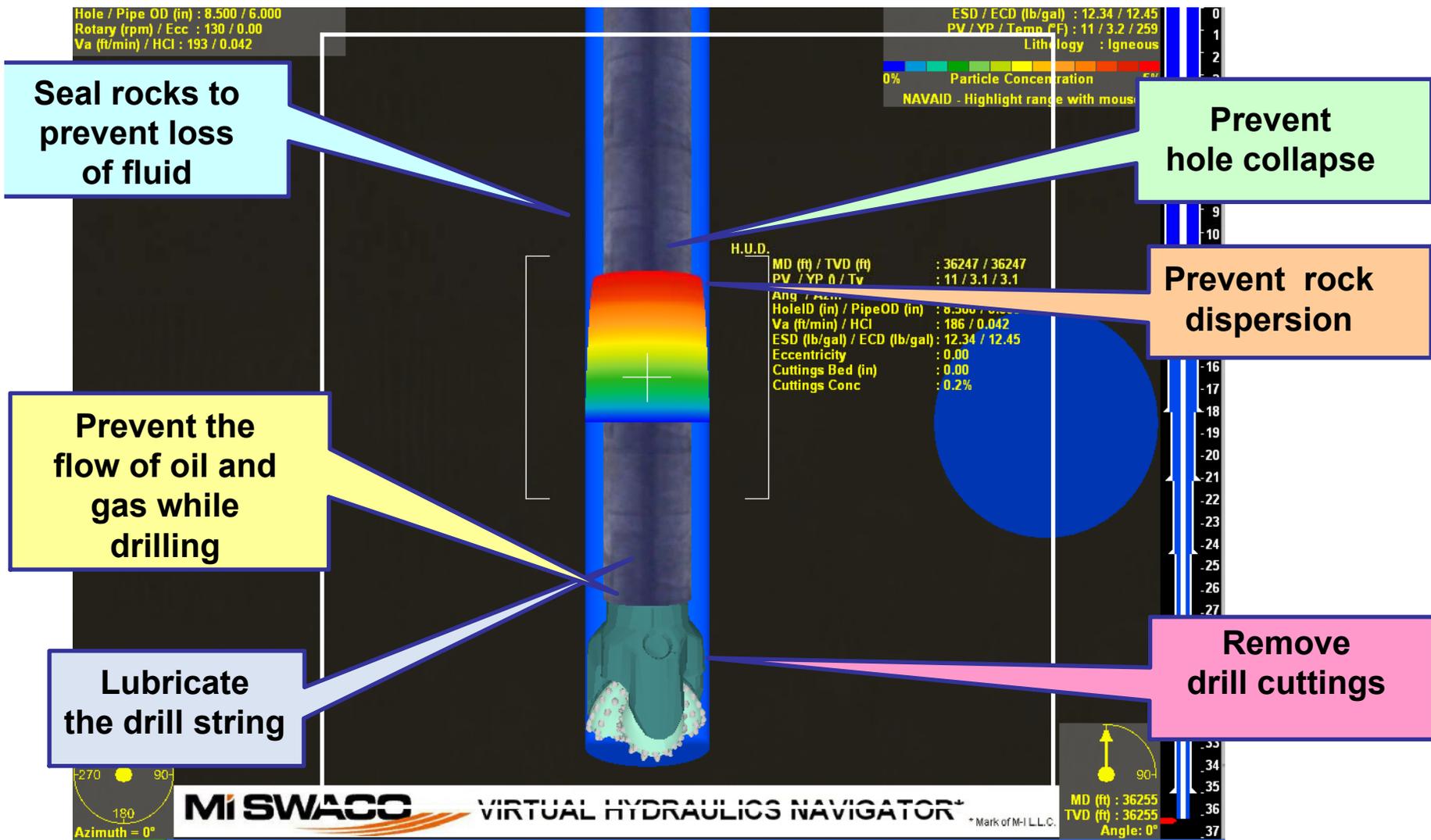


An Introduction to Drilling Fluid- And Making Deep Holes

Michael A. Freeman, PhD

Scientific Advisor/R&E Fellow

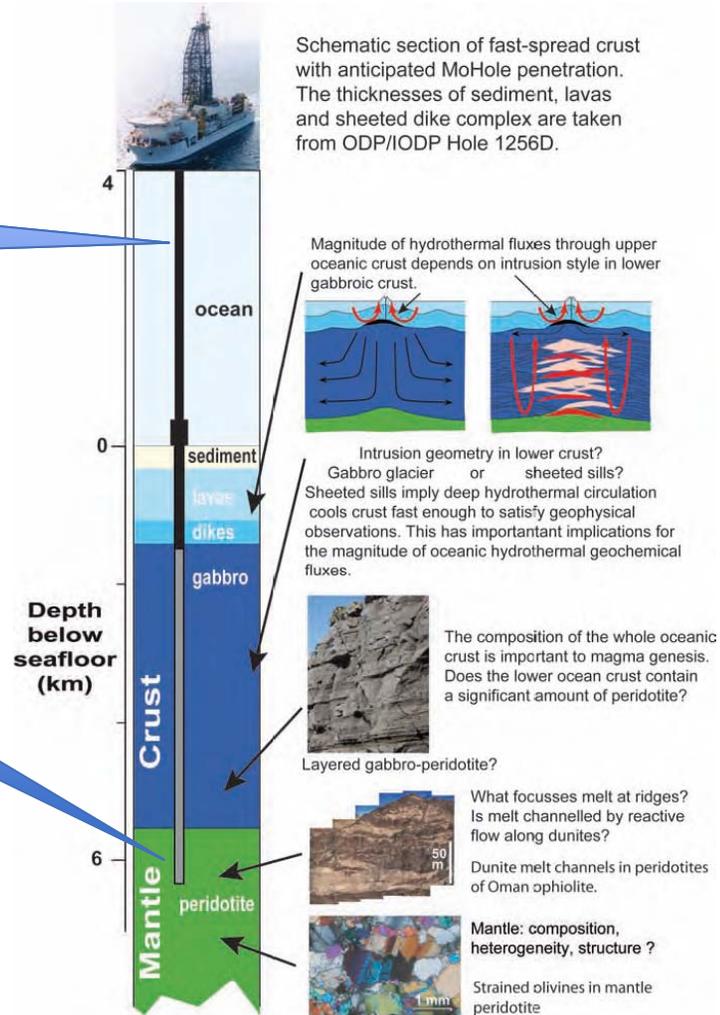
What Drilling Fluid (Mud) Does



To Get To The MoHo, You Must Make a Hole.

Drill with a pipe, and pump fluid down the center

Rock is broken by the bit and lifted to the surface

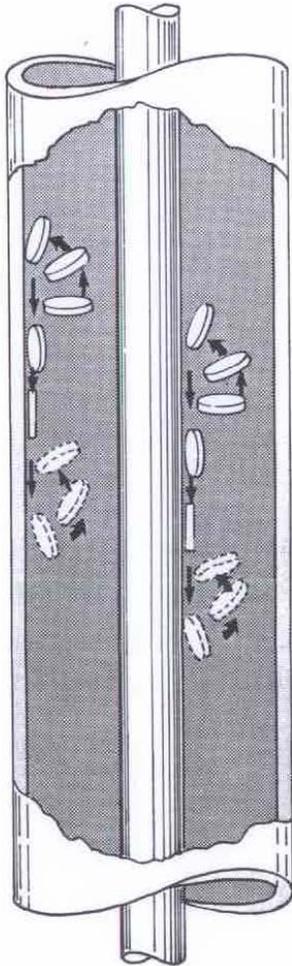


Water Can Not Lift Cuttings as Holes Go Deeper



Mud (clay suspension) cleans the hole!

Lifting Rock Up the Hole Requires Overcoming Gravity



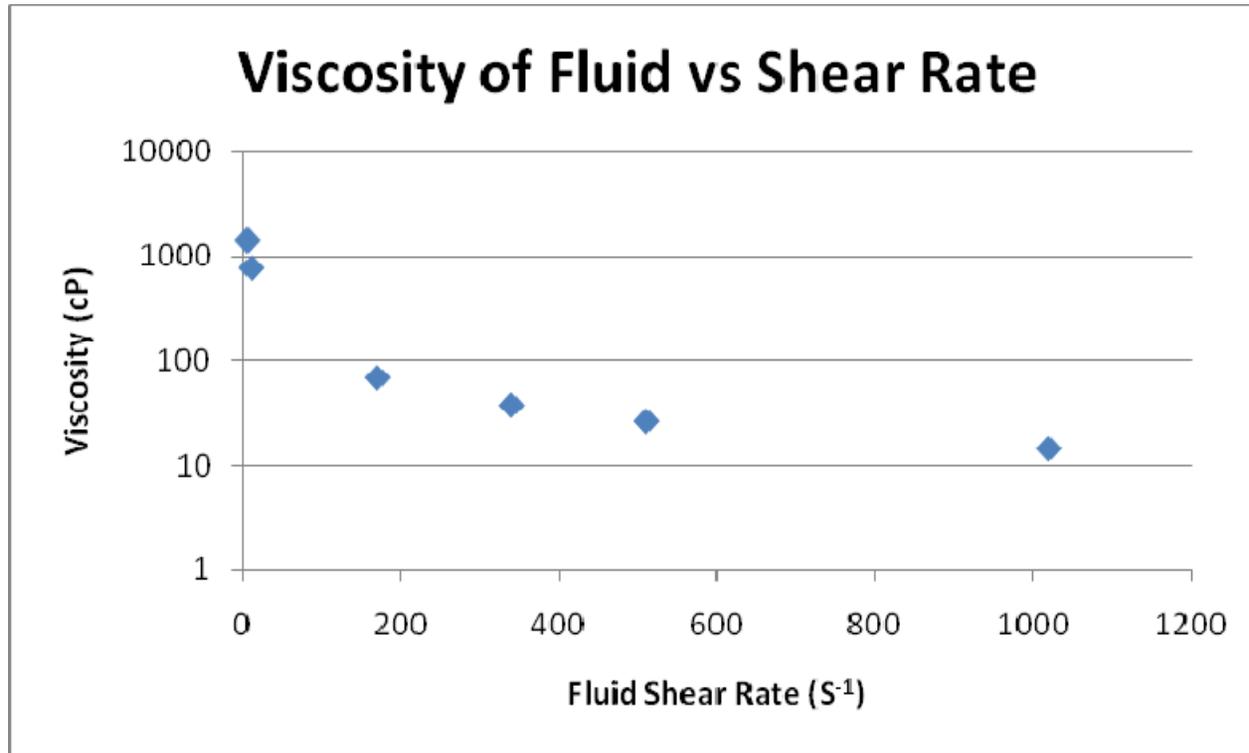
Stokes Law

$$V_s = kG \frac{d_c^2 (\rho_s - \rho_m)}{\mu}$$

V_s	=	Settling velocity
G	=	Gravitational Constant
k	=	Parametric Constant
d_c	=	Particle diameter
ρ_s	=	Density of Rock
ρ_m	=	Density of Fluid
μ	=	Viscosity of Fluid

Mud provides viscosity and density

Drilling Fluid Viscosity Decreases with Velocity

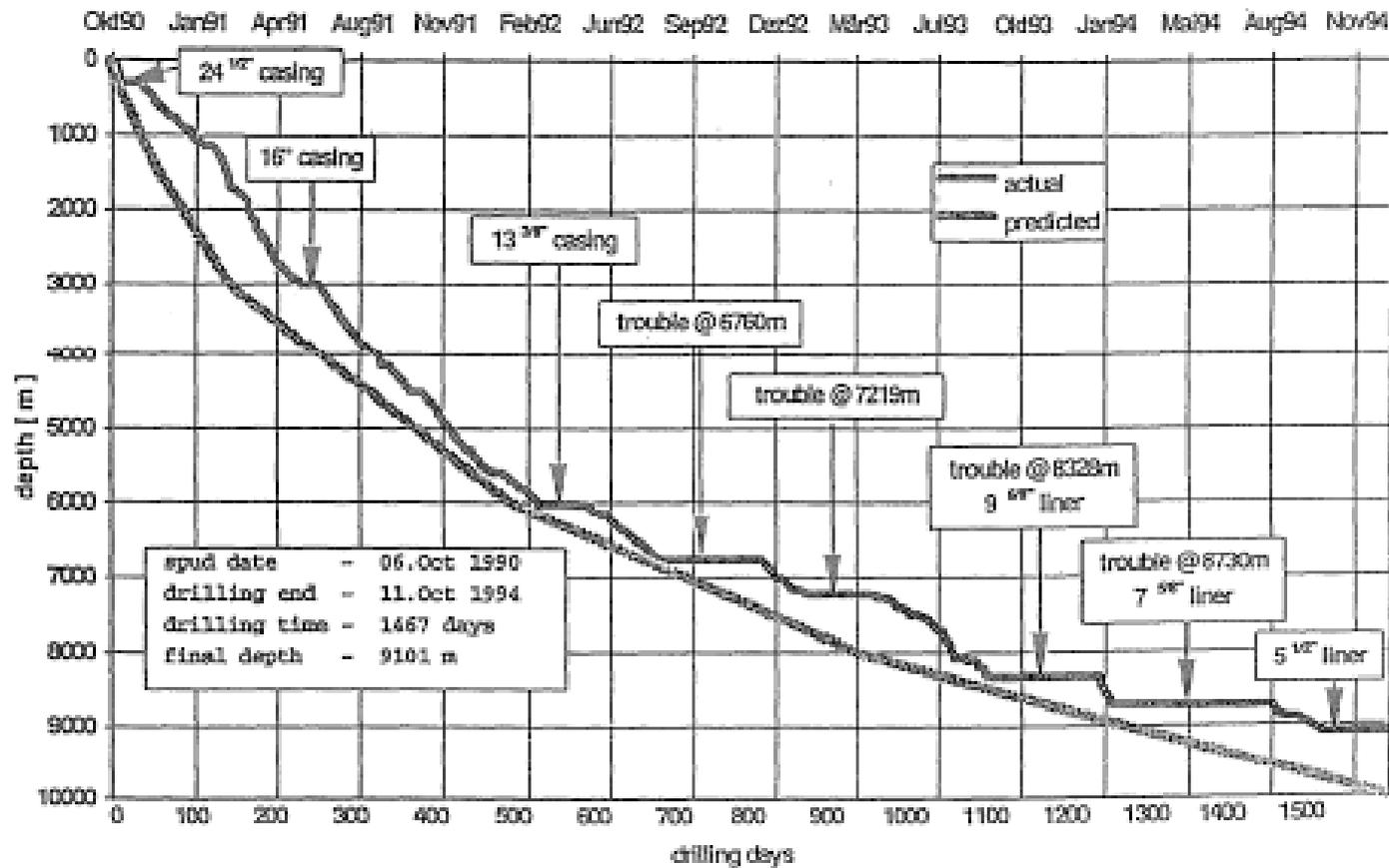


Fluid thickens as motion slows down, so settling is slowed

KTB SuperDeep Well Drilled with Mud



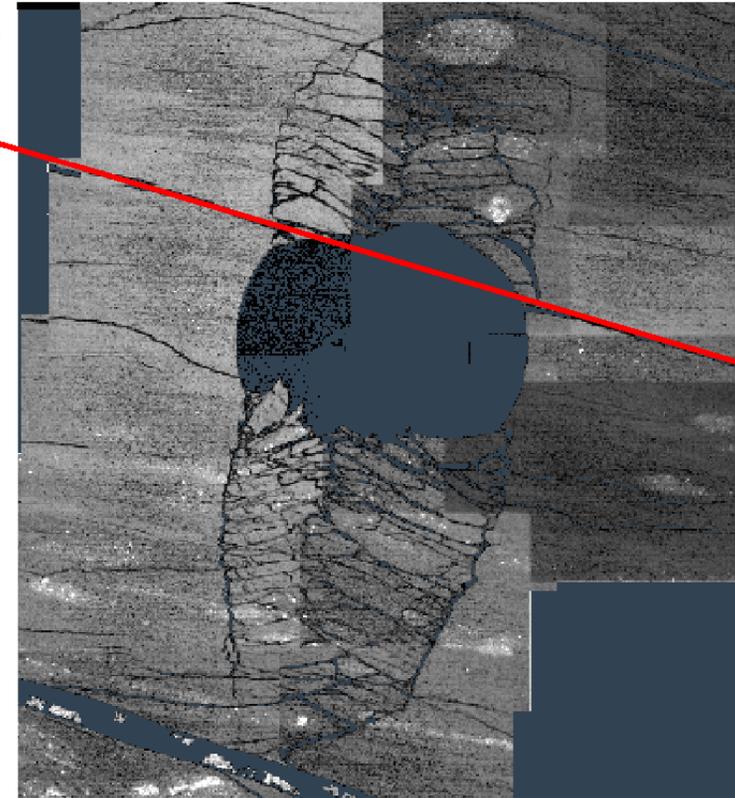
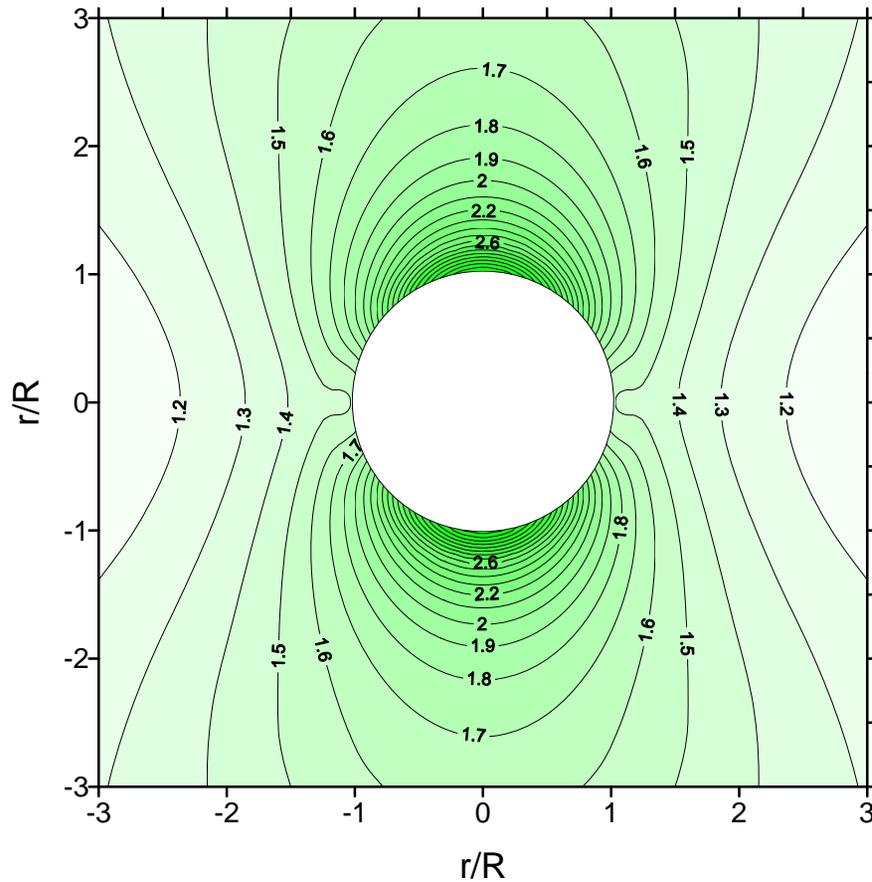
KTB Had Problems



Wohlgemuth et al. (1996)

Six Casing Strings Run- Smallest 5 1/2"

Boreholes Fail Because of Stresses



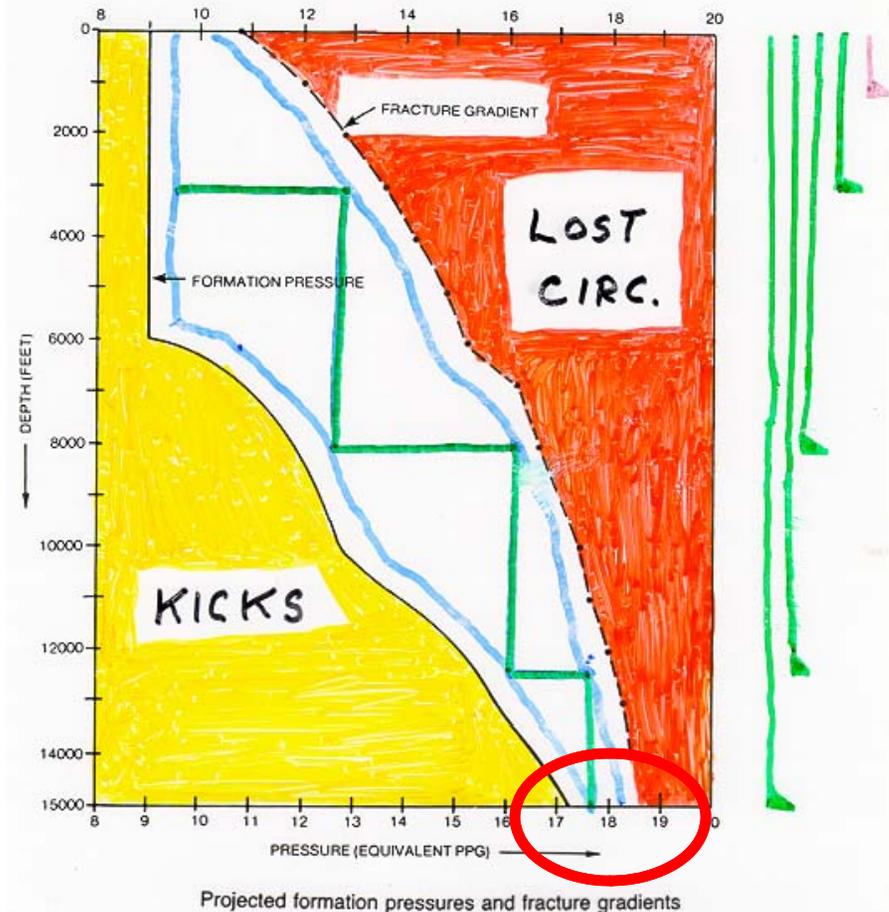
Weight of overburden and shifting of formations put stresses on rocks and fluids in them

Hydraulic Pressure Counters Stresses

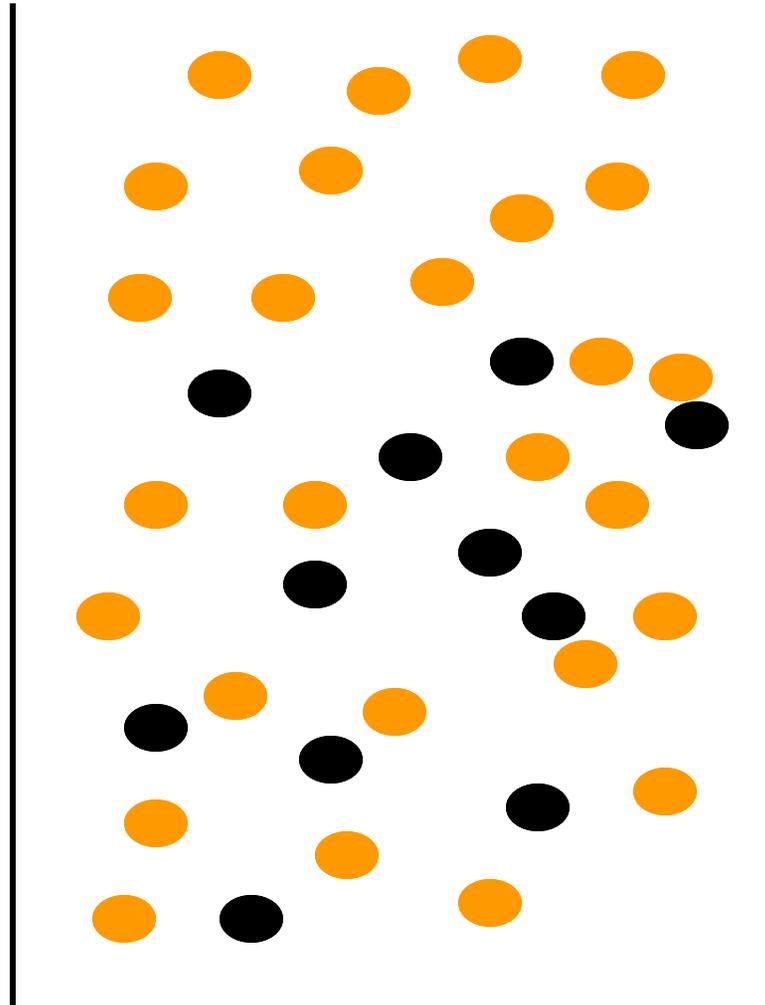
Pore Pressure Pushes Fluid and Rock Into the Hole, Balanced by the Pressure Exerted by Mud Density

Fracture Gradients Limit Mud Density

Limits of FG and PP Set Casing Points



4.2 sg Barite Provides Density



Barite
Also
Settles

The 'Window' Is Narrower In Deeper Water

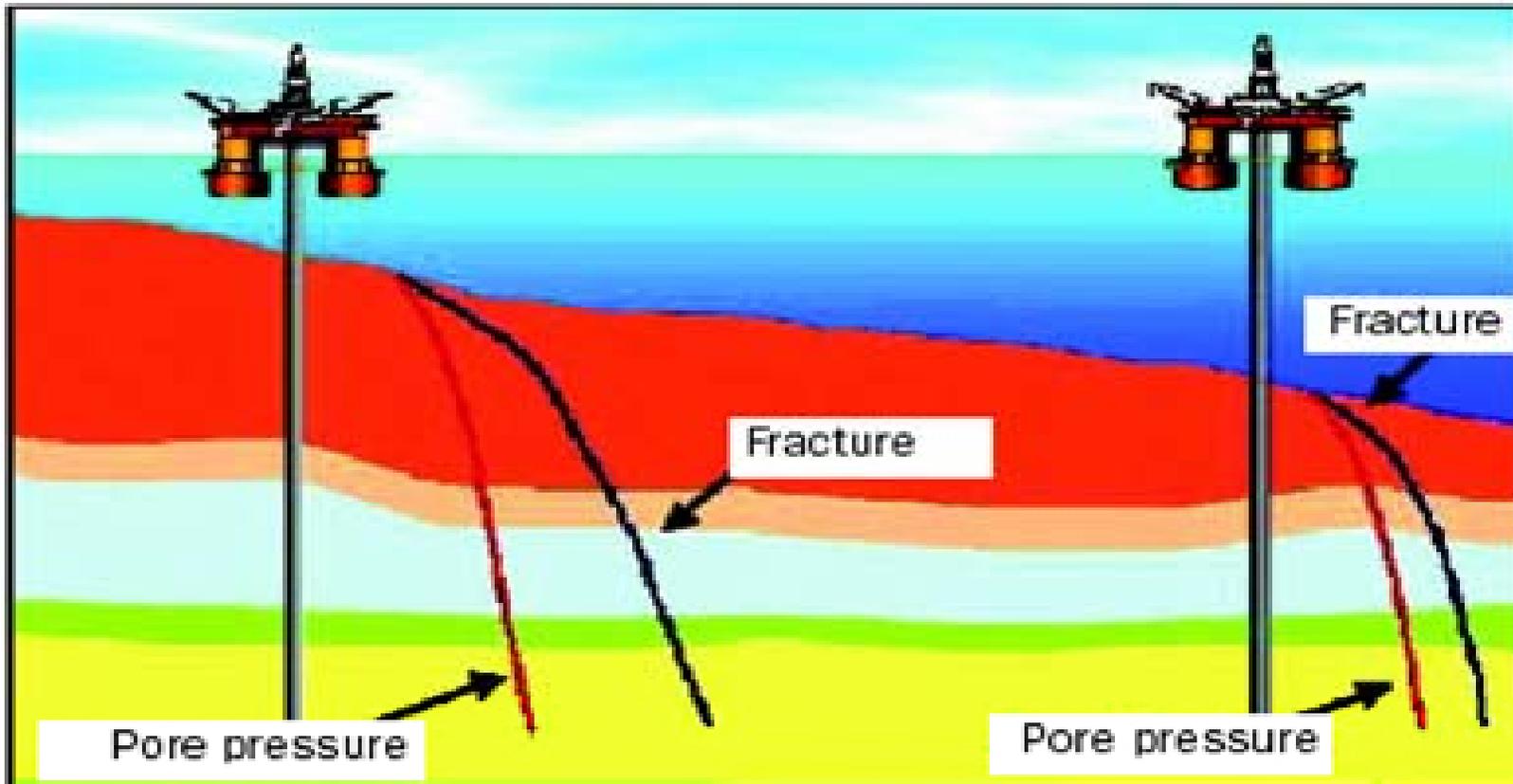
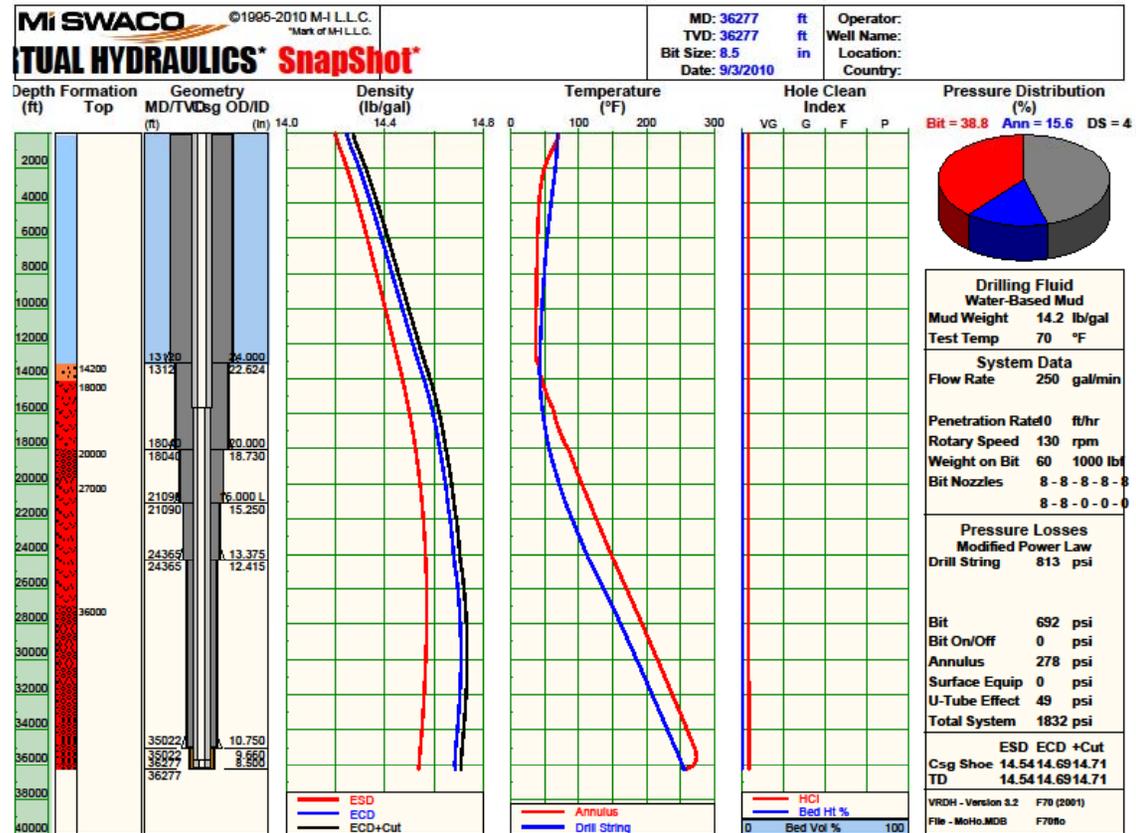


Figure 1a. As water depth increases, the mud weight window reduces.

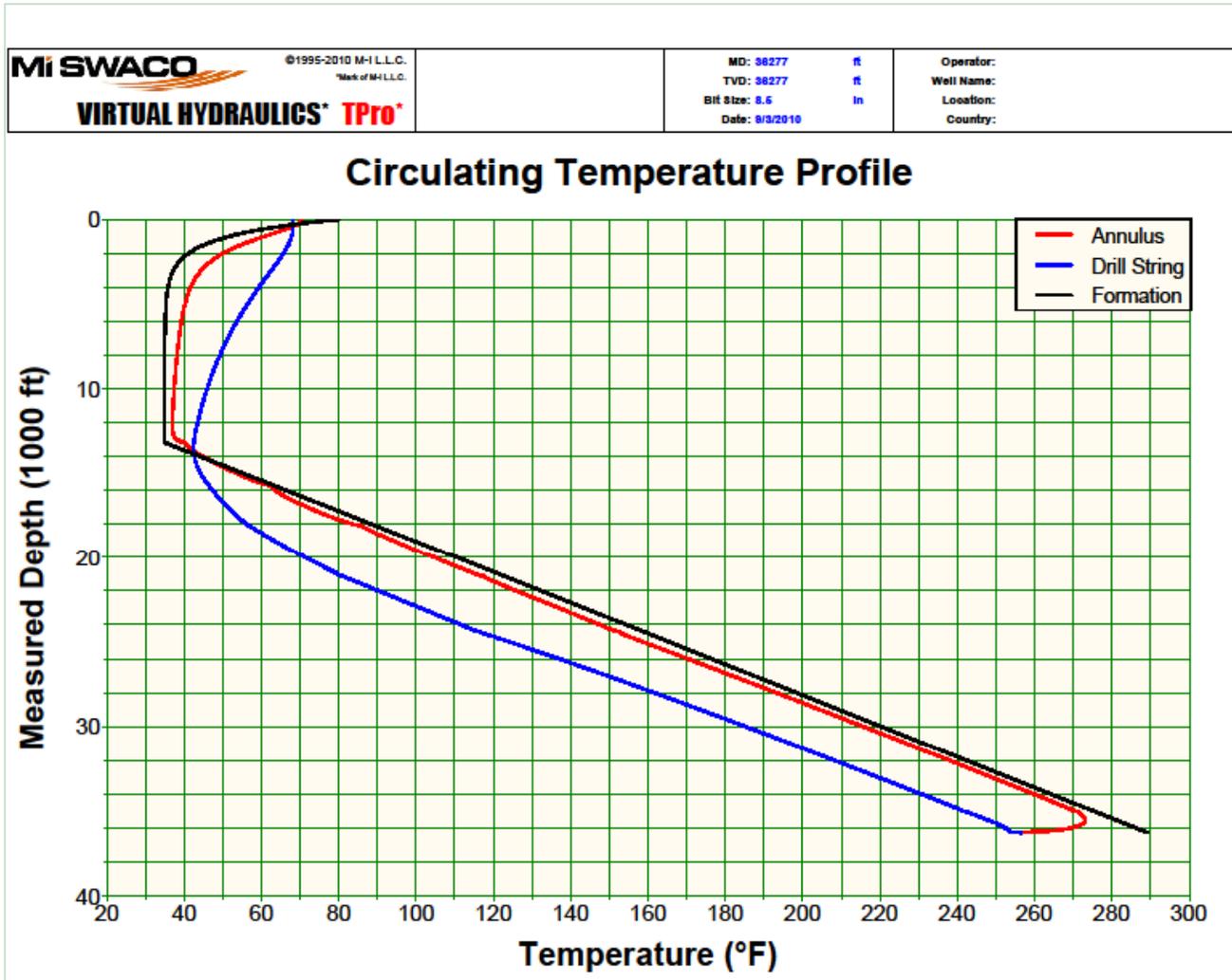
Viscosity + Density Create 'ECD'- Pressure While Drilling

Pressure and Temperature Change Static Density, "ESD"

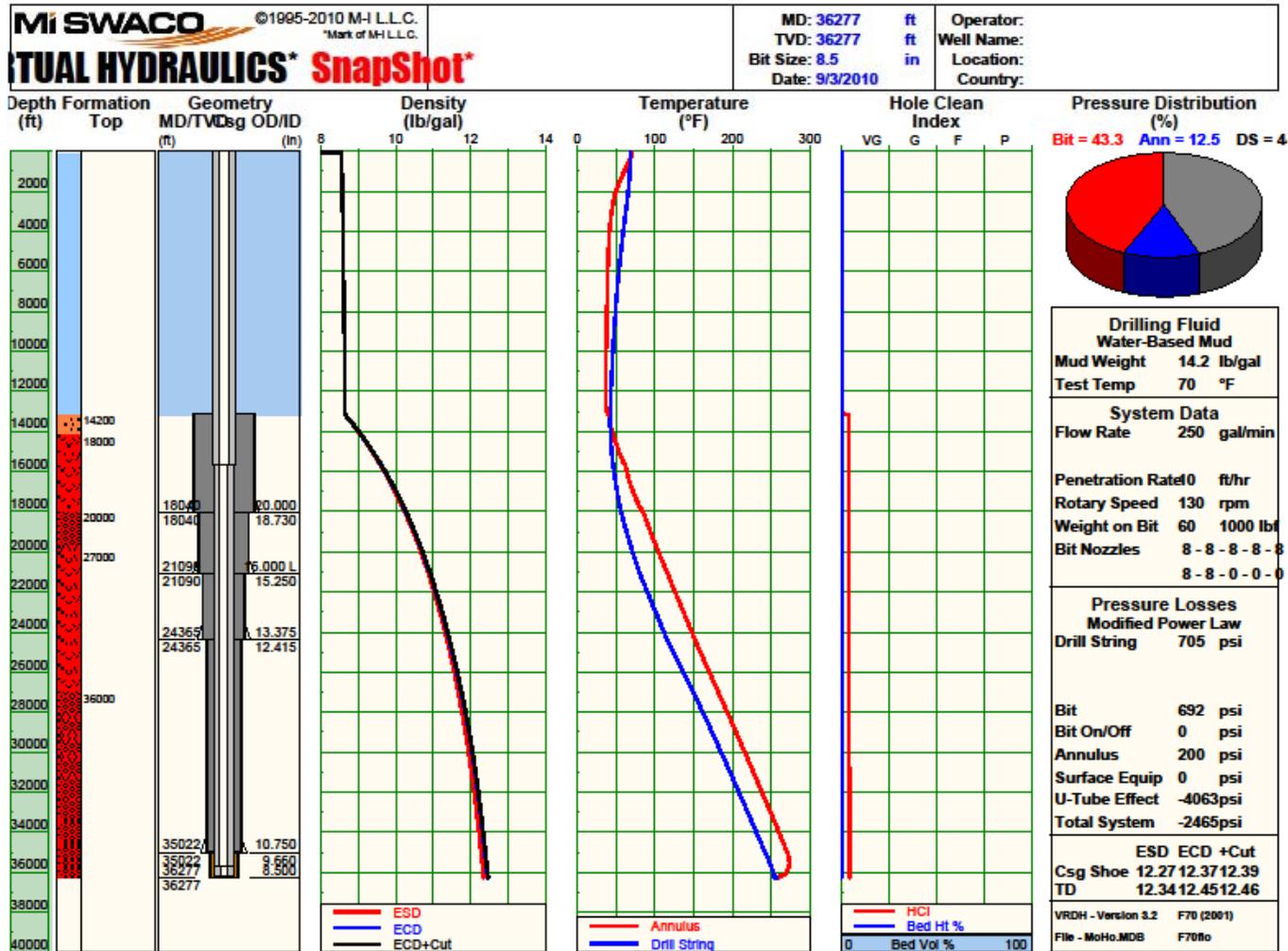
Resistance to Flow Adds On to Make ECD When Pumping.



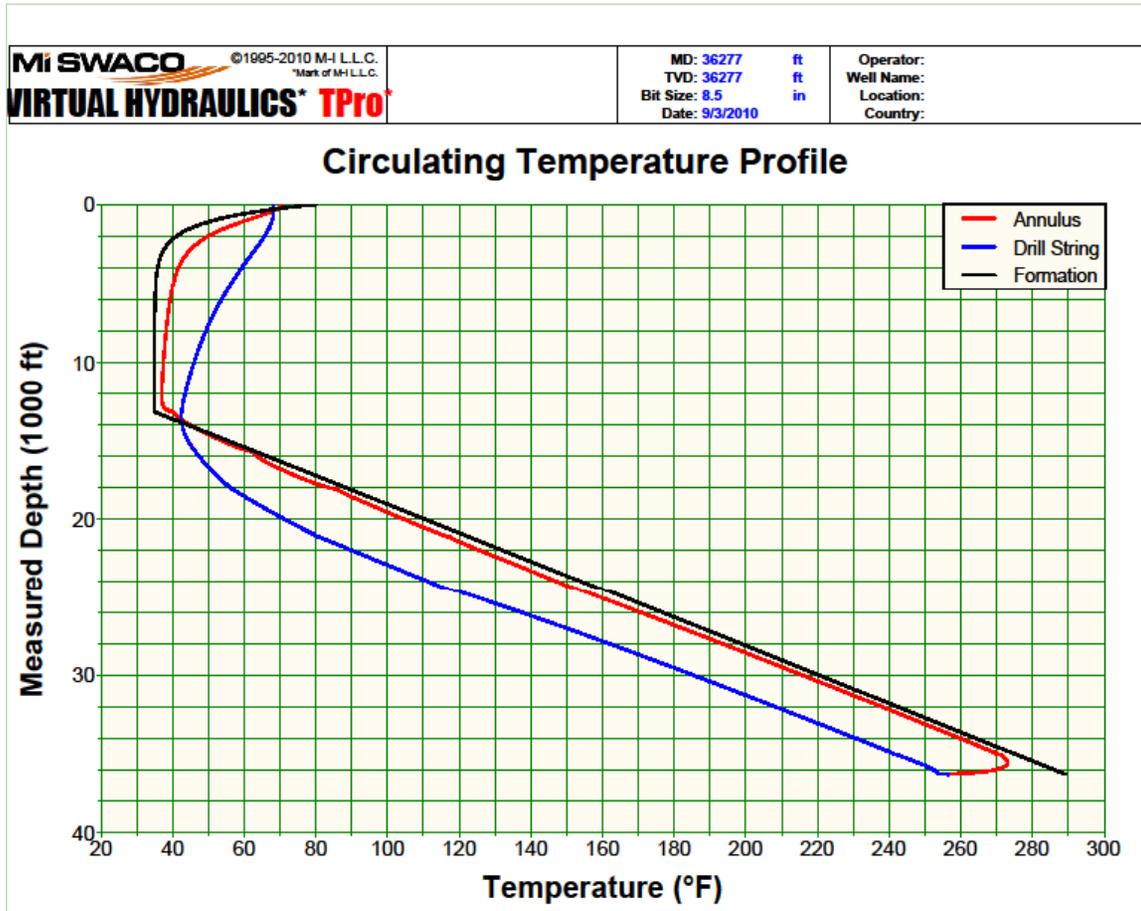
Circulating Temperature with a Riser- 40 °F Offset at Bit



Riserless Drilling Reduces Pressure

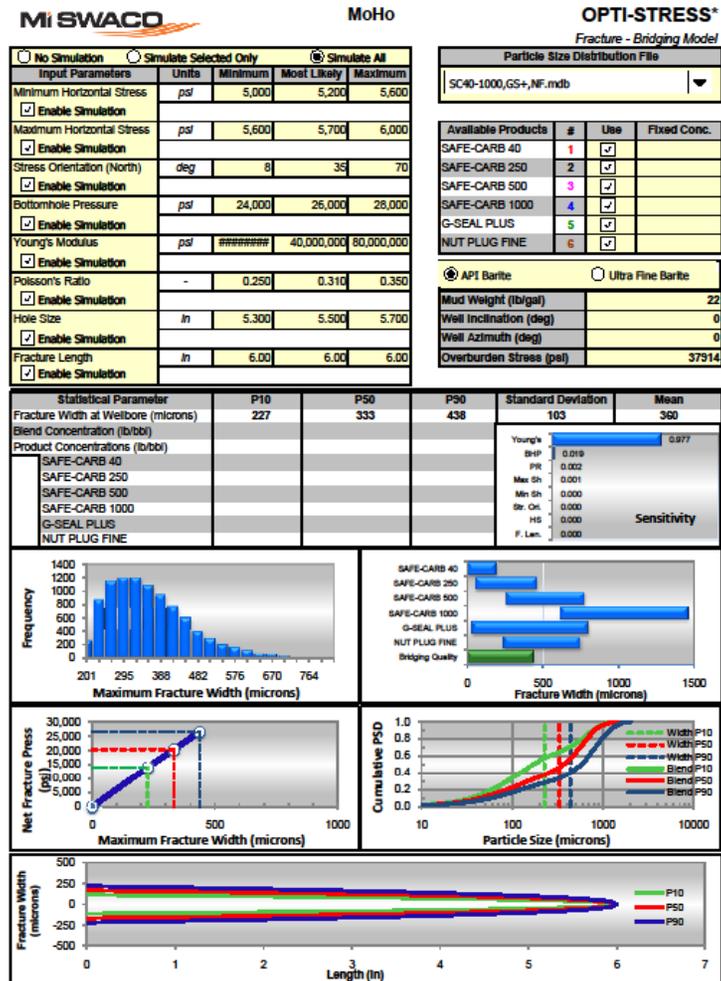


Without Further Cooling Formation -



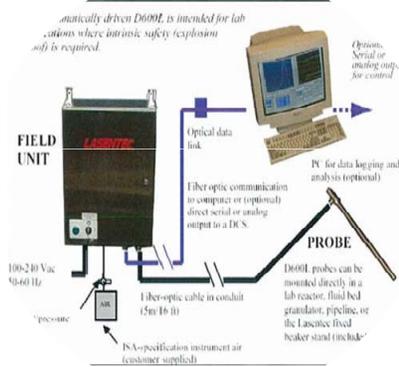
But will you thermally fracture the rock ?

Stress Cage Treatment of Fractures

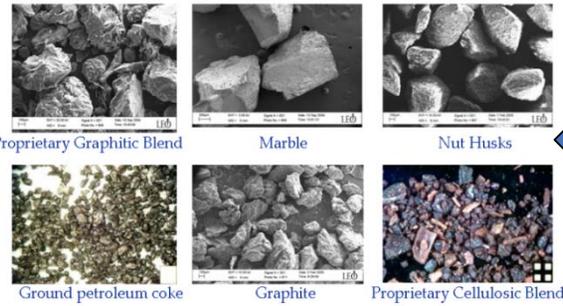


- Estimate fracture width using Rock Mechanics
- Picks WSM blend with particle size distribution required to bridge, prop and seal the fracture

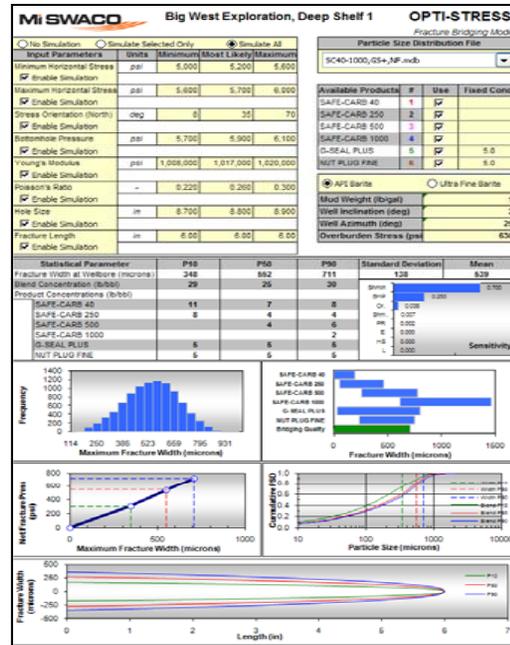
Wellbore Strengthening



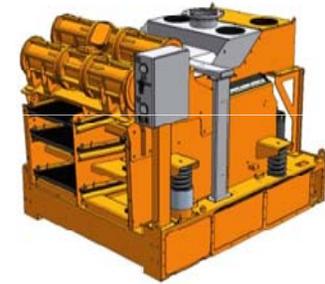
ON-SITE PARTICLE SIZE DISTRIBUTION



PARTICULATE WSM



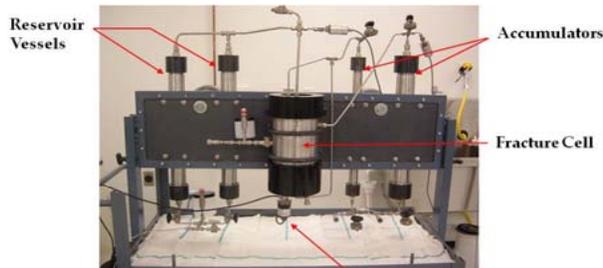
DESIGN OF WSM



WSM RECOVERY



CHEMICAL WSM



20 FRACTURE FILLING, BRIDGING & PLUGGING TESTS

RIGSITE WELLBORE STABILITY MODEL



Questions?

