Meeting the challenges for deep water exploration with drilling fluid and drilling hydraulics research at TUC

Vassilios C. KELESSIDIS
Technical University of Crete
Mineral Resources Engineering

Oil & Gas Exploration in Greece – Challenges and Opportunities
Chania, September 29, 2011

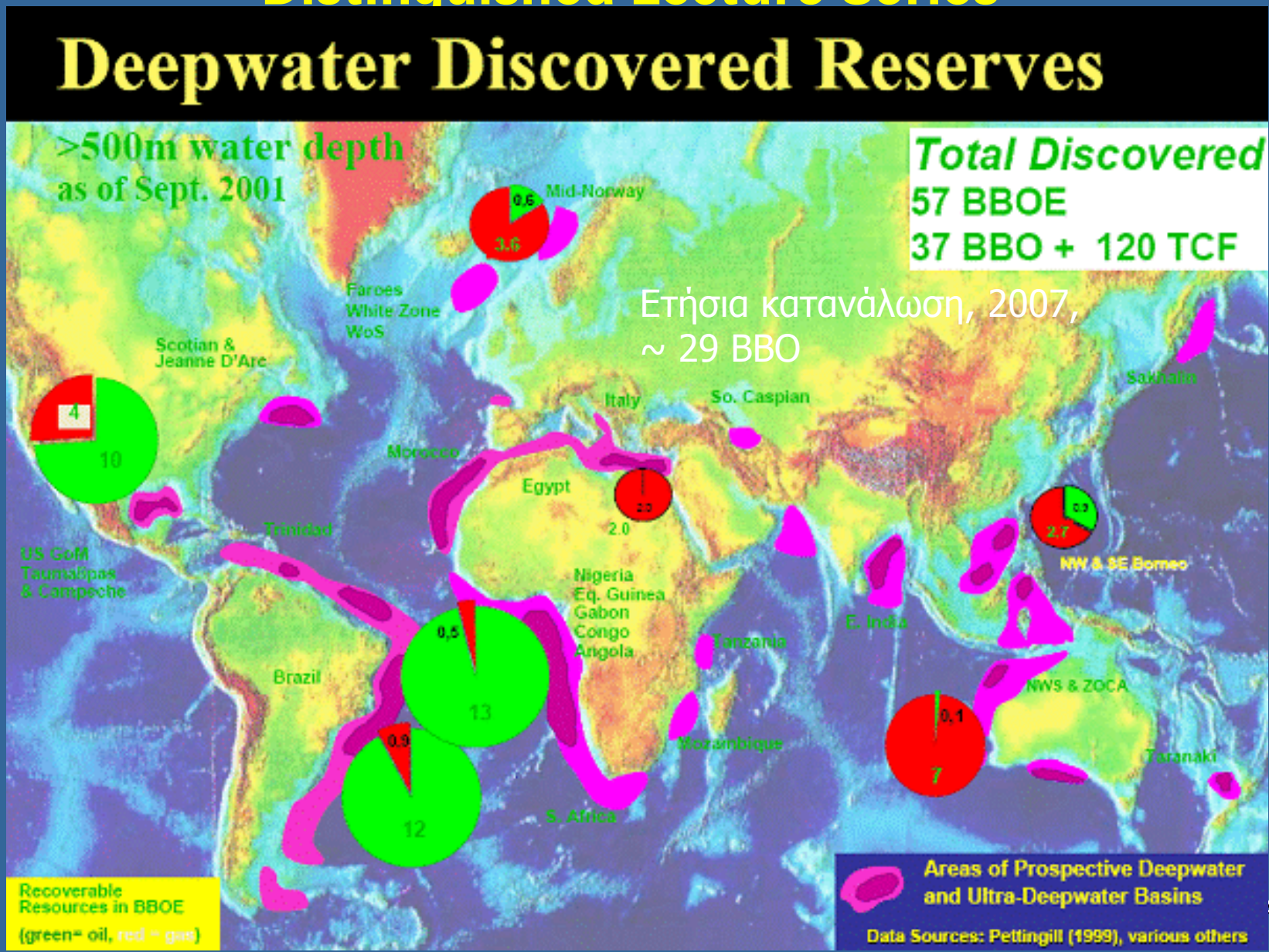
The problem

- Pythagoras saying 'whoever searches (DIGS), finds, he who never searches (DIGS), will never find'
- Drilling allows for access to subsurface target areas
- Drilling is very expensive
- Gather and exploit most pertinent data
- Optimum drilling practice → arrive to target in the most economical way, but with safety and with respect to the environment

The problem

- Drilling depths, total (~10000 m) and water (~ 3100m) depths, are ever increasing
- High pressures (>2000 bar) and high temperatures (>300^{0}C) are often encountered
- In Mediterranean water depths of max 4500 m

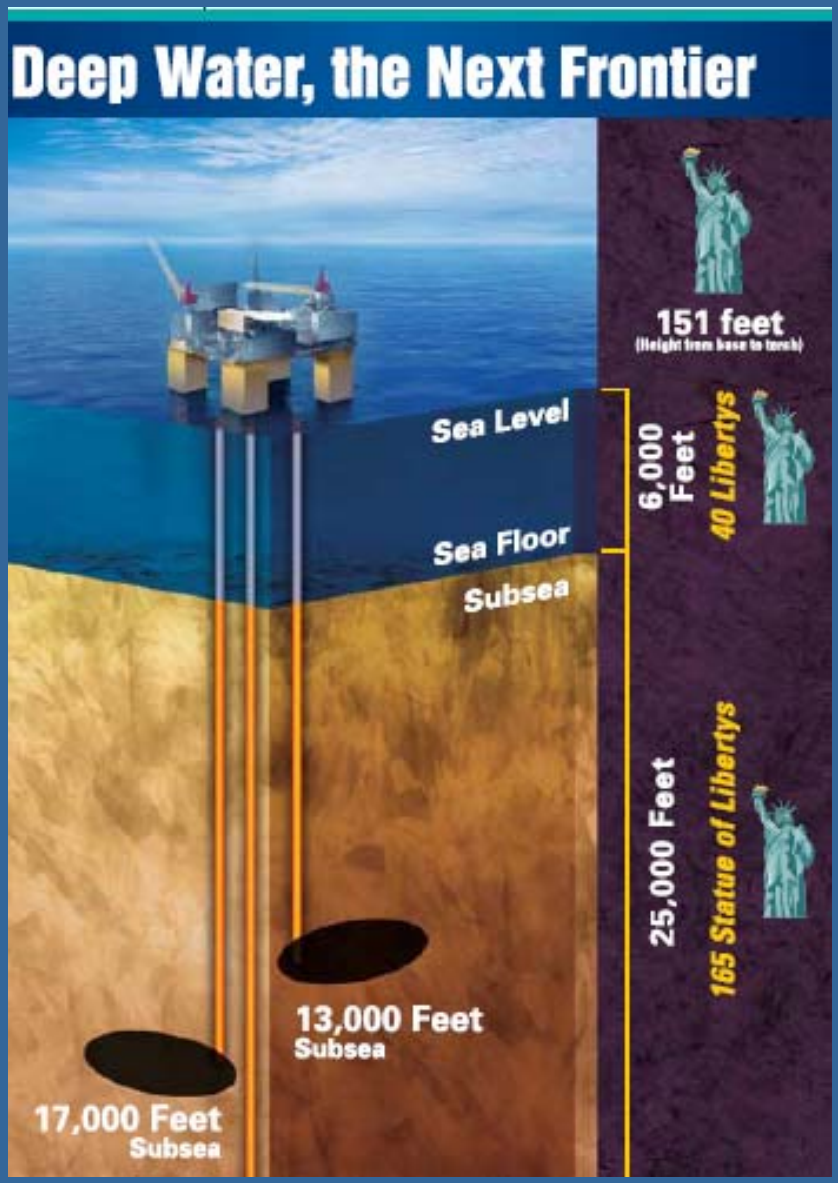
R.M. Slatt, Un. Oklahoma, 2001-02 AAPG Distinguished Lecture Series



The issues – Eastern Mediterranean

- Cyprus block 12, ~ 1500 m water depth, target sand ~5000 m
- Tamar field, water depth of 1670 m, target sand at 4880 m total depth
- Leviathan field, 1634 m water depth, target sand 5095 m (Leviathan 3 ~ 100 million US$)
- In South Crete, expected water depths of 1000 – 3000 m !
- 'normal' pressure and temperatures are expected

Gulf of Mexico – Very deep wells



1. Wells produce in > 2500 m water depth
2. Drilling in water depths of 3000 m
3. Total depth of up to 10000 m
4. 51% increase in number of producing wells
5. Assessment that potential reservoirs may exist at 4-7.6 klm below seabed

A price to pay, April 20, 2010, GoM

water depth – 1544 m
Macondo well – HPHT
planned to drill in 51 days @ 96 million $
extra 43 days, + 21 million $

66 km offshore Louisiana
120 people on board
11 killed
17 injured

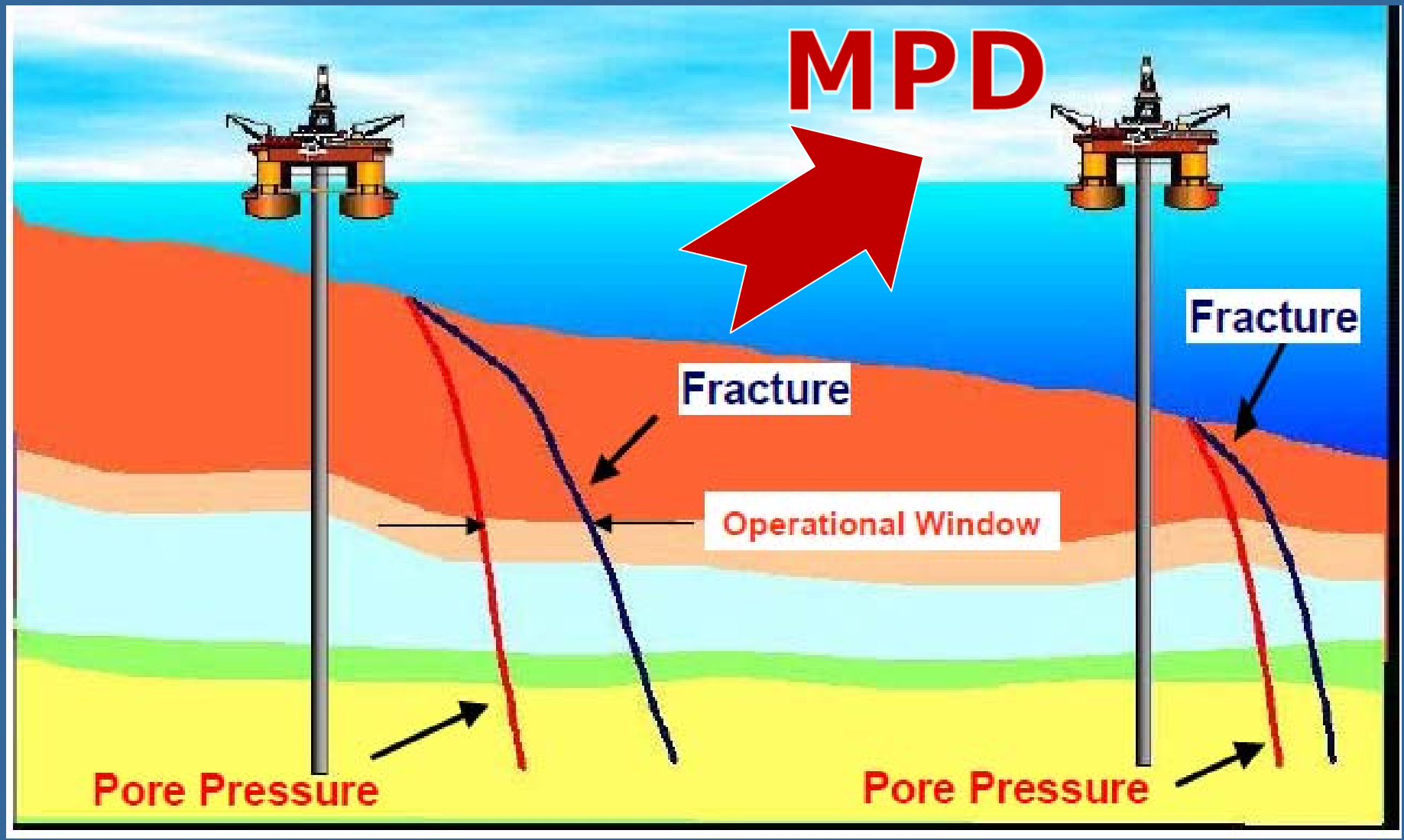
3 months of oil spill
4.9 million barrels oil
extensive damage to marine and wildlife habitat

The problems in deep water

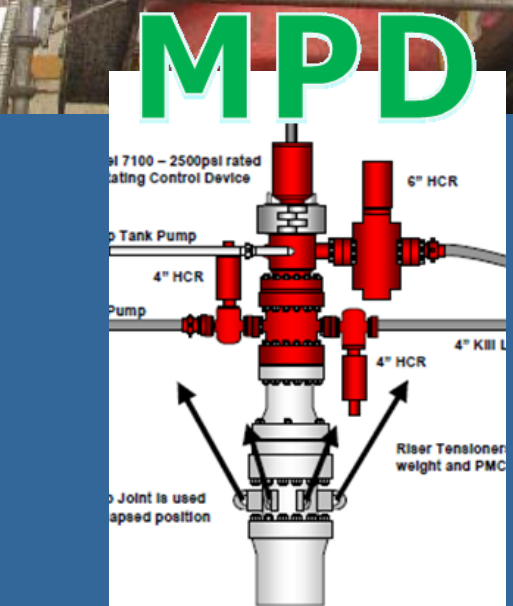
- Narrow pressure tolerances
- Lower fracture gradients (young deposits)
- Low temperatures – hydrate formation
- Very high rig cost (up to US$250,000 /day)

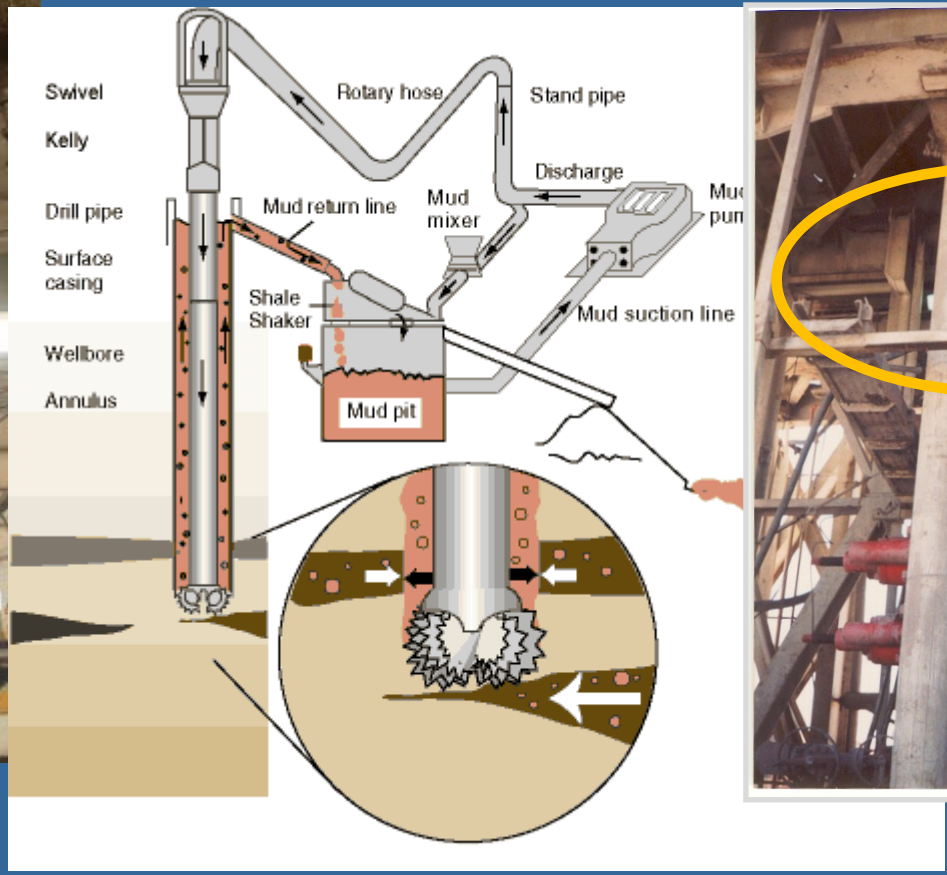
- Demand for better drilling fluids
- Avoid problems -understand behavior in such hostile environments
- Hydraulic programs for complex rheology
- Cementing challenges in deepwater – low temperature alters properties

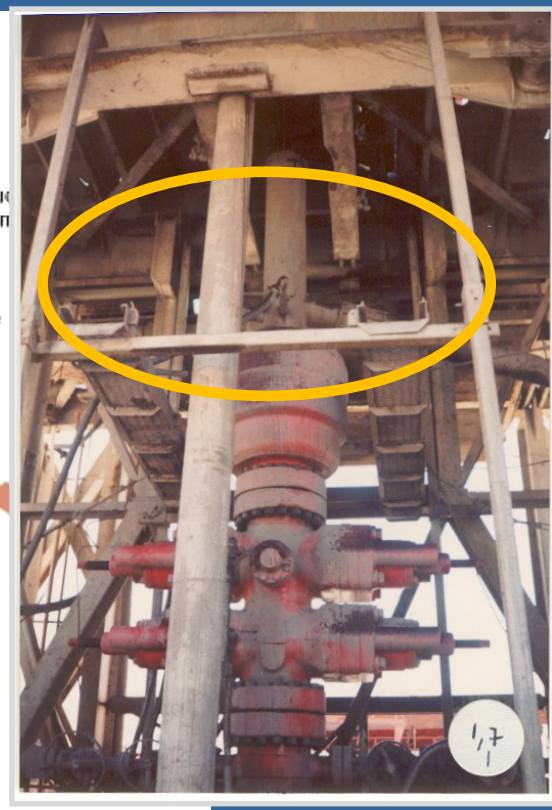
Deep water drilling challenges



MPD vs Conventional







Conventional

Demetra well
water kick?!
16.5 ppg @ 3900 m = 757 bar

Drilling fluid challenges for drilling in Greece

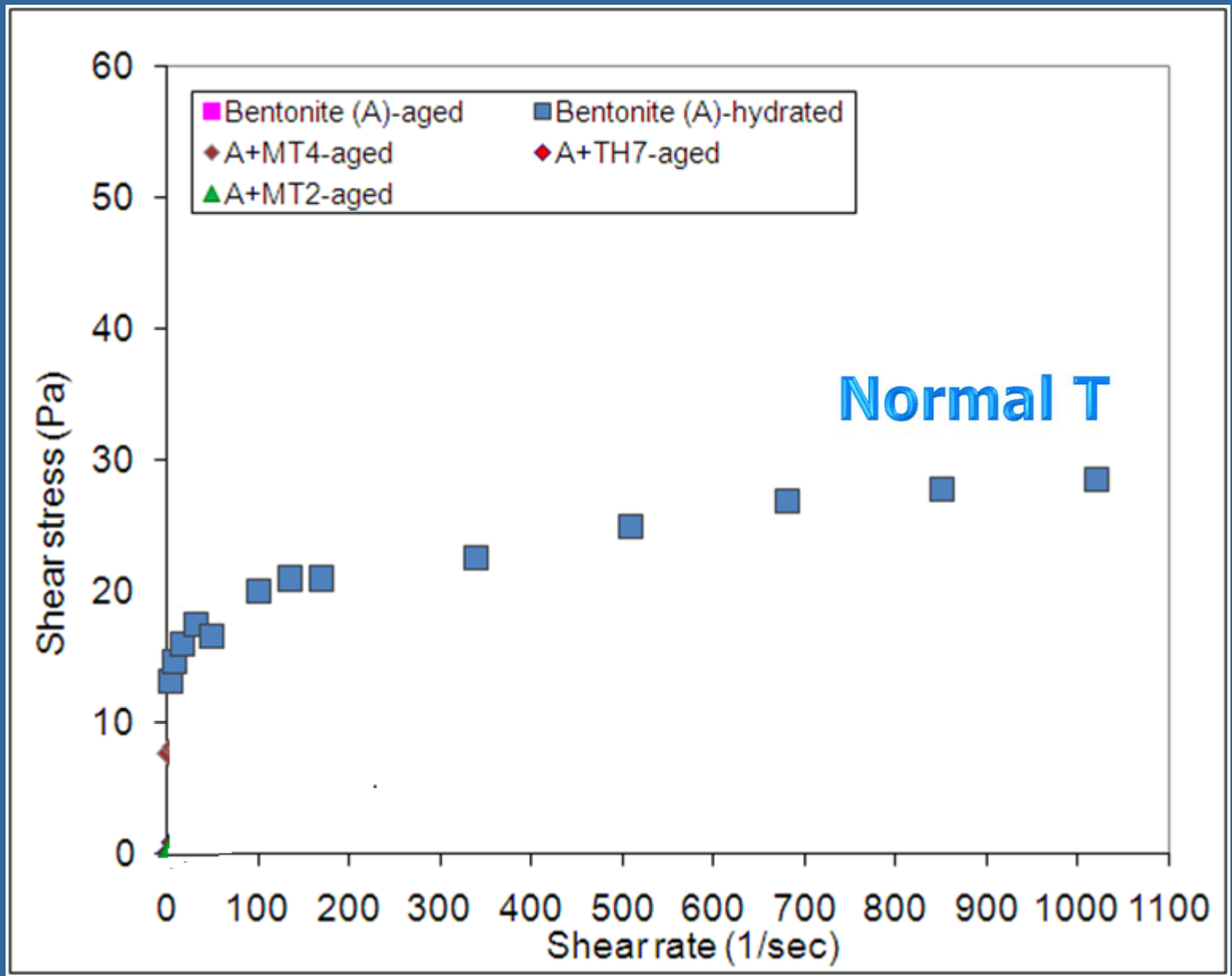
ROLE of Drilling Fluids

- The blood of the well
- Hydrostatic pressure – density / rheology
- Cuttings transport – rheology / density
- Cool the bit – flow
- isolate formation - filtration
- Wellbore stability – density / rheology

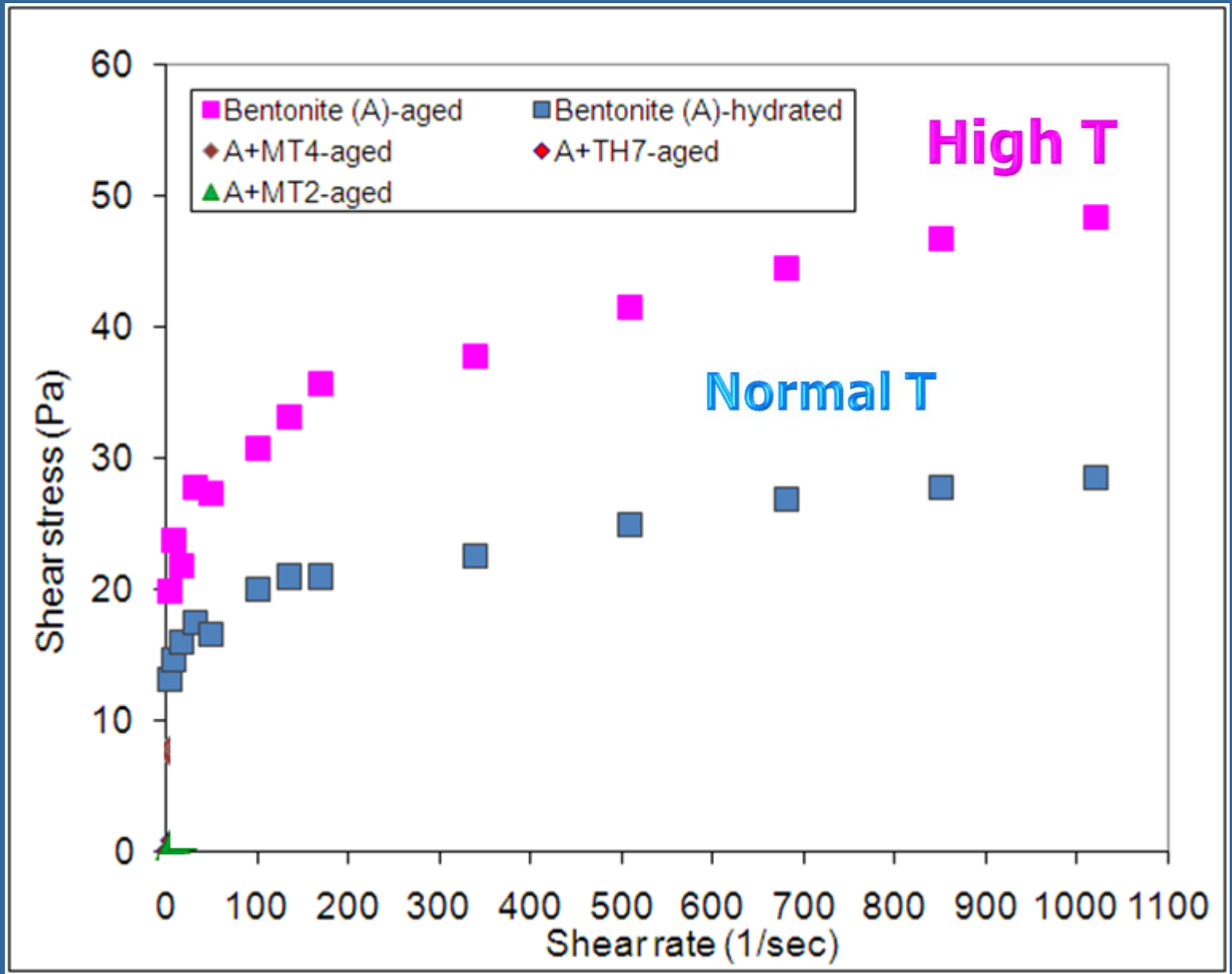
The challenges for deep water drilling

- Smart fluids
- Adaptable to specific conditions
- High temperature / Low temperature
- Stable and predictable density and rheology
- Environmental friendly – non toxic and non polluting
- Good drilling hydraulics models for multitude of conditions
- Monitoring and property assessment

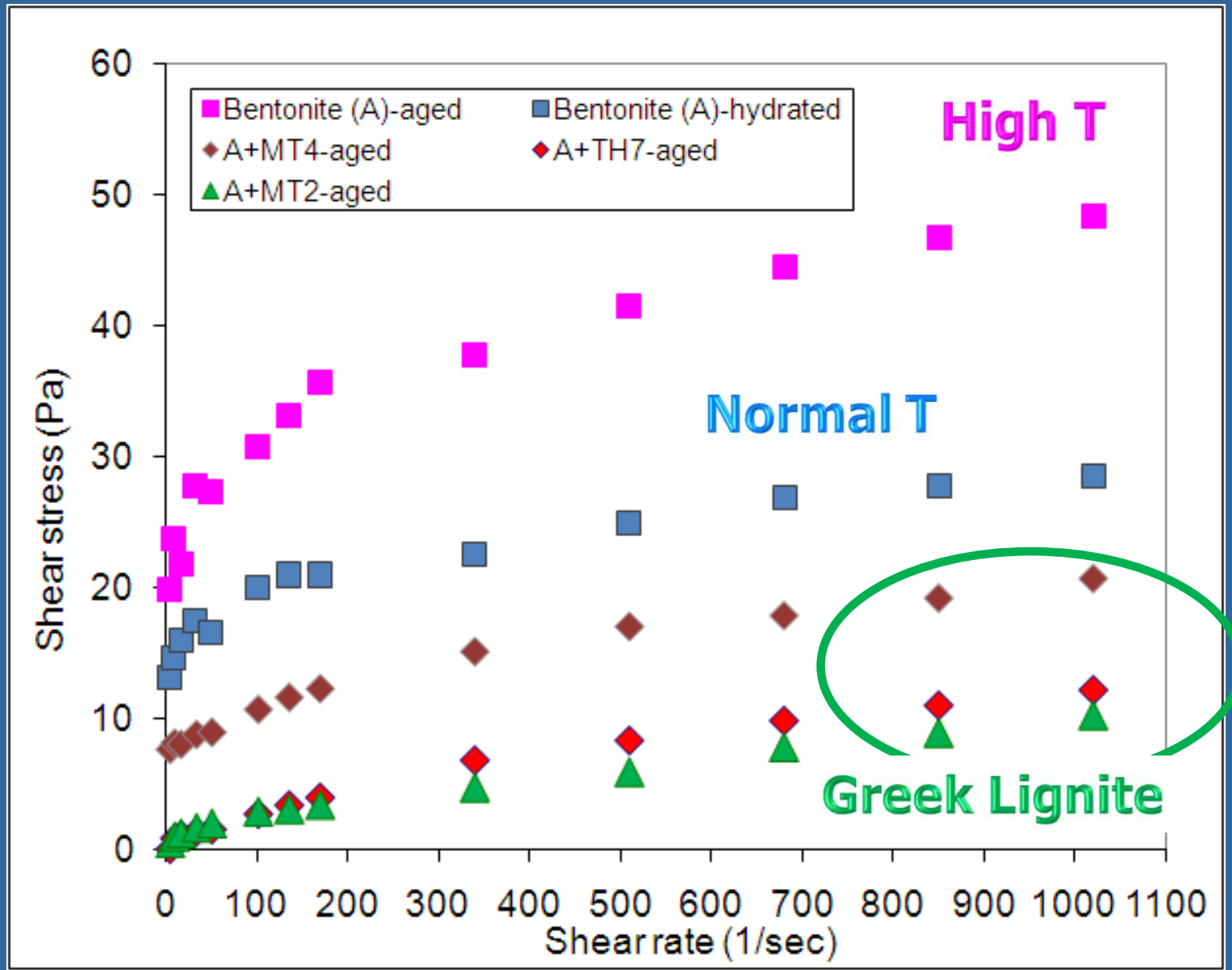
Lignite additive for T control



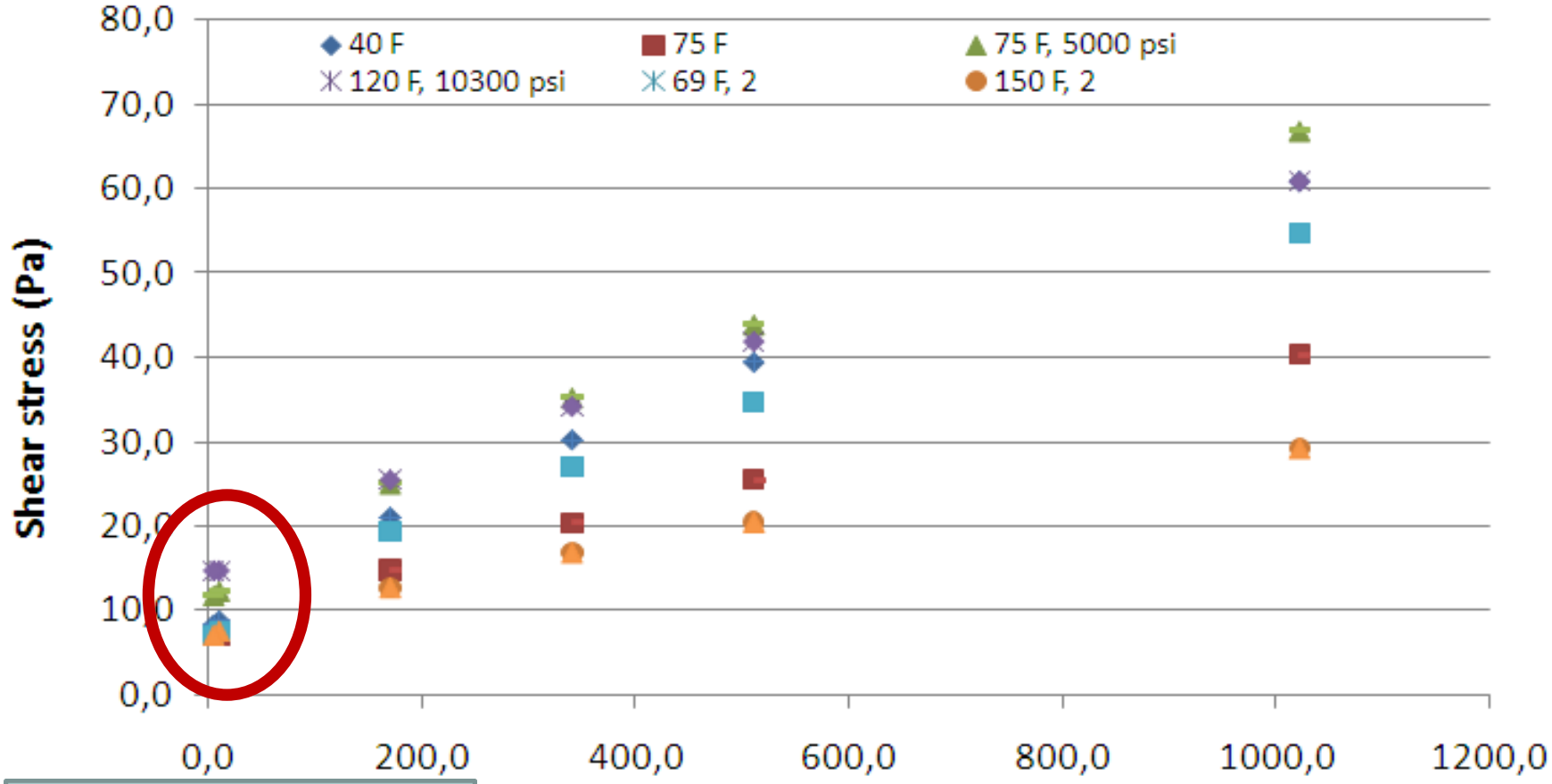
Lignite additive for T control



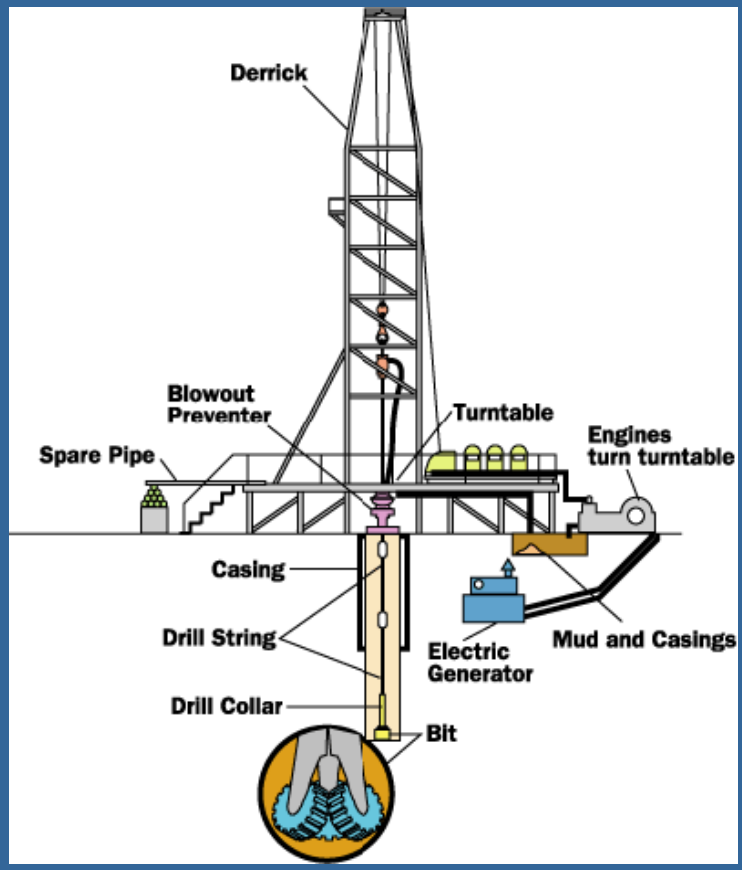
Lignite additive for T control



'Flat' rheology smart fluids – Hole cleaning



~ similar T_y



Drilling Engineering and Fluid Mechanics at TUC

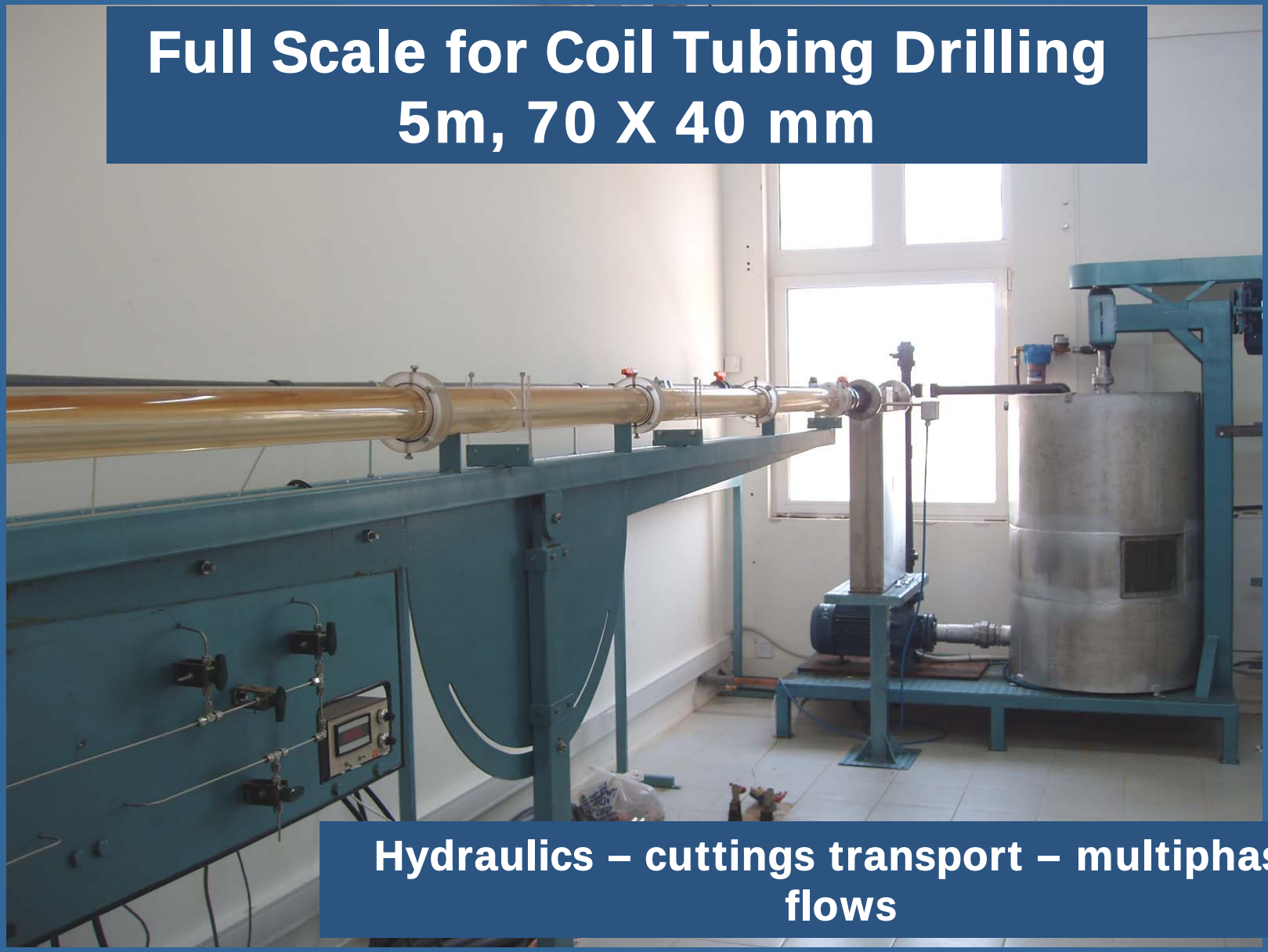
Aims of research of our laboratory

- Drilling fluid properties
- Smart fluids
- Optimal measurements
- Drilling hydraulics
- Cuttings transport
- Drilling Engineering & Mechanics

http://drillinglab.mred.tuc.gr

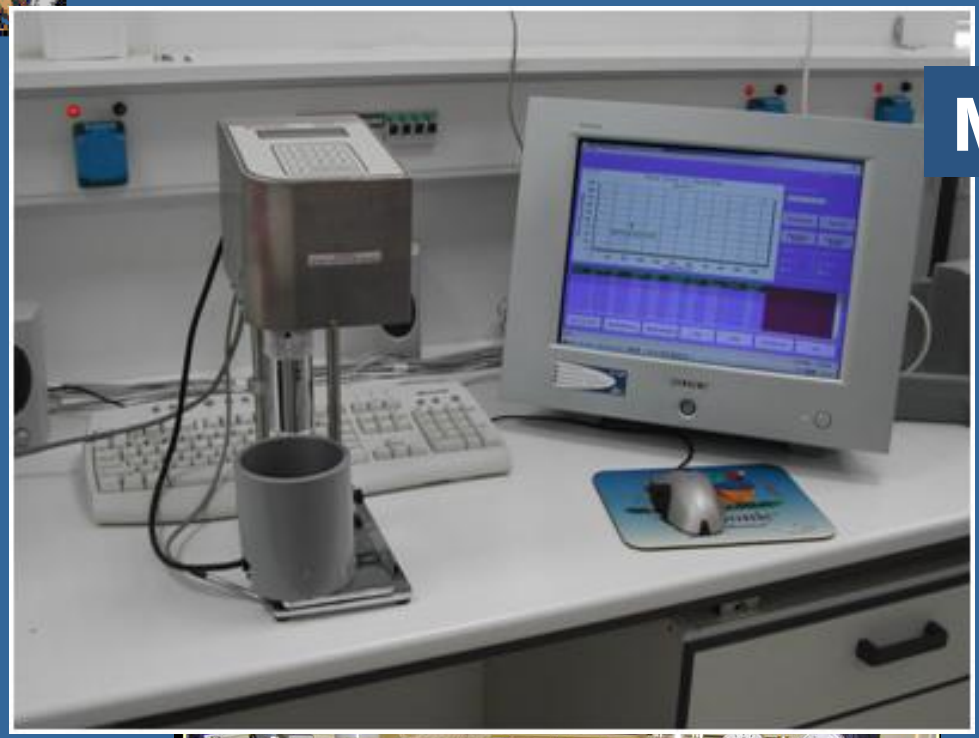
Facilities - Flow loop

Full Scale for Coil Tubing Drilling
5m, 70 X 40 mm



Hydraulics – cuttings transport – multiphase flows

Instruments - rheology



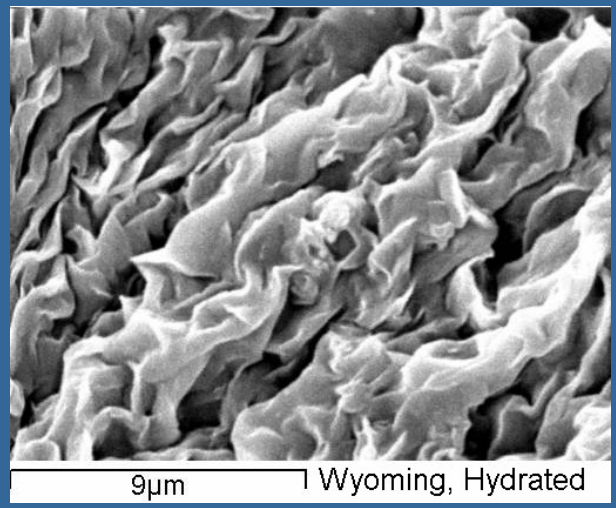
M3500a Viscometer

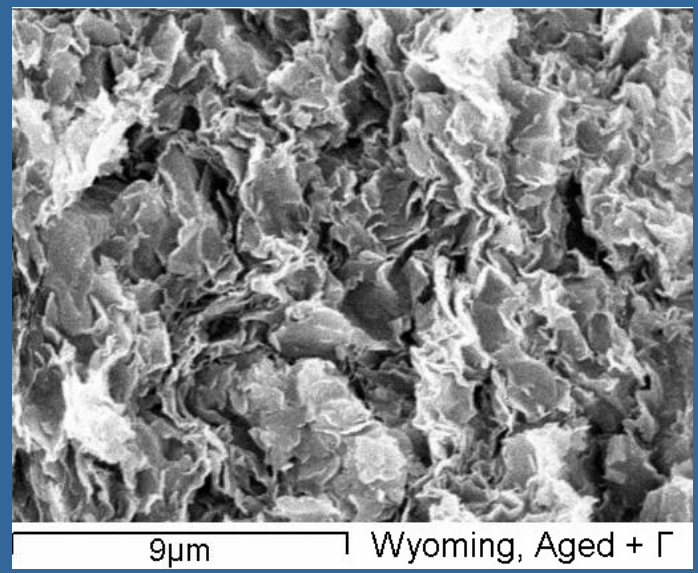
Vane Rheometer

Filtration

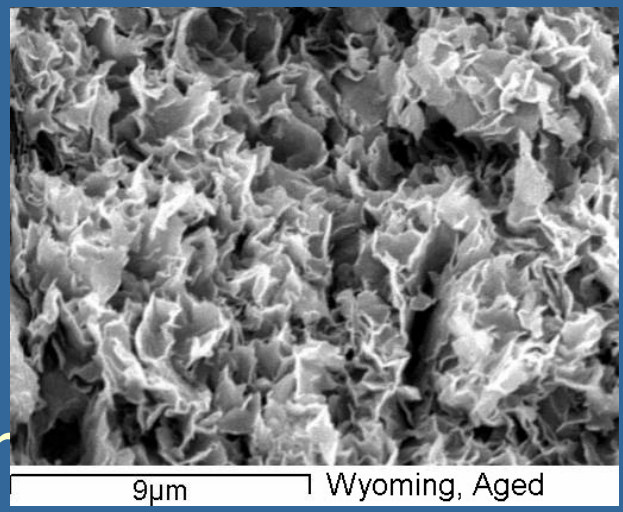
Collaboration with MRED Labs
SEM of filter cakes

Hydrated Suspension Very low permeability ~ 10^{-3} mD





Aged Suspension higher permeability ~ 4-10*10^{-3} m



Aged + lignite Very low permeability ~ 10^{-3} mD

Software

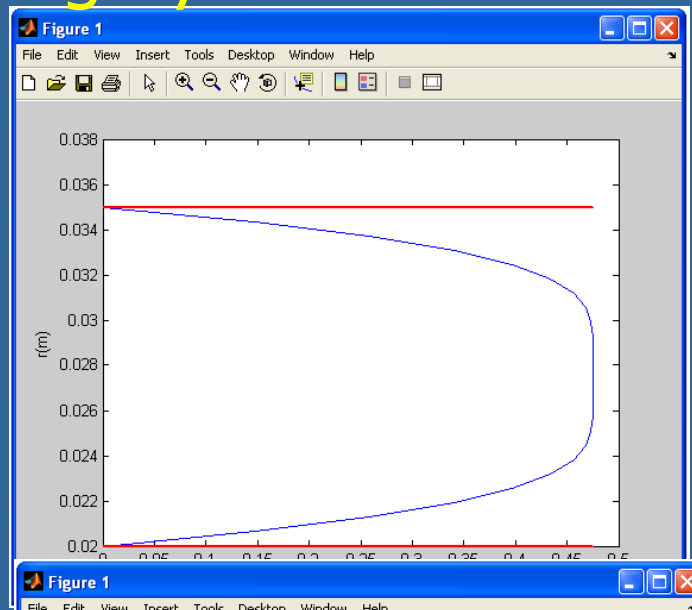
Own simulators

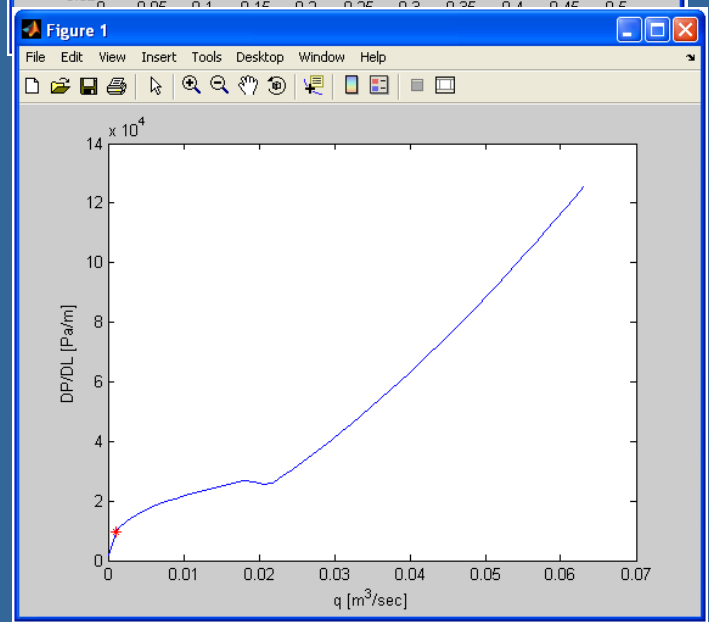
- Drilling fluid rheology
- Drilling hydraulics
- DDOS - Drilling design optimization software
- Cuttings transport simulator

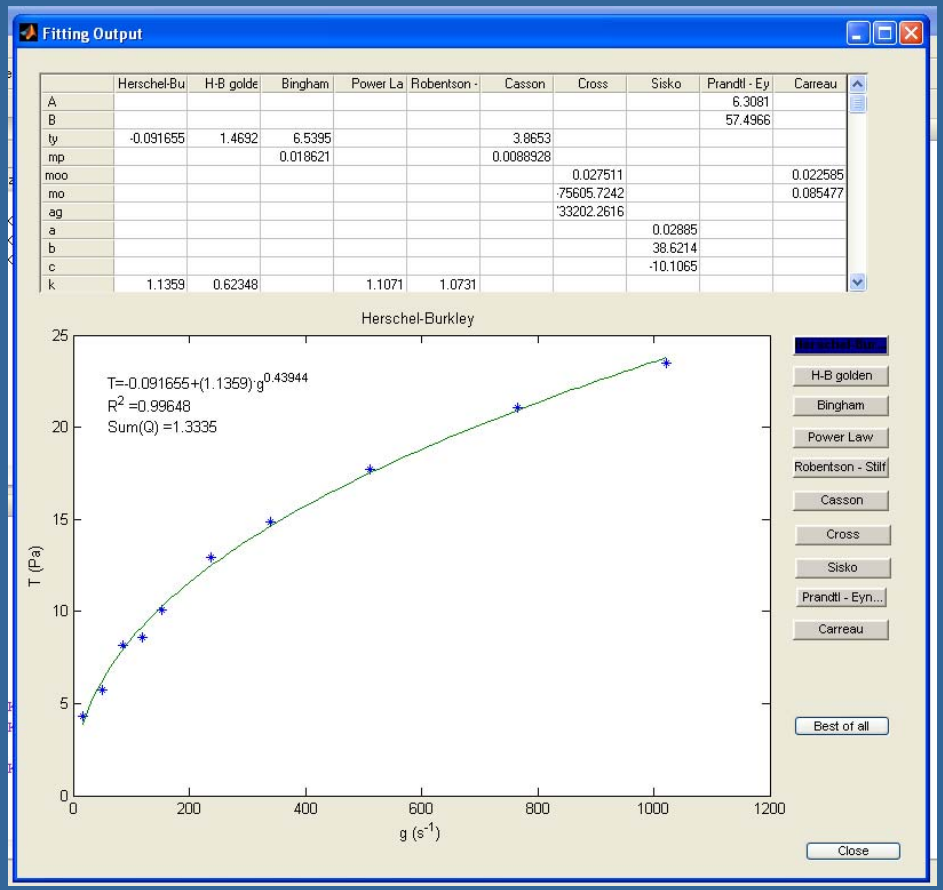
- Payzone Drilling simulator (Prof. Cooper)
- DrillNet – Petris Drilling Hydraulics simulator

Software

Drilling hydraulics simulator







Rheology simulator

Drilling Design Optimization Software

ΦOS
(Light in Greek)

Drilling Design & Optimization Software

Panayiotis Dalamarinis
Andreas Panakos

1st & 3rd Place – Undergraduate student contest
Offshore Europe, 2009; SPE ATC Florence 2010

Conclusions

- Exploration in Greece, deep waters and maybe deep wells
- Improved drilling techniques, Managed Pressure Drilling, narrow pressure margins
- Extreme environments → better drilling fluids
- Good and representative rheological models for the complex fluids
- Very good drilling hydraulics models

Conclusions

- The Drilling Engineering & Fluid Mechanics Research Unit focuses on drilling fluid and drilling hydraulics research
- Capabilities exist for providing support for technical and R&D issues for deep water drilling
- In cooperation with other Labs and the Drilling Contractors
- Oil companies should be open to such collaborations
- Government should see to this in the expected exploration and development contracts
- Win-win situations – training for future employees

Drilling → tough balances
We CAN meet the challenges !

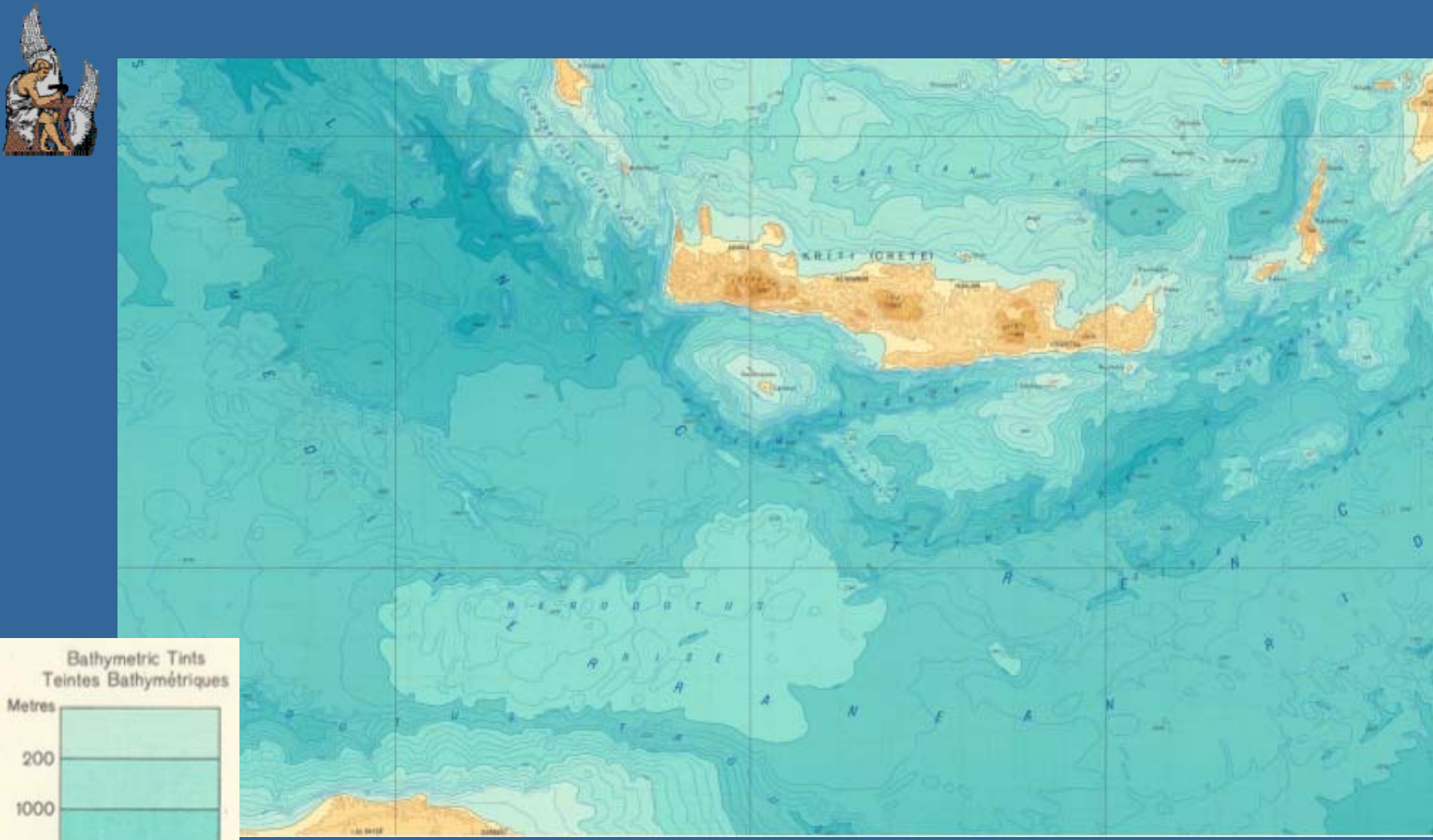
Transocean Ltd. Announces World Water-Depth Drilling Record in 10,194 Feet of Water

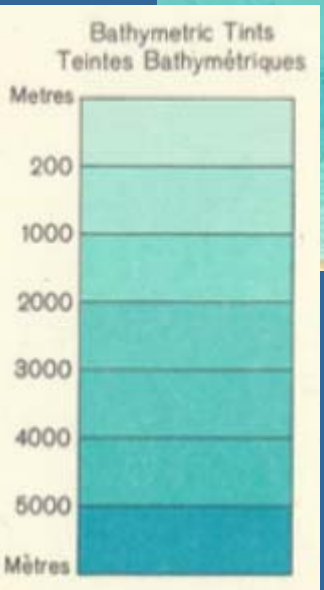
ZUG, SWITZERLAND, Apr 11, 2011 (MARKETWIRE via COMTEX) -- Transocean Ltd. (NYSE: RIG) (SIX: RIGN) today announced that the ultra-deepwater drillship Dhirubhai Deepwater KG2 has set what the company believes is a world record for the deepest water depth by an offshore drilling rig of 10,194 feet of water while working for Reliance Industries offshore India. The rig, which is owned by a joint venture with Quantum Pacific Group, surpassed Transocean's prior record of 10,011 feet of water, set in 2003 by the Discoverer Deep Seas working for Chevron in the U.S. Gulf of Mexico.

The new record comes approximately one year after the dynamically positioned Dhirubhai Deepwater KG2 was placed into service in India under a five-year drilling contract. The vessel is equipped to work in water depths of up to 12,000 feet and outfitted

2005 - Deepwater Nautilus sets world record for deepest offshore oil and gas well. 32,613 feet True Vertical Depth – 9940 m
2005 - Discoverer Spirit sets world record for deepest offshore oil and gas well. 34,189 feet Measured Depth – 10420 m

http://nyjobsource.com/transocean.html





International Bathymetric Chart of the Mediterranean (IBCM)

http://www.ngdc.noaa.gov/mgg/ibcm/