



**Sustainable drilling for oil and gas:
challenging drilling environments demand
new formulations of bentonite based
drilling fluids**

V. C. Kelessidis

Technical University of Crete

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Industry

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Summary of the presentation

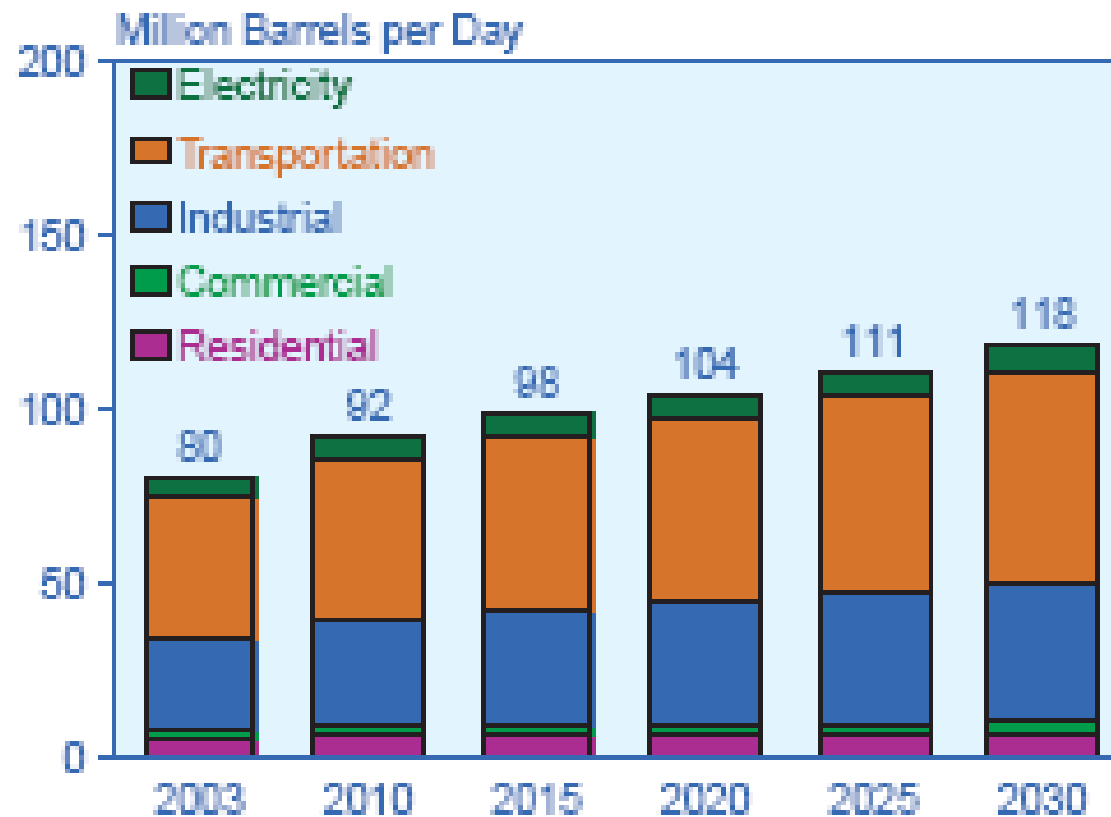


- Introduction
- Energy Demand & Drilling environment
- Drilling fluids
- Demands for drilling techniques & drilling fluids
- Challenges for bentonite industry
- Summary / Conclusions

Energy demand will continuously increase



Figure 26. World Oil Consumption by Sector, 2003-2030



Sources: 2003: Derived from Energy Information Administration (EIA), *International Energy Annual 2003* (May-July 2005), web site www.eia.doe.gov/iea/. Projections: EIA, *System for the Analysis of Global Energy Markets* (2006).

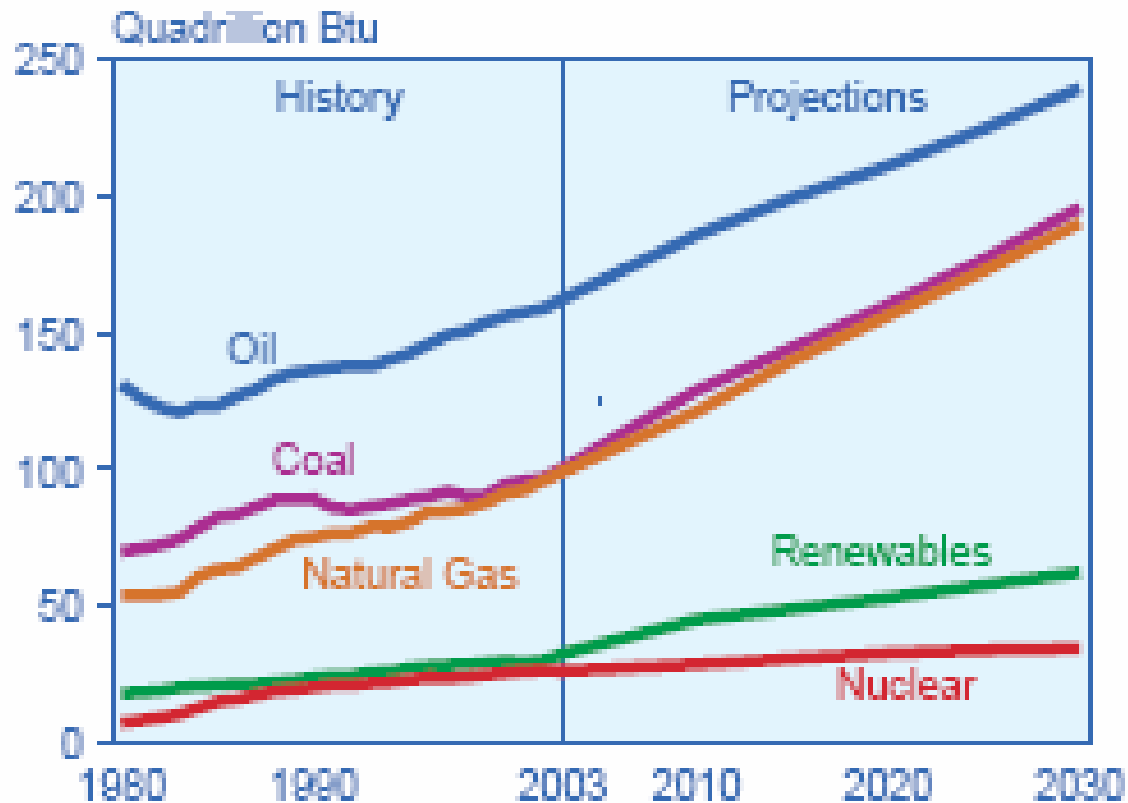


Where will this
energy come from ?

Mainly Oil - Gas - Coal

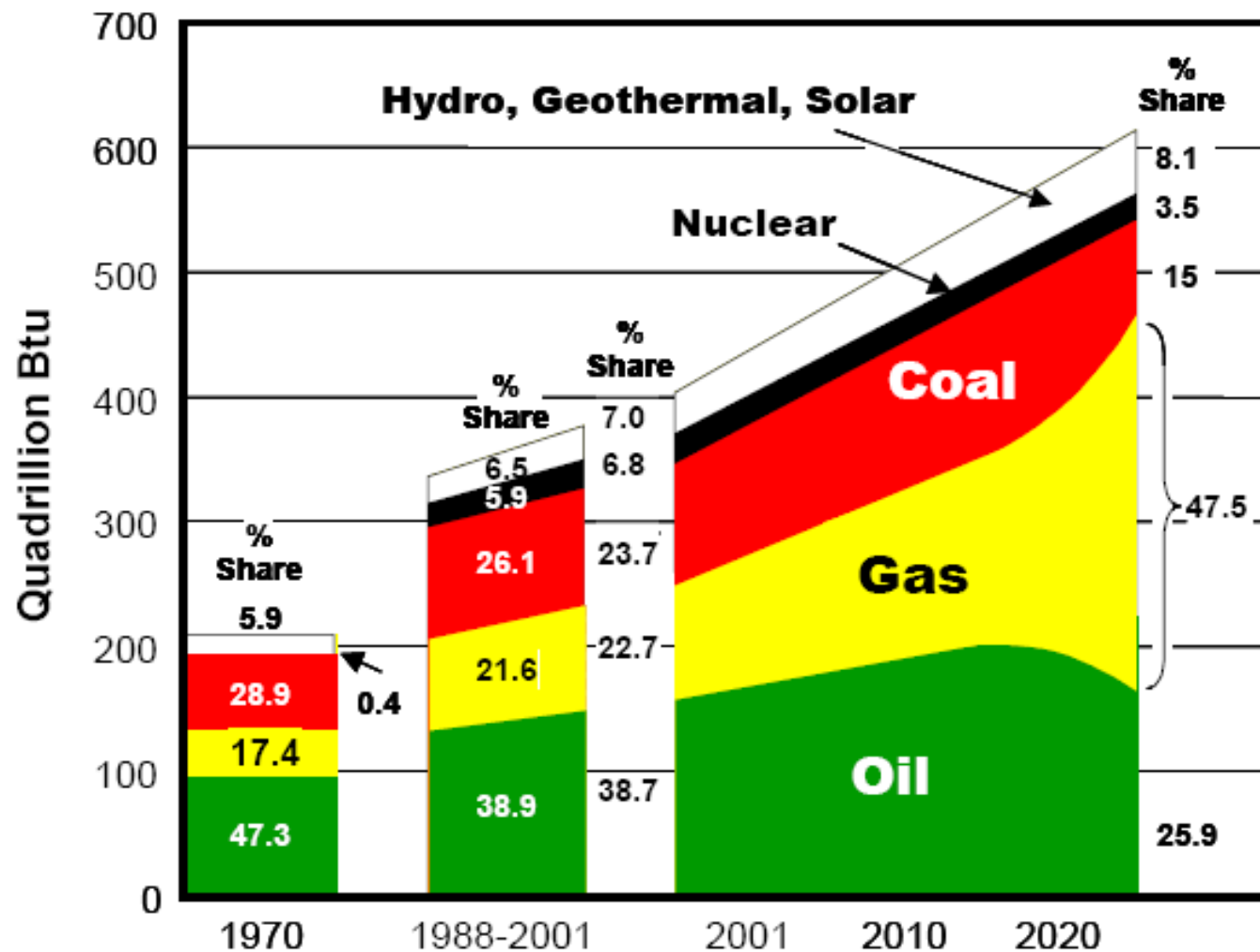


Figure 10. World Marketed Energy Use by Fuel Type, 1980-2030



Sources: History: Energy Information Administration (EIA), *International Energy Annual 2003* (May-July 2005), web site www.eia.doe.gov/iea/. Projections: EIA, *System for the Analysis of Global Energy Markets* (2006).

Economides and Oligney "Twist" Forecast of World Energy Consumption





Where the new
oil & gas
will come from ?

Deep & Ultra-deep water !

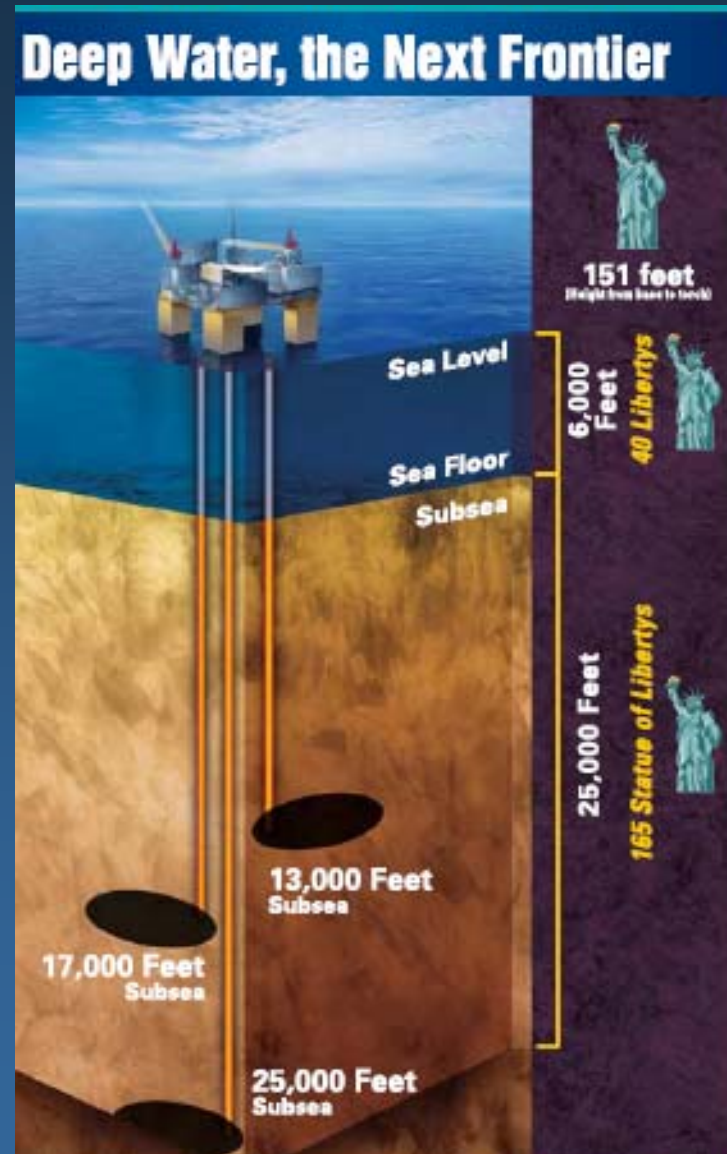


'hydrocarbon potential is not considered adequate to give any optimism for the deeper waters providing substantial additions to the reserves of exploitable hydrocarbons'

Wharman, 1978.

Transactions of the Royal Society of London.

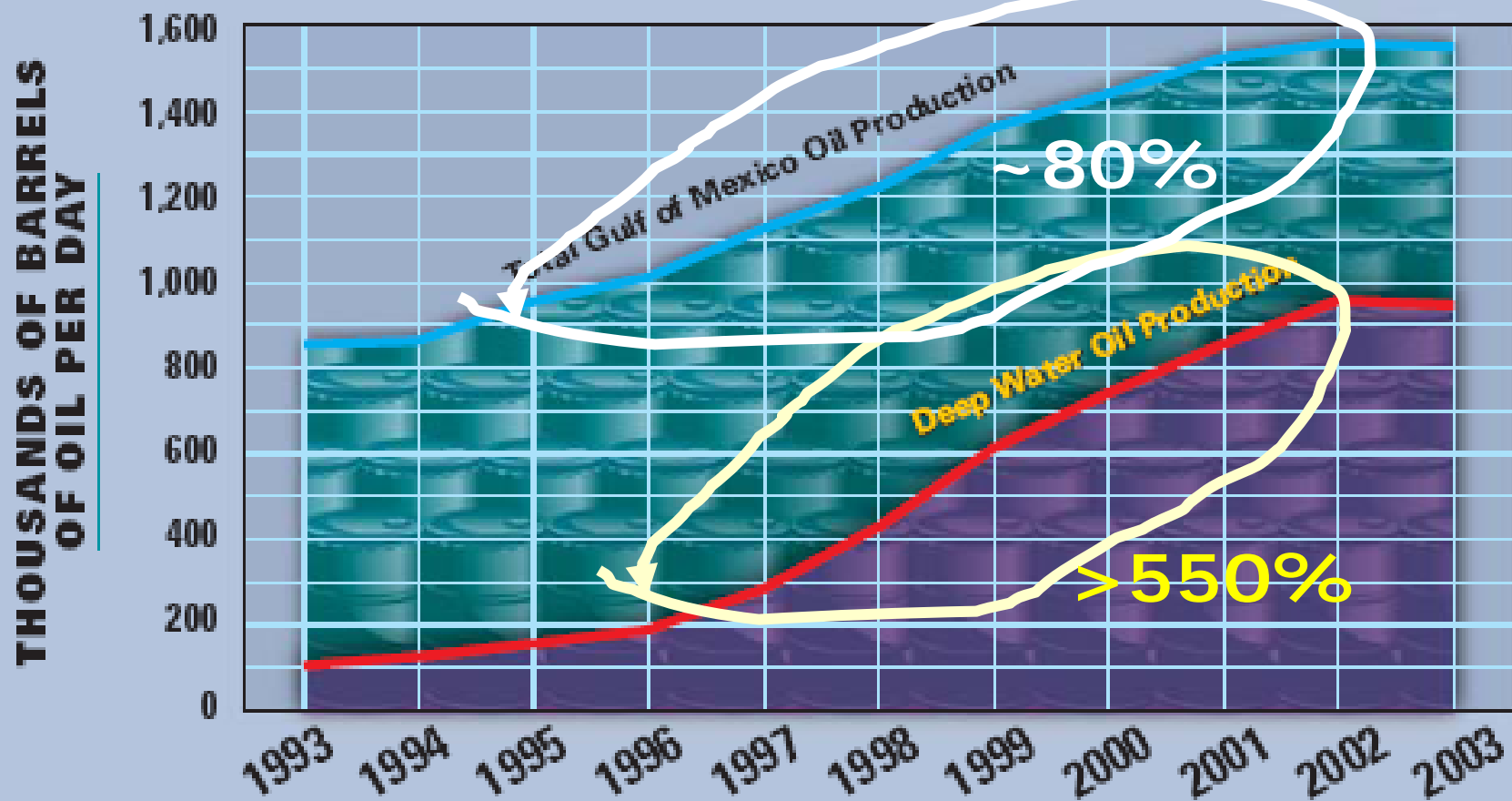
How things change !



Strong potential of subsurface ocean waters ! (deep > 300 m)



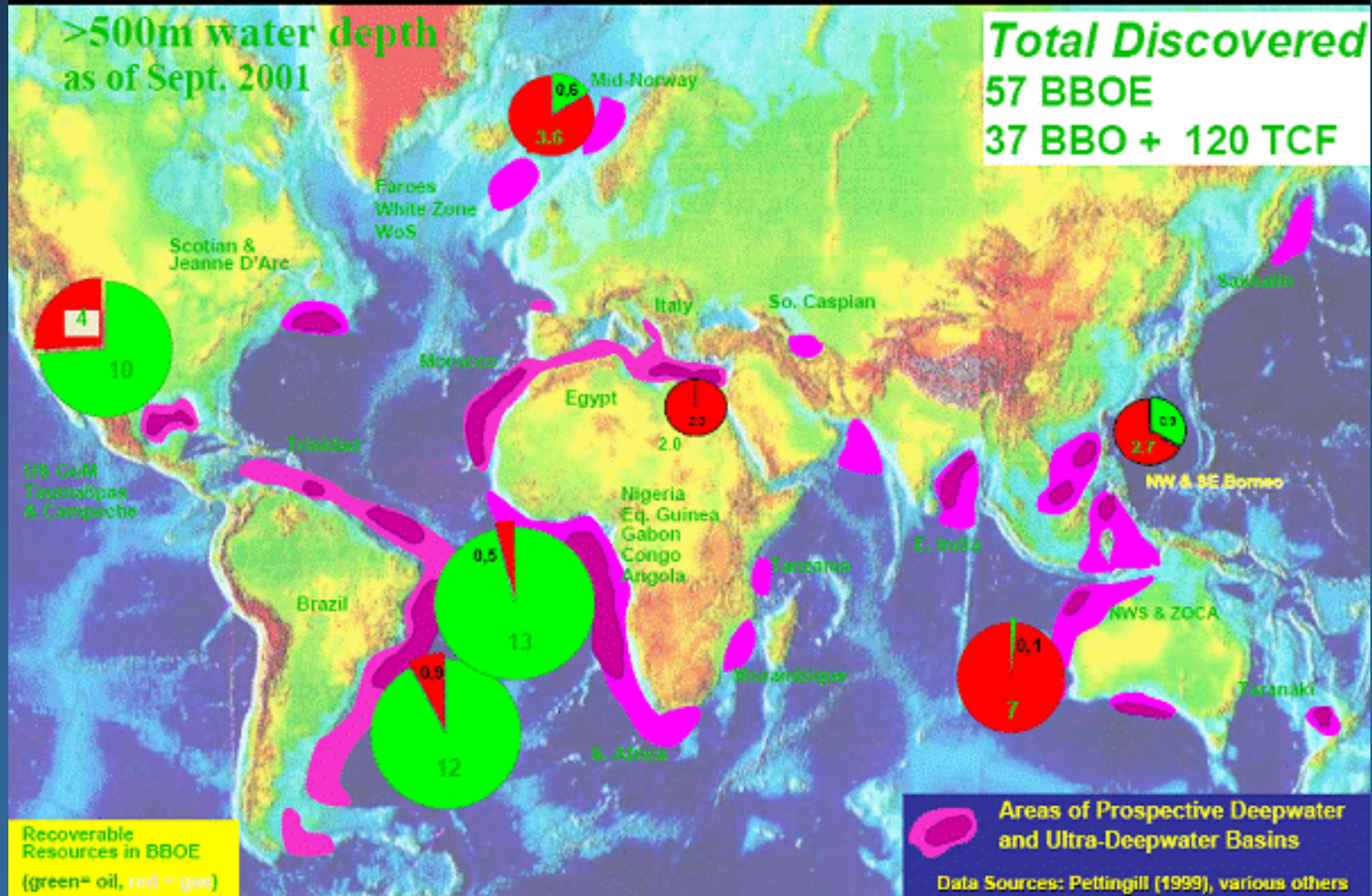
Gulf and Deep Water Oil Production



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



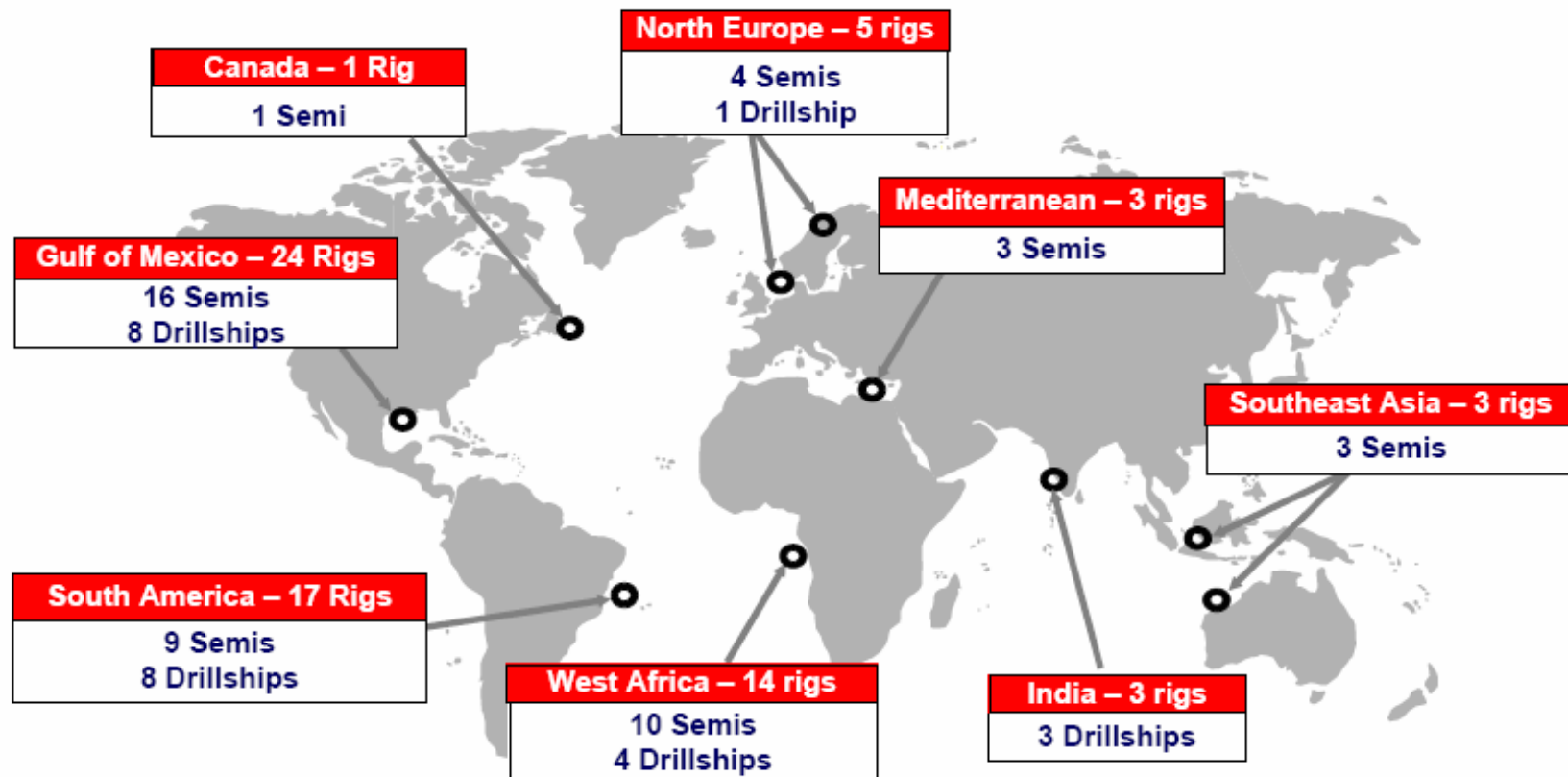
Deepwater Discovered Reserves



Fleet from one operator



The Deepwater Fleet (4500+ ft. Water Depth)



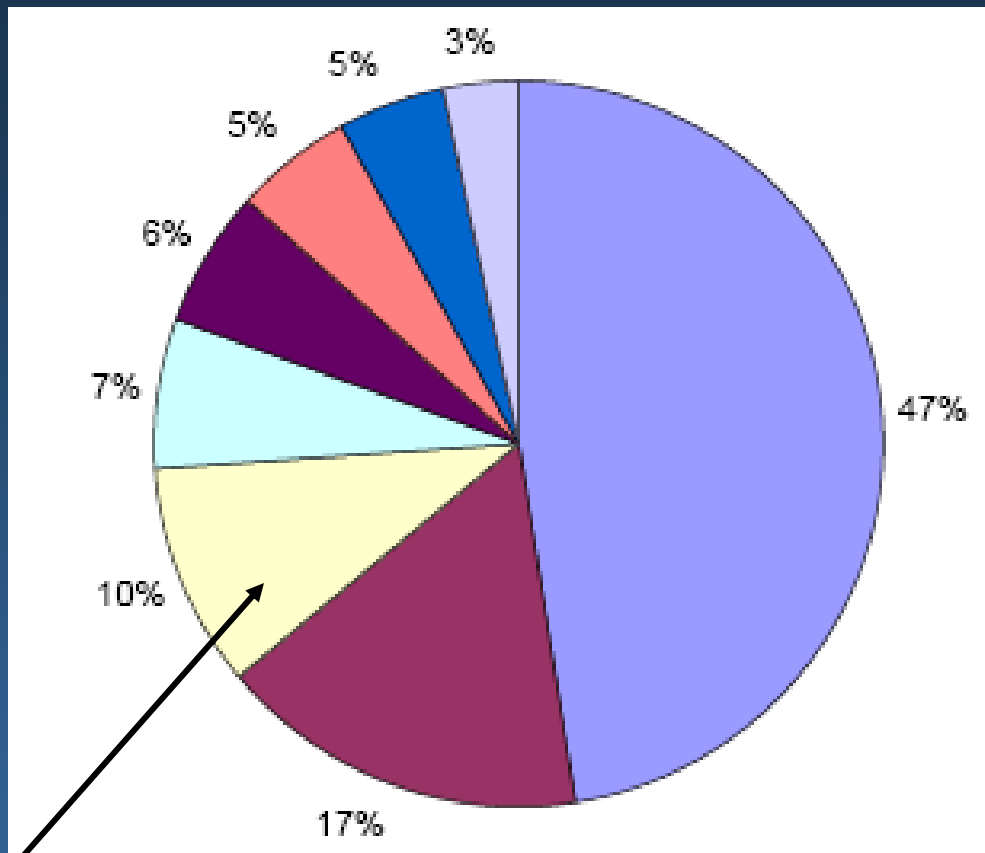
As of April 27, 2004, above display excludes 4 rigs under construction and 1 rig out of service.

But all come at a price !



- US \$ 10 - 50 million , single well
 - for 300 - 1500 m water depth
- US \$ 3 - 9 million,
 - for onshore (TD ~5000 m)
 - or offshore shallow water (TD ~ 6000 m)
- 50% costs for Drilling / tripping
- 9.5% for Drilling Fluids (3rd largest)

Cost distribution for deep drilling



- DRILLING / TRIPPING
- TUBULARS (CASING, LINERS, AND TUBING)
- DRILLING AND COMPLETION FLUIDS AND SERVICES
- WIRELINE / COMPLETION / STIMULATION
- ENVIRONMENTAL / REGULATORY / INSURANCE
- DATA GENERATION AND MONITORING
- PERSONNEL / MANAGEMENT / SUPERVISION
- CEMENTING

drilling fluids

but many problems are drilling fluid related

BENCHMARKING DEEP DRILLING

FINAL REPORT

Schlumberger
Data and Consulting Services
Pittsburgh, Pennsylvania

Drilling fluids

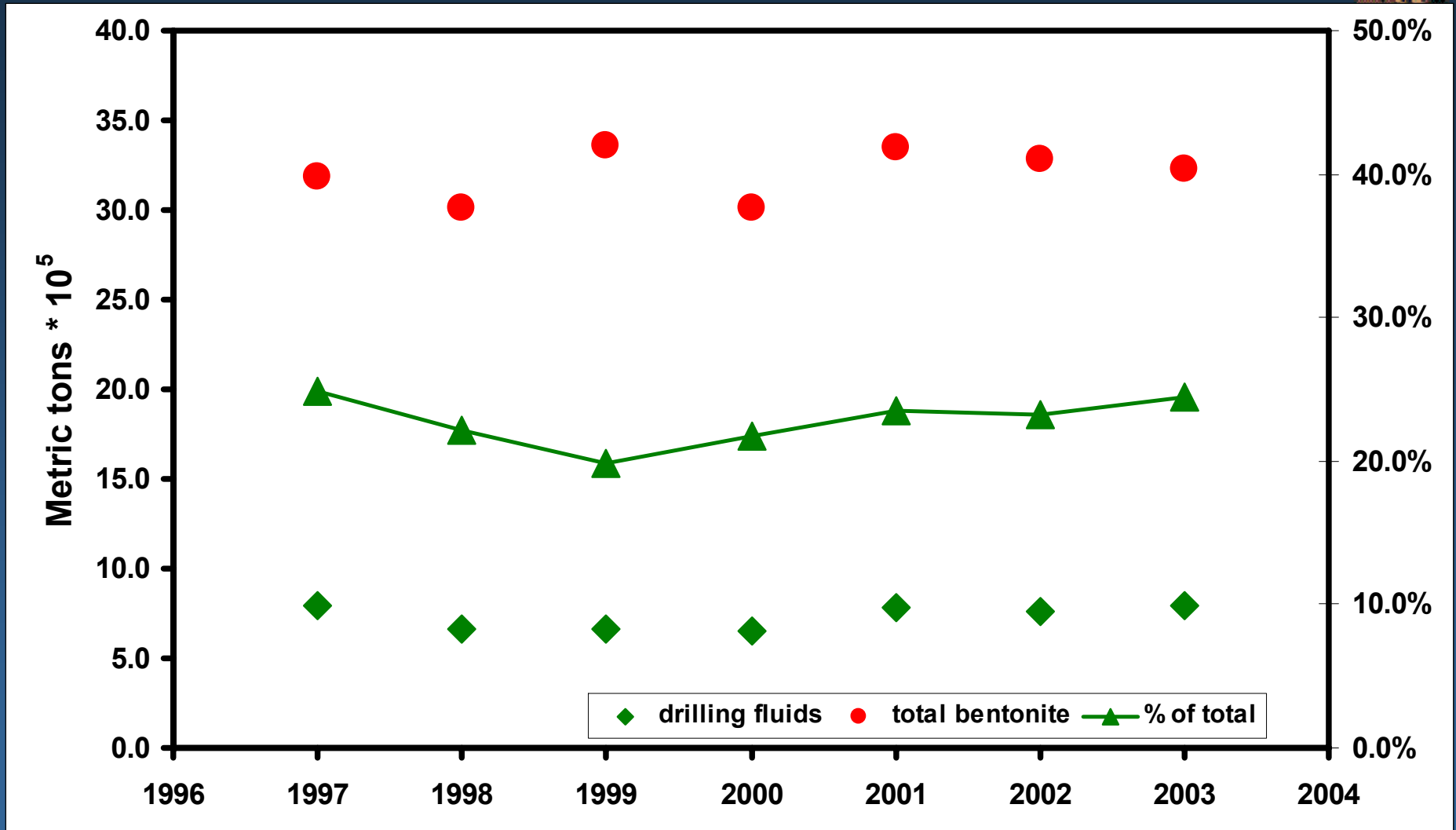


- the 'blood' of the well
- cool & lubricate the bit
- transfer cuttings to surface
- apply hydrostatic pressure (safety)
- maintain stability of wellbore

INGREDIENTS

water oil (diesel or synthetic)
bentonite polymers
many - many additives

Bentonite use in USA (USGS, 2005)



Greece ~ 5%
South Africa ~ 5%

Drilling fluid costs



- 1990, total ~ 4.0 billion US \$ (1996)
- per well, deep wells, 2006, 500.000\$
- very difficult wells, reported savings of up to 1.0 million US \$

Drilling fluids base, pros & cons



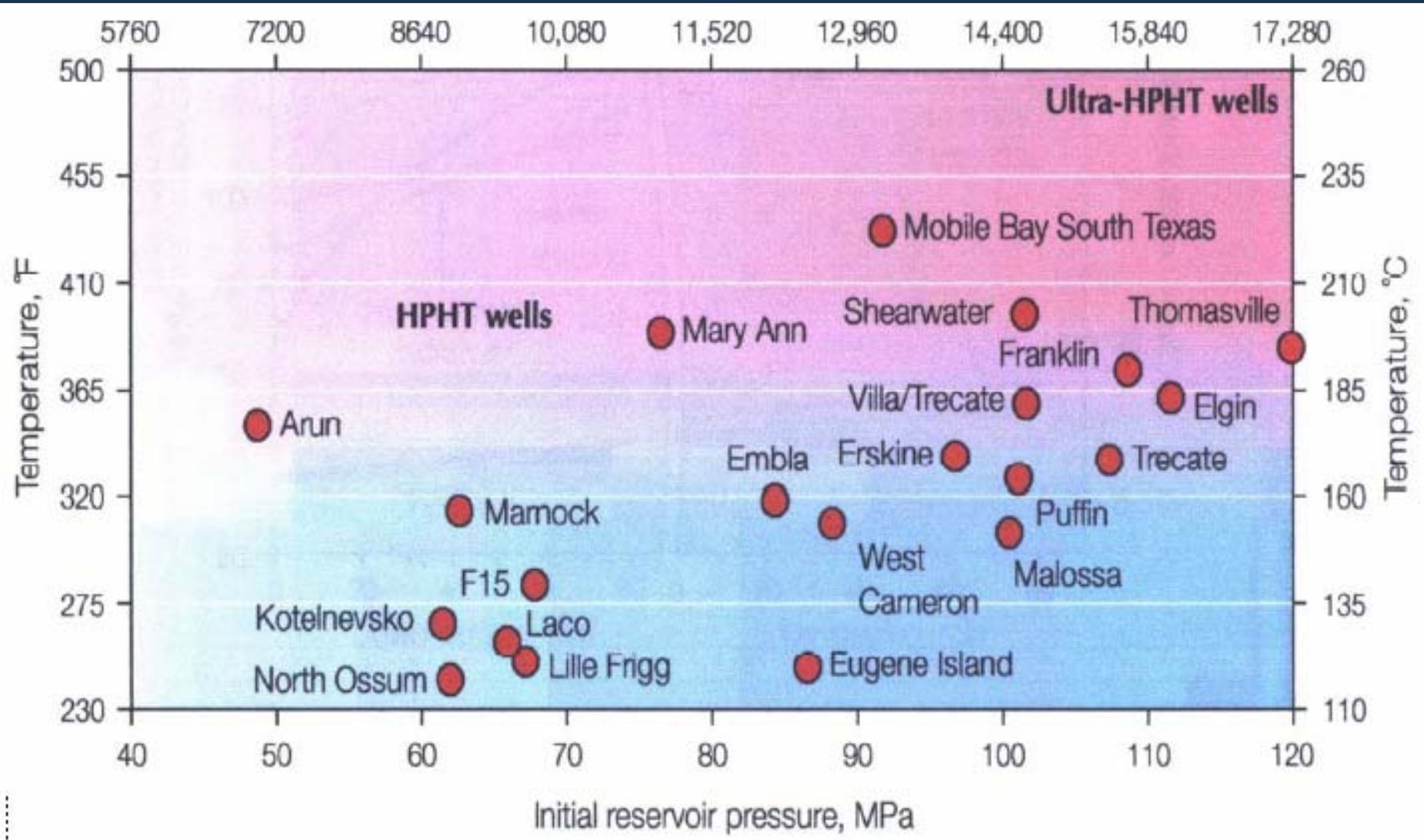
- Synthetic based muds, ~ 825 \$ / ton
 - C_{14} - C_{24} , esters, ethers, poly- α -olefins
 - beneficial but costly
 - deep water, pressure margin very narrow
 - great chances for fracturing formations
→ losses of very expensive fluids !
- Oil based muds, less expensive but environmental problems
- Water based muds, even less expensive

Incentive !



- Water based muds, reduce costs & protect environment
- significant ingredient, bentonite
- but at high & low temperatures, loss of
 - rheological properties
 - filtration properties
- Additives, particularly for HPHT wells

HPHT Wells



Challenges for drilling fluid industry



- Difficult well environment → Holistic approach
- flexible drilling fluids
- different formulations at different depth intervals
- adjustable parameters
- new additives

challenges for bentonite industry →
find additives to expand operating
range of water based fluids

Case histories



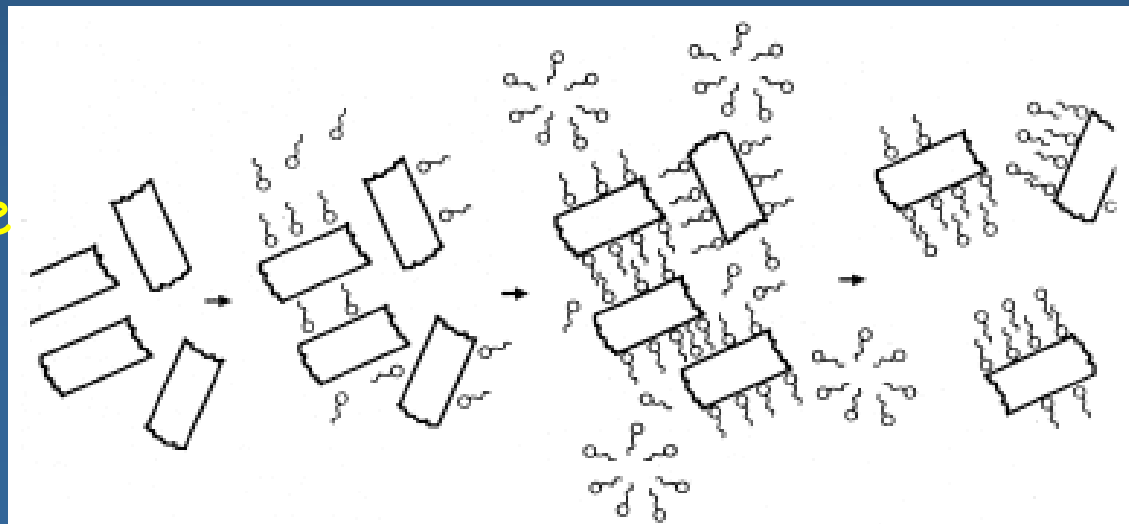
1. South China Sea, ~ 4.700 m, > 200°C, > 1000 bar, WBM, bentonite - resin/lignite - glycol
2. Offshore Louisiana, high salinity, polyols + sulphonated asphalts & oxidized subbituminous coal
3. Onshore Mississippi, ~ 5.600 m, 140°C blowout, WBM, bentonite, low weight co-polymer, synthetic interpolymer, modified lignite copolymer

Additives for bentonite fluids



- polymers
- lignite
- expand operating range
- in search for mechanism of operation

Representation of adsorption of cationic surfactants on bentonite particles (from Alemdar et al., 2000)



Our recent work - Greek lignites

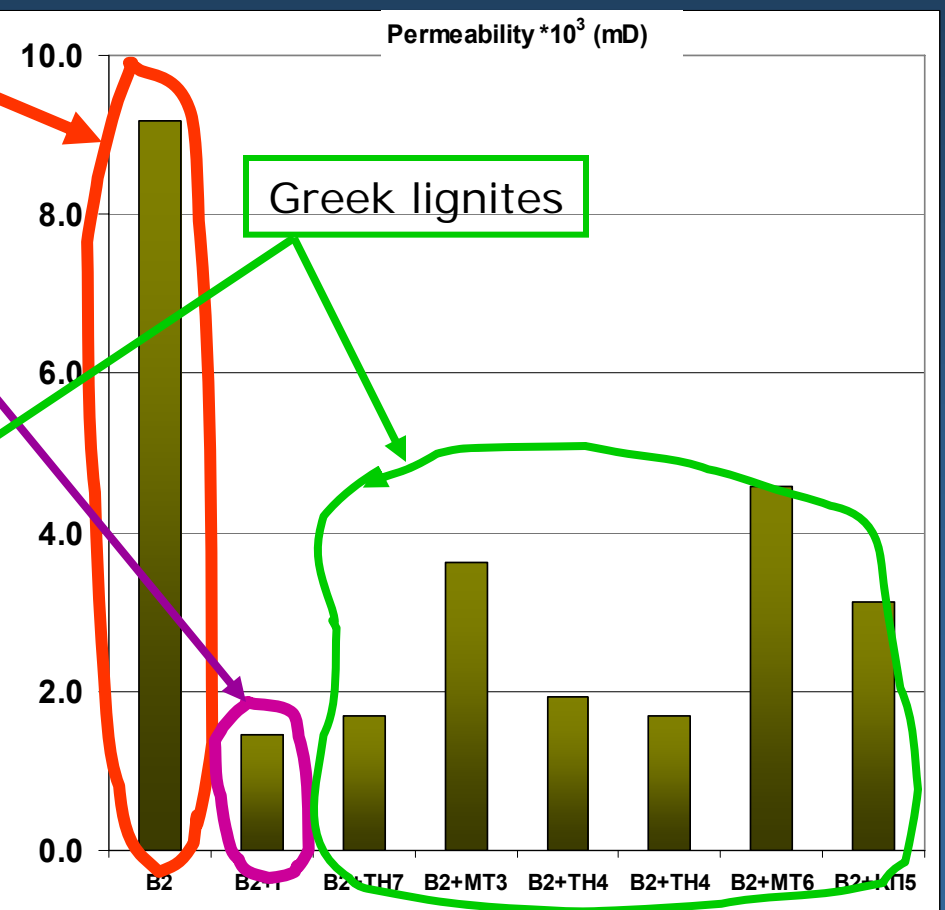
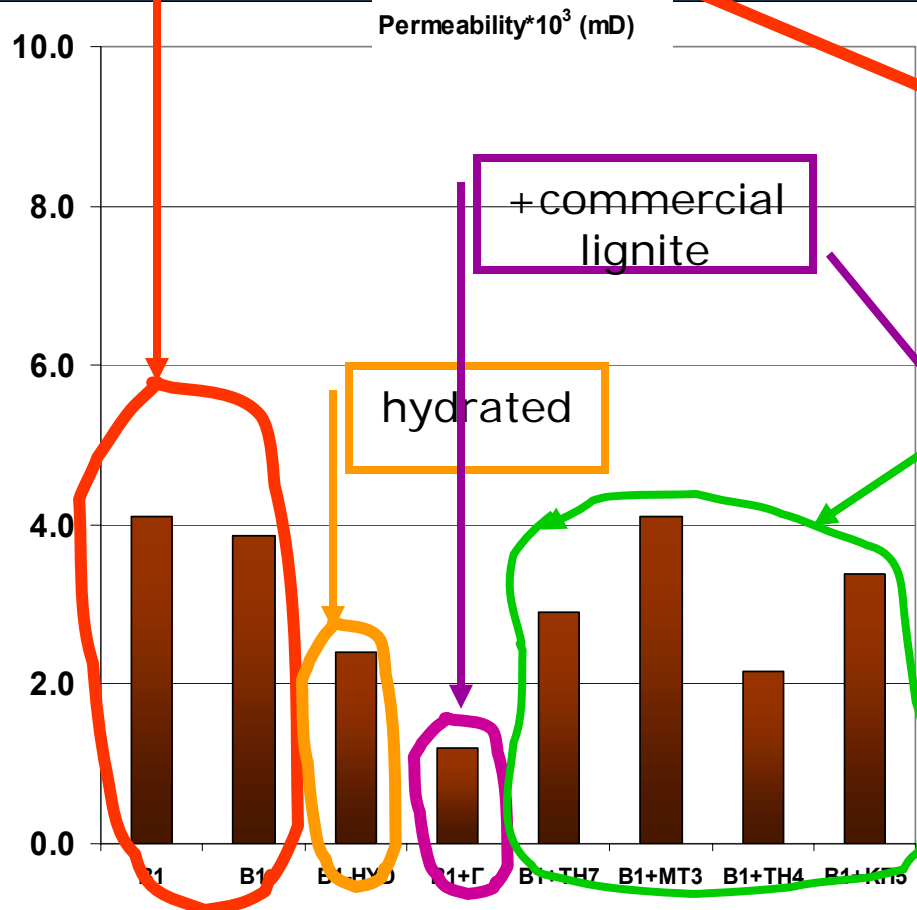


- methodology for lignite 'activation'
- techniques for measuring performance
- excellent performance of most Greek lignites as HT additives
- stable slurries for
 - rheology and filtration control
 - maintaining original core permeability

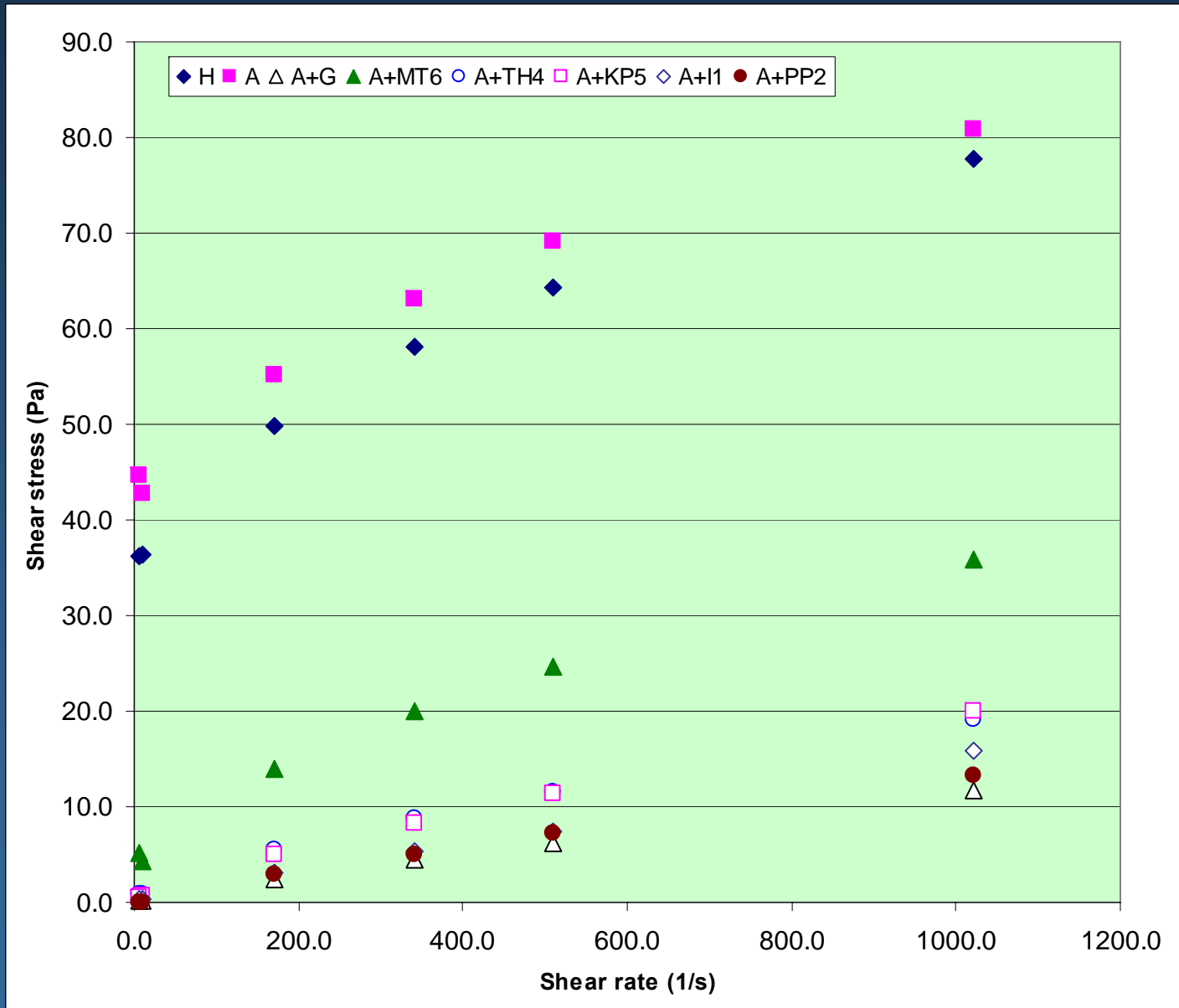
Permeability of filter cake (177°C)



aged



Rheological control with lignites

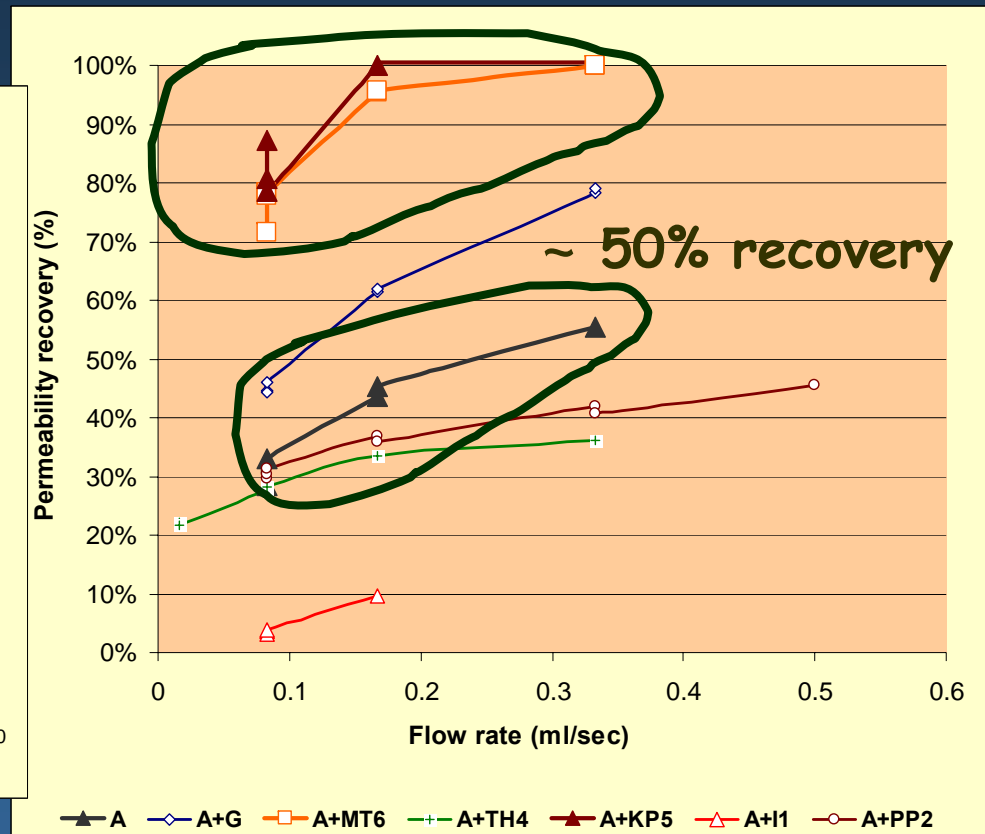
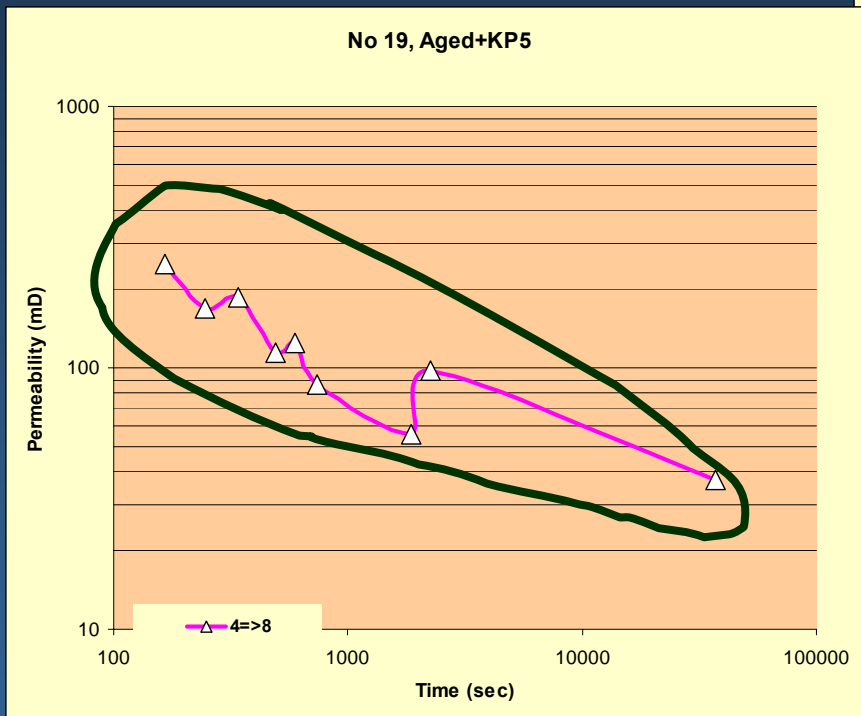


Retention of core permeability



~ 100% recovery

minimal damage



Summary



- Demand for hydrocarbons will be on the rise
- > 1500 m water depth, > 6000 m wells
- high and low temperatures
- need for excellent performing fluids
- in search for flexible drilling fluids
- WB fluids less expensive & environmentally friendly
- bentonite additives can expand operating ranges

**THE CHALLENGE ? focused
research and product development** ²⁷

the challenge
is there !

