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

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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.
Where will this energy come from?
Mainly Oil - Gas - Coal

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

Quadrillion Btu

History

Projections

Oil

Coal

Natural Gas

Renewables

Nuclear


Economides and Oligney “Twist” Forecast of World Energy Consumption

- **Hydro, Geothermal, Solar**
- **Nuclear**
- **Coal**
- **Gas**
- **Oil**

**Quadrillion Btu**

- **1970**
  - Hydro: 5.9%
  - Geothermal: 17.4%
  - Solar: 47.3%

- **1988-2001**
  - Hydro: 6.5%
  - Geothermal: 21.6%
  - Solar: 38.9%

- **2001**
  - Hydro: 7.0%
  - Geothermal: 23.7%
  - Solar: 38.7%

- **2010**
  - Hydro: 8.1%
  - Geothermal: 15%
  - Solar: 47.5%

- **2020**
  - Hydro: 3.5%
  - Geothermal: 15%
  - Solar: 25.9%

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*China Energy*

*Prof. Michael J. Economides*

*January 17, 2003*
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’


How things change!
Strong potential of subsurface ocean waters! (deep > 300 m)
Fleet from one operator

The Deepwater Fleet
(4500+ ft. Water Depth)

Canada – 1 Rig
1 Semi

North Europe – 5 rigs
4 Semis
1 Drillship

Gulf of Mexico – 24 Rigs
16 Semis
8 Drillships

Mediterranean – 3 rigs
3 Semis

South America – 17 Rigs
9 Semis
8 Drillships

West Africa – 14 rigs
10 Semis
4 Drillships

Southeast Asia – 3 rigs
3 Semis

India – 3 rigs
3 Drillships

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

but many problems are drilling fluid related
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-a-olefins
  - beneficial but costly
  - deep water, pressure margin very narrow
  - great chances for fracturing formations
    \( \rightarrow \) 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
Challenges for drilling fluid industry

• Difficult well environment ➔ Hollistic 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
- +commercial lignite
- Hydrated

Permeability *10³ (mD)

Greek lignites
Rheological control with lignites

Shear rate (1/s) vs. Shear stress (Pa) graph showing different lignite mixtures and their shear stress-shear rate behavior.
Retention of core permeability

~ 100% recovery

minimal damage

~ 50% recovery
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
the challenge is there!