The Reclamation Industries' Impact on the Evolution of Drilling Fluids

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Agenda

- Functions of Drilling Fluids
- History of Drilling Fluids
- Regulatory Changes
- Fluids of Today
- Waste Management Techniques

Functions of Drilling Fluids

- Carry cuttings from beneath the bit, transport them up the annulus and permit there separation at surface
- Cool and clean the bit
- Reduce friction between the drill string and the sides of the hole
- Maintain stability of uncased sections of the borehole
- Prevent the inflow of fluids – oil, gas or water
- Form a thin low – permeable filter cake which seals the pores and other openings
- Assist in collecting and interpretation of information such as cuttings, logs and cores.

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First Mud Systems - Clay

- Development and use of first mud laden fluid was in 1913 to control pressures
  - Gumbo Clays
- In 1928 the use of bentonite was initiated to over come hole problems
- By the 1930's it was widely recognized that drilling fluid would optimize the drilling practices and new products and systems were developed to over problems such as:
  - Caving formations
  - High pressure gas
  - Salt water flows
  - Salt formations

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Salt Water Mud Systems

- These problems lead to the development of salts based muds
- Salt water will stabilize salt zones and is tolerant to salt water flows
- They also found that salt is able to reduce the amount of caving shales as it stabilizes them
- Varying concentrations of salt added from 2% to saturation point
- Learned they had to add pre-hydrated Gel
- Traditional salts used where:
  - Potassium Chloride
  - Calcium Chloride
  - Sodium Chloride

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Oil Based Systems - Invert

- 1940's the first commercial oil based muds became available
- This allowed people to drill deeper and directional wells
- In 1960 the first water in oil emulsion fluid systems were developed
- Contains 10-40% Water, emulsifiers, wetting agents in a refined oil

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Invert becomes More and More Prevalent

- By 1975 drillers began to target wells with extreme properties
  - Very deep
  - High pressures
  - High temperature
  - Corrosive environments
  - Plastic Salts
  - Required deviation
- They did attempt to drill them with water and it proved to be unsuccessful
- Learned that the properties of Invert mud system were important and a necessity

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Benefits of Invert Mud Systems

- Able to drill troublesome shales
- Provides a high rate of penetration
- Able to drill deep, hot holes
- Able to drill salt, anhydrite, gypsum and potash zones
- Able to drill and core pay zones
- Able to drill through H_2S and CO_2 containing formations
- Able to decrease torque and drag
- As a packer fluid for corrosion control
- To minimize the likelihood of differential sticking

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Invert Buried Waste

Invert Buried Waste

Stock Piled Invert

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Development of Waste Management and Reclamation Guidelines

- 1975: drilling waste regulation - ERCB's ID-OG-75-2.
- 1993: Interim Directive 93-1 and Guide 50: Drilling Waste Management
- 1996: Revision to Guide 50 and eventual renaming to Directive 50.

Development of Waste Management and Reclamation Guidelines

- 2003: Upstream Oil and Gas Reclamation and Remediation program came into effect.

- Assessing Drilling Waste Disposal Areas: Compliance Options for Reclamation Certification (latest revision Feb 2009)

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Incompatible Mud Systems

- AENV Tier 1 Soil & Groundwater Remediation Guidelines provide endpoints for salts and hydrocarbon.
- Invert and salt based mud systems incompatible with Tier 1 endpoints.

Water Based Systems Must Provide

- Viscosity
  - To carry cuttings
  - To hold barite for pressures
- Shale Stabilization
  - Provide wellbore stability - as well as Invert or KCl
- Lubricity
  - Lubricants that can be disposed of cost effectively
- Cost effectiveness
- Environmentally Friendly
  - Meet requirements on hydrocarbon content, salt and metal loading, and toxicity

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Polymer Systems – No Solids

Fluid Loss Polymers

- PAC – Polyanionic Cellulose
  - Drispac, MF PAC
- Starch
  - Stardrill, MF STAR, Drillstar

Polymers that Provide Viscosity

- Xanthan Gum
  - **MF Vis, Milzan, Kelzan, Flozan**
- Hydroxyethylcellulose
  - Natrsol, HEC 10

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Polymer Systems – No Solids

Lubricants – Reduces Torque and Drag

- Boreglide
- Torquese
- EZ Drill

Shale Stabilizer – Eliminates Swelling and Dispersion

- Amine
- PHPA
- Silicate

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Inhibitive Additive - PHPA

The mechanism of PHPA is that the anionic groups attach to the positive edges of the clay particles. Due to the shape of the polymer it will coat or encapsulate the clay particles and the wellbore restricting water from entering. It also stabilizes the shale by viscosifing the drilling fluid.

- Passes Microtox at 3.0 kg/m^3

Inhibitive Additive - Amine

- Polymers are added for viscosification- XCD or HEC can be used
- PAC and starch are usually added for fluid loss
- Works with similar mechanisms as KCl
- Fits in between the clay platelets to prevent swelling and dispersion
- Works very well with PHPA
- Is environmentally friendly – Passes Microtox at 20L/m^3

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Inhibitive Muds - Amine

- If the amine system is being used gel can not be added directly to the system – will act as a contaminant and viscosity
- Is non corrosive - unlike KCl
- Does not effect electrical conductivity

Water

Amine

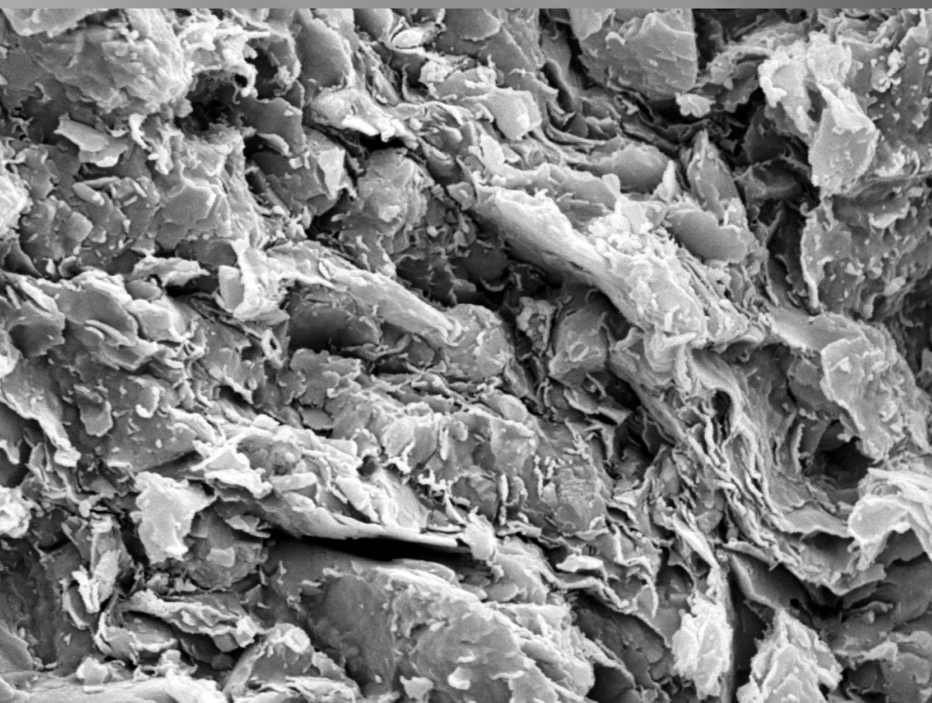
KCl

Potassium Silicate

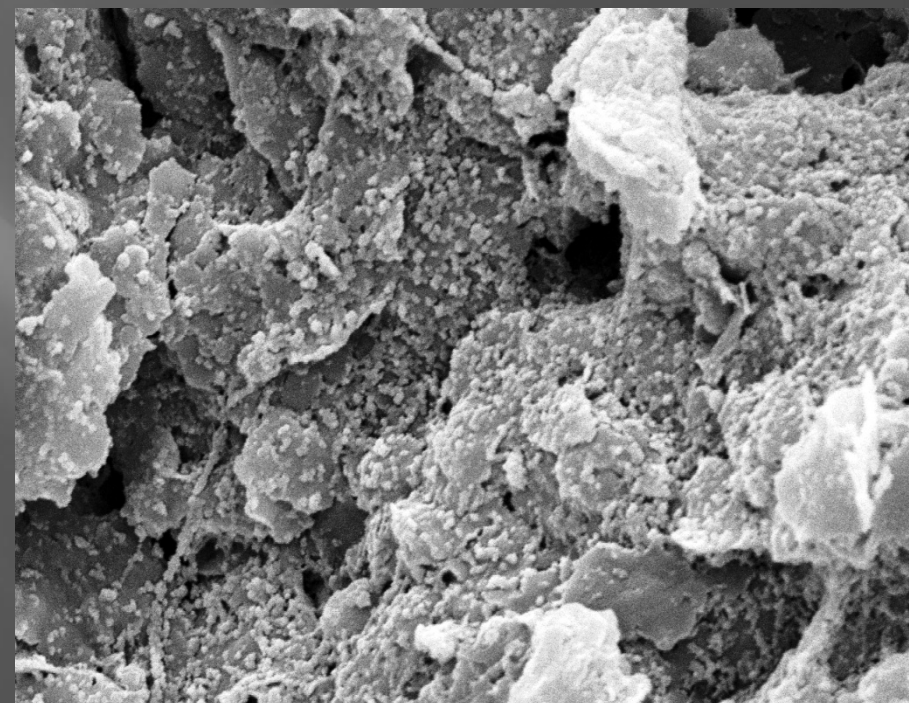
Silicates protect the shale by in-situ precipitation and gelling. This occurs when the silicate comes in contact with neutral pore fluid in the shale and /or the polyvalent cations such as calcium or magnesium in the formation.

Pore water: pH < 10.5 (major)
Mg^{2+} / Ca^{2+} ions (minor)
} 'glass' coating on the shale surface

Shale Stabilization Mechanism of Potassium Silicate



Shale (dried)



Stabilized Shale Reacted with Silicate

Silicate System Maintenance:

- **Shale Inhibition:**
  - Potassium Silicate (EcoDrill 317): 1 – 10 % (volume)
- **Fluid Rheology:**
  - Kelzan XCD
  - (Drispac R)
- **Fluid Loss:**
  - Drispac R / SL
  - Starch
- **pH Control:**
  - Caustic Soda: **pH 10.5 – 11.0)**
- **Microtox: Passes at 200L/m^3**

Disposal of Water Based Mud Systems

Drilling Waste
Solids + Liquids

Storage in Waste Sump

- Pump-Off
- Mix-Bury-Cover
- Landspreading
- Landspray After Drilling

Sumpless Disposal

- Landspray While Drilling
- Disposal on Forested Public Lands

Primary Disposal Criteria

Detailed Salinity Testing:

- Electrical Conductivity
- Total Dissolved Solids
- Sodium
- Potassium
- Calcium
- Magnesium
- Sodium Adsorption Ratio
- Chloride
- Nitrate
- Nitrite
- Sulfate
- Sulfite

Toxicity Testing

- Microtox

Hydrocarbons Testing (Oil)

- Total Hydrocarbon Content
- Hydrocarbon Fractions F1-F4
- Aromatic Content (BTEX)

Metals Testing

- Barium (mg/L)
- Zinc (mg/L)
- Others

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Microtox

- There are several types of toxicity analyses or bioassays: trout, earthworm, seed root elongation, etc.
- For drilling waste, the most commonly used toxicity bioassay is the Microtox test.
- The test measures changes in light output from luminescent bacteria when exposed to a potentially toxic substance.
- The test endpoint for drilling waste is the concentration of sample required to reduce the bacteria light output by 50% over a 15 minute period, denoted as EC50(15)
- An EC50(15) of greater than 75% must be obtained to meet disposal requirements.

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Advanced Gel Chemical Mud Systems

- On August 28, 2001 the ERCB released Informational Letter 2001-03: Management of Drilling Wastes Associated with Advanced Gel Chemical systems
- Advanced Gel Chemical drilling fluids are those water based drilling fluids that have additives not addressed in current D-50 Guidelines
  - i.e. potassium sulphate, sodium and potassium silicates, potassium formate, potassium nitrate, ammonium nitrate and potassium iodide tracers
- A special application must be made to the ERCB prior to disposing of Advanced Gel Chemical systems
- Approvals typically consist of ensuring that salinity maximum levels in soils are not exceeded after soil waste mix
- Typically Advanced Gel Chemical systems are placed in sumps to accommodate for time in getting government approvals and lab data back prior to disposal

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Conclusion

In conclusion the drilling fluids industry is constantly striving to produce environmentally friendly products and additives that will match the drilling performance provided by an invert mud system.

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