2023 BC Ground Water Well Introductory Mud School

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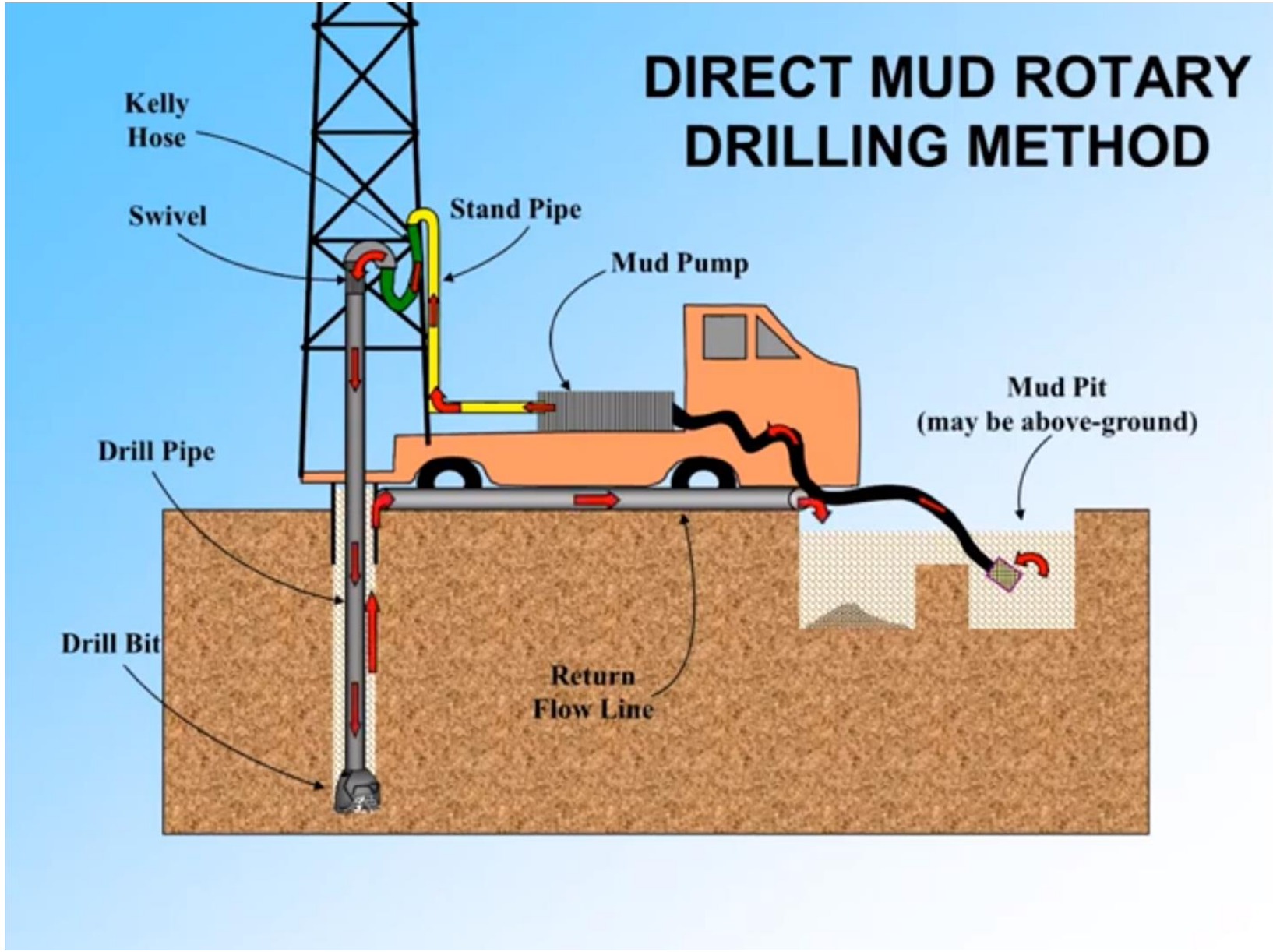
Safety
Be Aware of Your Surroundings

Todays Objectives

- Introduce “drilling fluids” and where and why they fit in the drilling process
- Simplify the drilling process
- Introduce the core Baroid IDP products used for vertical wells today

An **Excavation** Means A Hole In The Ground

- Drill a hole
  1. Create a cutting
  2. Clean the hole
  3. Stabilize the bore
  4. Protect the formation and formation fluids



MUD ROTARY DRILLING

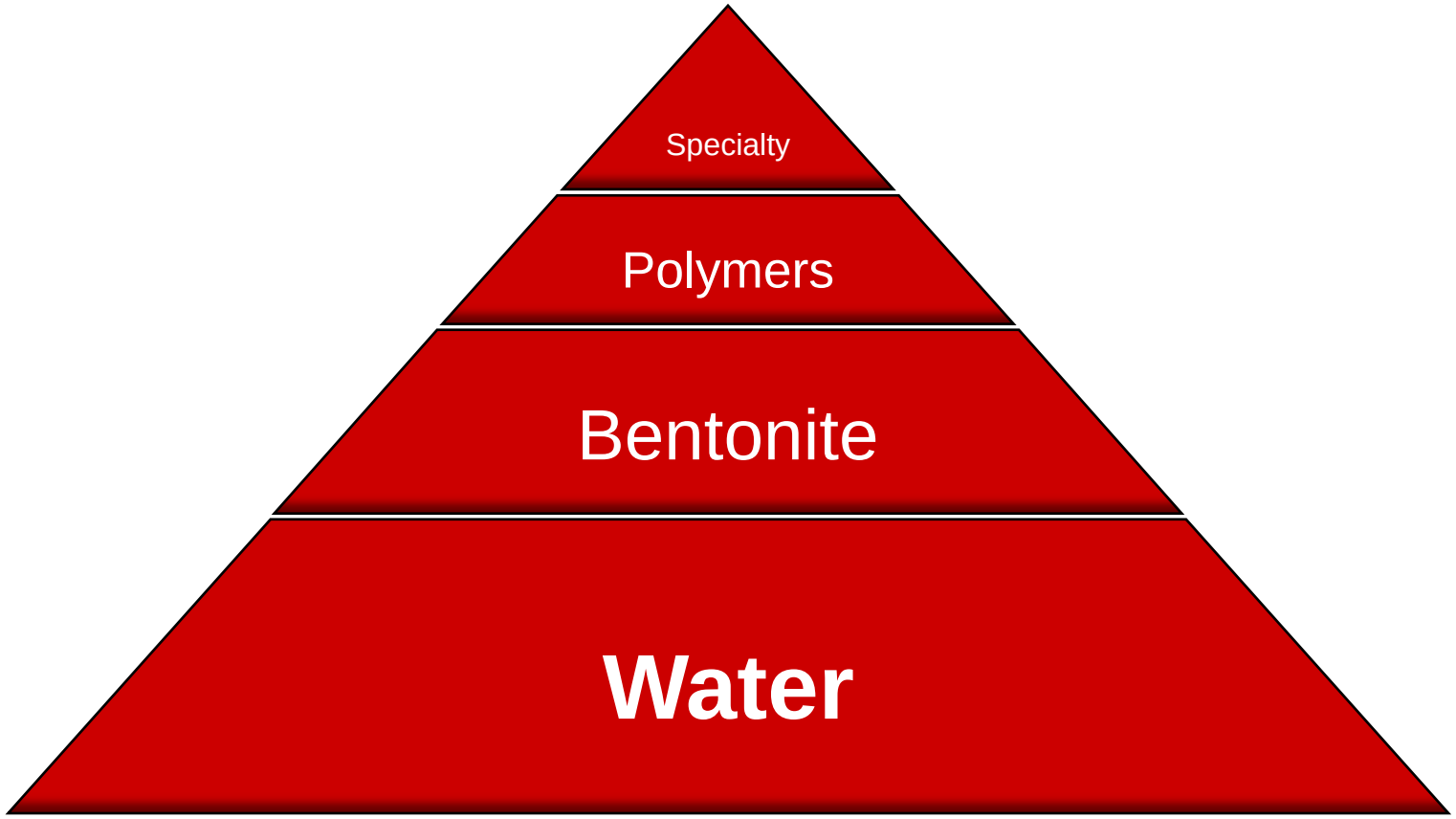
- **Advantages of Mud Rotary Drilling**
  - Stabilized borehole, even in unconsolidated formations
  - Good data collection & analysis capabilities
  - Formation problems (e.g., swelling clays or lost circulation conditions) can be addressed

- **Disadvantages of Mud Rotary Drilling**
  - Drilling fluid additives add cost in some cases
  - The water table cannot be directly identified during drilling

Myths and Misconceptions

- I always drill with water, until I have problems
- All I need is one additive that gets thick quick
- Drilling fluid additives – especially polymers – are too expensive to use
- All bentonite, polymers and other drilling fluid additives are the same

What is Drilling Fluid?



NOT DESIGNED TO GET US OUT OF TROUBLE

DESIGNED TO KEEP US OUT OF TROUBLE IN THE FIRST PLACE

WHAT DOES A DRILLING FLUID NEED TO DO TO KEEP US OUT OF TROUBLE?

Functions of a DRILLING FLUID

1. Remove cuttings from the bit and transport them to the surface
2. Allow the cuttings to be removed at the surface
3. Suspend cuttings when not circulating
4. Stabilize and support the Wellbore
5. Protect the formation and the formation fluids
6. Insure reliable geologic information
7. Control subsurface pressures
8. Cool and Lubricate the bit and drillstring
9. Transmit hydraulic energy to the bit
10. Maximize Wellbore Value

Fluid properties are the language of drilling fluids

- Drilling Fluid Properties describe the fluid
- Drilling Fluid Properties tell us if the fluid is performing its functions
  - The properties tell us if the fluid is working for us or against us
- Understanding properties allows:
  - Building desirable fluid properties initially
  - Maintaining desirable fluid properties during use

Drilling Fluid Properties

- Viscosity
- Rheology
- Density
- Sand Content
- Filtration
- Calcium Hardness
- pH

Viscosity

- Thickness of the fluid
  - Defined as the fluids “Resistance to flow”
- The only property we can see
- Measured with a Marsh Funnel or a Rheometer
- Why?
  - Influences hole cleaning, cuttings settling, borehole stability
  - Increases pumping pressures

Marsh Funnel Viscosity

Marsh Funnel and Cup

- Field measurement of the thickness of a fluid
- Reported in seconds per quart
- Water = 27 sec/quart or 28 sec/liter

Rheological Properties

- Plastic Viscosity, PV
  - Determined by size, shape, and number of solids in the mud
- Yield Point, YP
  - Measures the attractive forces between the particles in the mud
  - Measured in lb/100 ft² (Pa)
- Gel Strengths
  - Measures the strength of the gelled structure of a drilling fluid while at rest
  - Measured at 10 seconds and 10 minutes
  - Reported in lb/100 ft² (Pa)

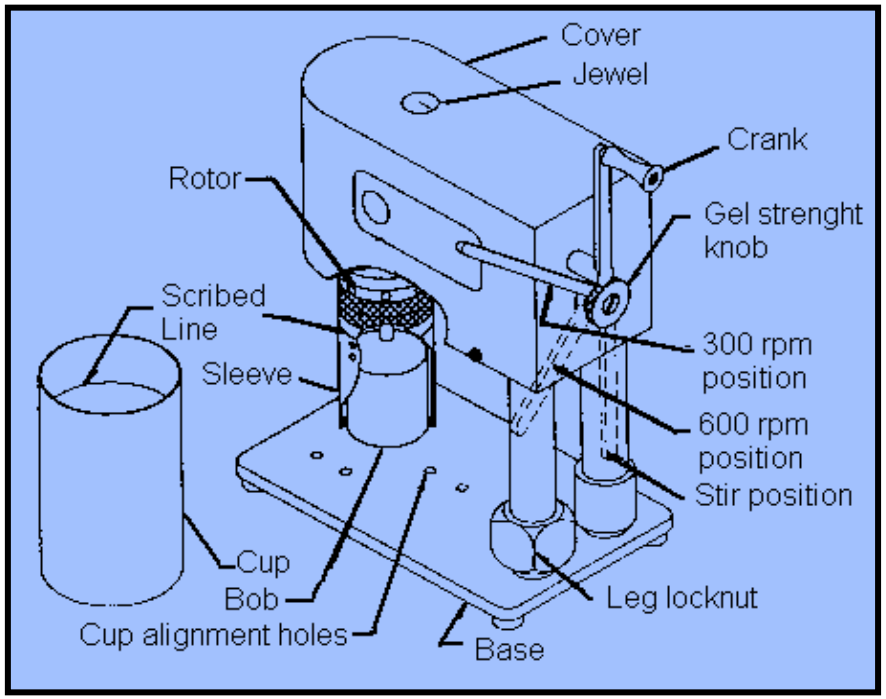
Rheological Properties PV, YP and Gel Strengths

- Why?
  - PV and YP tells us what actually creates the viscosity we see
  - PV and YP used for hydraulics and pressure loss equations
  - Yield point defines carrying ability when fluid is in motion
  - Gel strengths define suspension ability when fluid is static
  - Gel strengths indicate the relative force required to initiate fluid flow

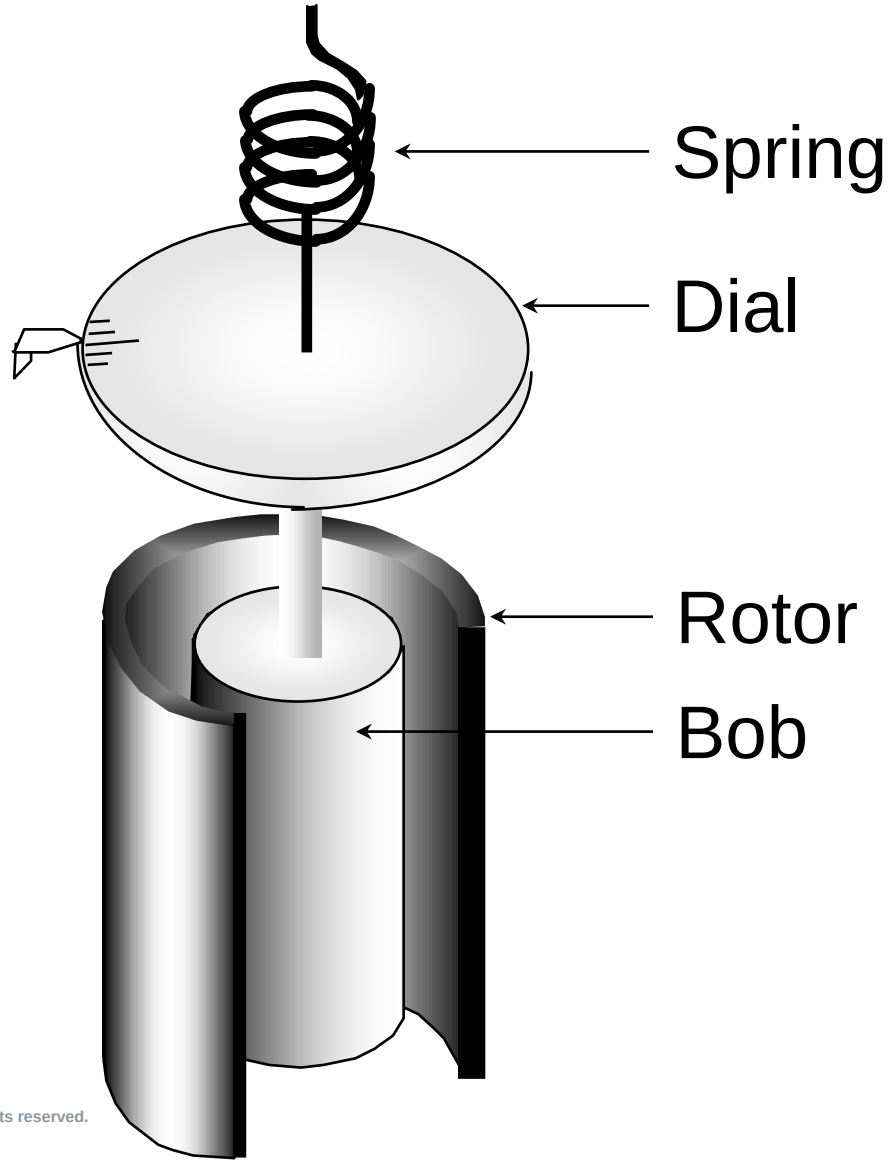
Rheology

fann® Rheometer

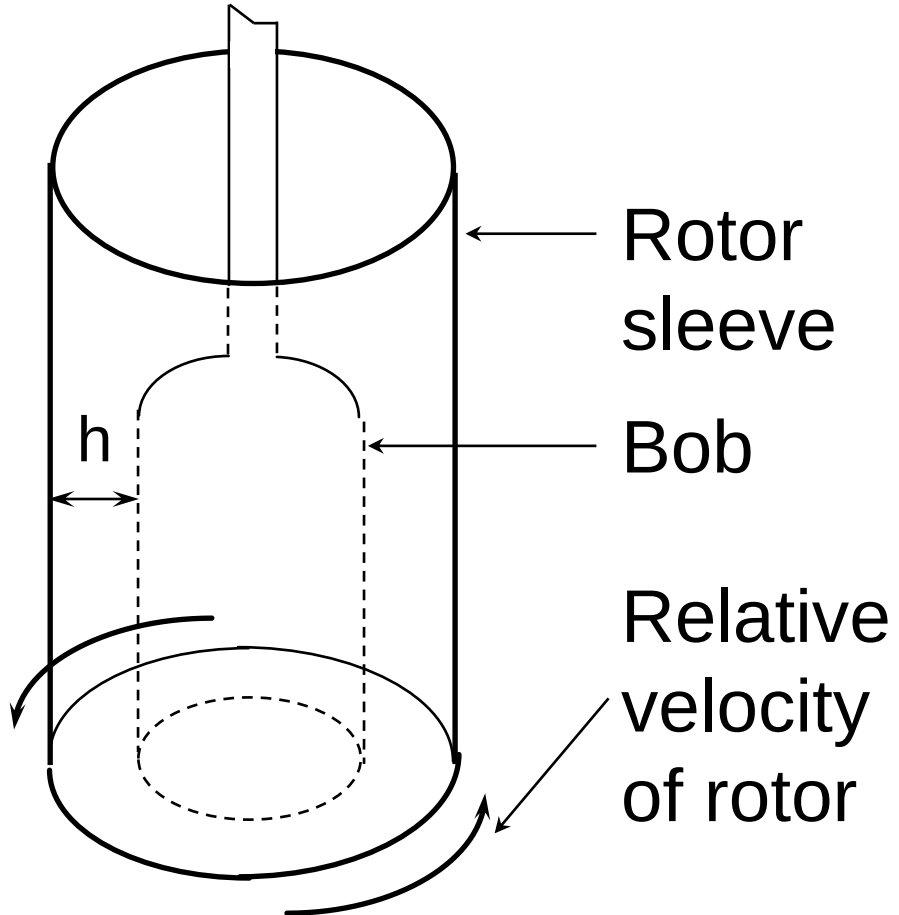
Model 280 Field Rheometer



Direct Reading Viscometer



Deflection in degrees is read from the graduated scale on the dial



Poor Man’s Rheometer

Density

- Mass per unit volume
  - Weight of the fluid
- Measured with a mud balance
- Why?
  - Used to calculate hydrostatic head
  - Used to calculate total solids content of the mud
  - Used to determine the efficiency of solids control equipment

Density

Mud Balance

- Reads in Pounds Per Gallon (lb/gal), Specific Gravity, Pounds per Cubic Foot, and PSI per 1000 Feet of Depth
  - Pounds per gallon (lb/gal) or Specific Gravity are the standards
- Water = 8.34 lb/gal, 1.0 specific gravity, 1000kg/m3

Hydrostatic Head Calculation

Hydrostatic Head (psi) =

Fluid weight (lb/gal) x vertical depth (feet) x .052

Example:10 lb/gal x 100 feet x .052 = 52.0 PSI

Hydrostatic Head (Pa) = Density of fluid(kg/m^3) x acceleration of gravity(9.81 m/s^2) x Vertical depth (m)

Example:1200 kg/m3 x 9.81 m/s2 x 30 m = 353,160 Pa (353 kPa)

Solids Content Calculation

% Solids* = (Fluid Weight, lb/gal - 8.3) X 8

% Solids = (11.3 - 8.3) X 8

3 X 8 = 24% Solids

% Solids* = (Fluid Weight, kg/m3 - 1000) X 0.064

% Solids = (1355 - 1000) X 0.064

355 X 0.064 = 23% Solids

* by volume - assumes 2.6 S.G. solids

Sand Content

- Measures the sand sized particle content of the drilling fluid
  - Sand is a size and not a mineral for testing purposes
  - Sand size is defined as anything retained on a 200 mesh screen (greater than 74 microns)
- Measured with a Sand Content Test Kit
- Reported as % by volume
- Why?
  - Indicates the abrasive constituent of the drilling fluid
  - High sand content slows penetration rate
  - Indicates effectiveness of solids control.
    - When recycling, As low as possible.Less than 1% is preferred

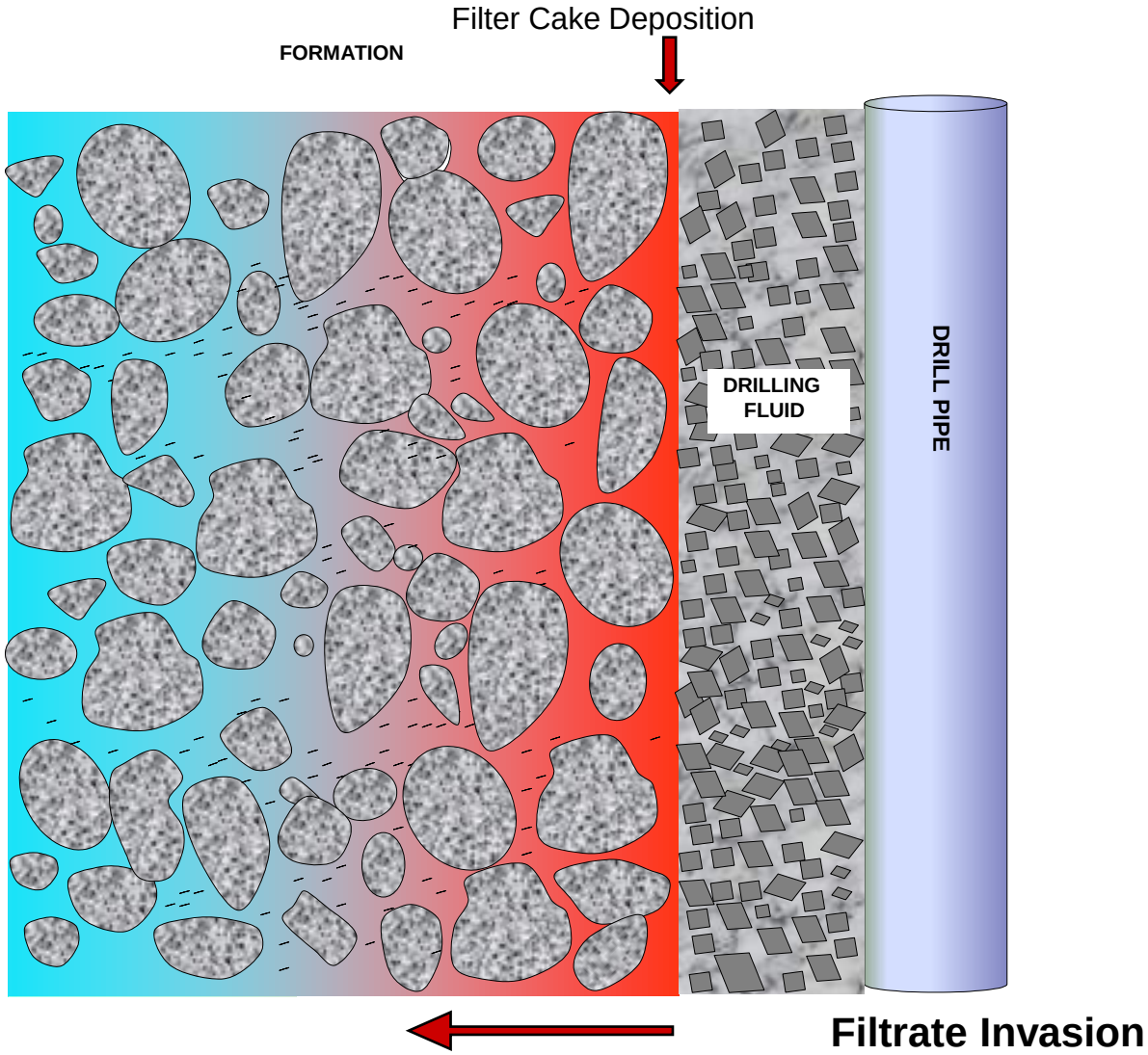
Sand Content

Sand Content
Test Kit

Filtration

- Measured with a Filter Press
- Filtrate reported in milliliters/30 minutes
- Filter Cake reported in 32nds of an inch or millimeters
- Why?
  - Wallcake building
  - Borehole stability
    - » Filtrate is the water phase of the drilling fluid available to react with the formation and drilled solids
  - Keep mud in the hole
  - Minimize stuck pipe

Mechanics of Filtration



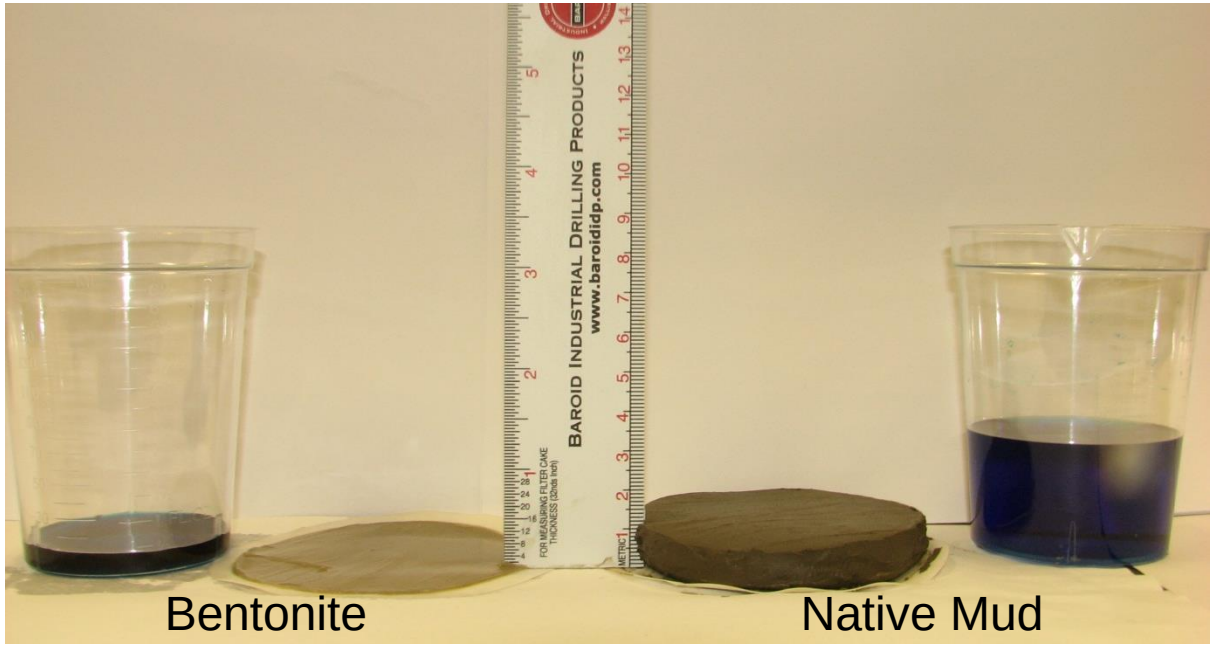
Filtration

Filter Presses

Filtration Properties

Filtrate Volume and
Filter Cake Thickness

Filtration



- Filtrate volume less than 15 milliliters / 30 minutes is recommended for most applications
- Filtercake less than 2/32 inch is recommended
- Low filtrate volumes generally denote tighter, firmer filter cakes

Total Hardness / Calcium Hardness

- Measures the concentration of cations contributing to total hardness
- Reported in milligrams per liter (mg/l) calcium
- Check the hardness of the make up water and mud filtrate
- Measured with calcium indicator strips or titrations
- Why?
  - In mixing water: Retards hydration of bentonite and polymers when greater than 100 mg/l
  - During drilling: Indicates contaminants picked up while drilling
- Calcium Levels As Low As Possible Are Desirable

  Less Than 100 mg/l is Recommended

Hardness

Total Hardness
Test Strips

pH

- Indicates the Acidity or Alkalinity of a Fluid
  - A pH of 7 is neutral
  - Acidic environments range from 0 to less than 7
  - Alkaline environments range from greater than 7 to 14
- Check the pH of the make up water and mud filtrate
- Measured with pH strips, papers or meters
- Why?
  - pH 8.5 – 9.5 is optimal for hydration of bentonite and polymers

Acid

10,000,000	pH= 0	Battery acid, Strong Hydrofluoric Acid
1,000,000	pH = 1	Hydrochloric acid secreted by stomach lining
100,000	pH = 2	Lemon Juice, Gastric Acid Vineger
10,000	pH = 3	Grapefruit, Orange Juice, Soda
1,000	pH = 4	Acid rain Tomato Juice
100	pH = 5	Soft drinking water Black Coffee
10	pH = 6	Urine Saliva
1	pH = 7	"Pure" water

Alkaline

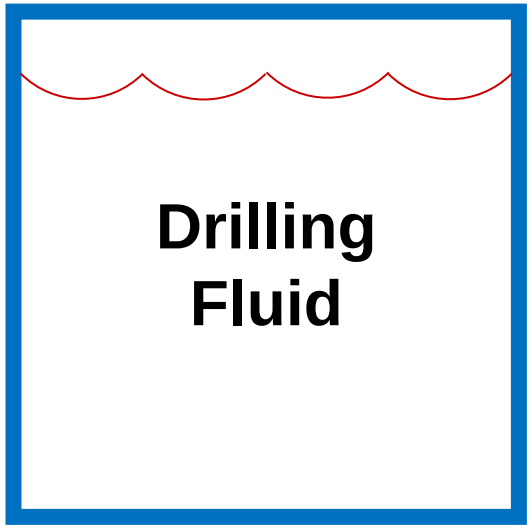
1	pH = 7	"Pure" water
1/10	pH = 8	Sea water
1/100	pH = 9	Baking soda
1/1,000	pH = 10	Great Salt Lake Milk of Magnesia
1/10,000	pH = 11	Ammonia solution
1/100,000	pH = 12	Soapy water
1/1,000,000	pH =13	Bleaches Oven cleaner
1/10,000,000	pH = 14	Liquid drain cleaner

pH

Wide-Range pH Strips
(0 To 14)

FLUID SELECTION Considerations

- Drilling Fluid
- Geology
- Hole geometry
- Rig
- Tooling
- Pumping volumes
- Fluid flow



Geology: Simplified soil types

- **COARSE SOILS**
  - SAND
  - GRAVEL
  - ROCK
- **FINE SOILS**
  - CLAY
  - SHALE

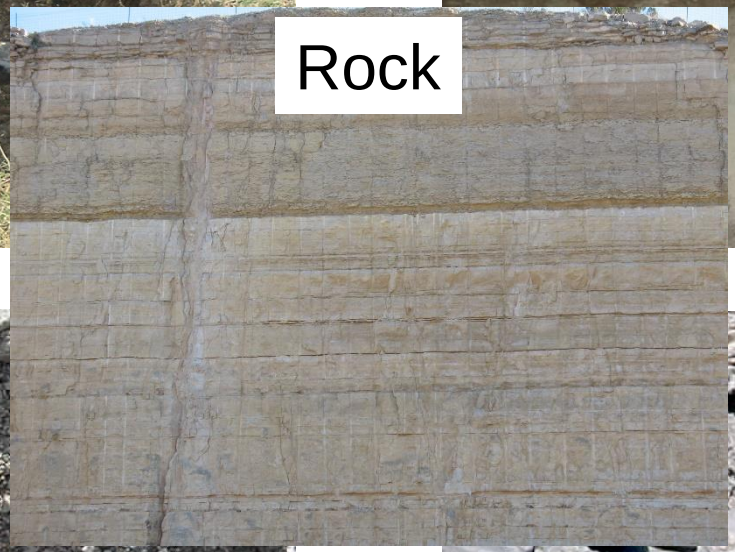
COARSE SOILS

- POROSITY & PERMEABILITY
- INERT & NON-REACTIVE
- DON’T SWELL
- DON’T GET STICKY
- CAN BE UNSTABLE

FINE SOILS

- REACTIVE
- THEY SWELL
- THEY GET STICKY
- CAN AGGLOMERATE
- CAN DISINTEGRATE

There is no ***universal*** soil…



Rigs, bits, tools

Rigs:

- Provide the power
- Sized according to
  - Bore diameter and length
  - Geology

Bits:

- Cutting tools
- Responsible for steering control

There is no universal

Rig or bit!

WATER

The *Original* Drilling Fluid

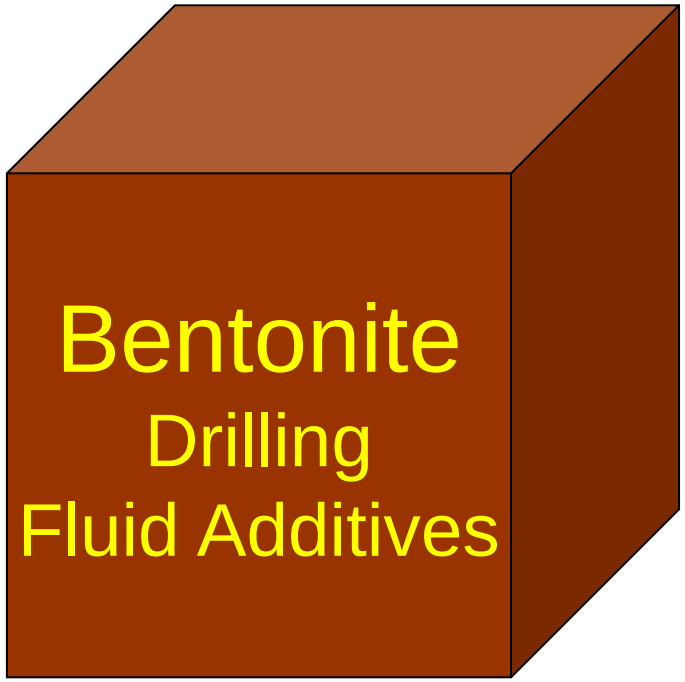
ADDITIVES ARE ADDED TO MAKE
WATER MORE USER-FRIENDLY

Coarse Soils

- KEEP THE HOLE OPEN
- KEEP THE FLUID IN THE HOLE
- SUSPEND and TRANSPORT CUTTINGS

- COARSE SOILS PRESENT MECHANICAL-TYPE PROBLEMS
- THE SOLUTION : BENTONITE

The Backbone



Viscosifier

Carrying Capacity

Gellant

Filtration Control

Bore Hole Stabilization

Lubrication

Bentonite Products

QUIK-GEL® **QUIK-GEL GOLD®**

BORE-GEL® **QUIK-BORE™**

AQUAGEL® **AQUAGEL GOLD SEAL®**

TUNNEL-GEL® PLUS **TUNNEL-GEL™ SW**

BORE-GROUT™

KEEP THE FLUID IN THE HOLE
LOWER FILTRATION AND IMPROVE FILTER CAKE

QUIK-TROL® GOLD

QUIK-TROL® GOLD LV

SUSPEND CUTTINGS
INCREASE GEL STRENGTH/VISCOSITY

NO-SAG®

KEEP THE FLUID IN THE HOLE
BRIDGING/PLUGGING, LCM

N-Seal™

Benseal®

Fine Soils

- USE CHEMICAL-TYPE SOLUTIONS
- INHIBITIVE POLYMERS TO MINIMIZE WATER WETTING

Inhibitive Polymers
Seal Clay surfaces and minimize water wetting

EZ-MUD® GOLD

EZ-MUD® **QUIK-MUD® D-50** **EZ-MUD® DP**

EZ-MUD® DP GOLD **EZ-MUD® PLUS**

POLYBORE™

CLAY-DRILL™ SYSTEM

PERFORMATROL® 930 SYSTEM

MIXING

The 5 Step Process

5 Simple Steps To Set Up Your Fluid Mix

1. FIX YOUR WATER
2. CREATE SUSPENSION
3. CREATE A SHIELD AROUND THE BORE
4. CREATE A SHIELD AROUND CUTTINGS
5. ADDRESS SPECIAL NEEDS

1. FIX YOUR WATER

- Remove Contaminants
  - Contaminants interfere with hydration and functioning of drilling fluid additives
  - Calcium (hardness) if >100 mg/l
  - Chlorides (salt) if >500 mg/l
- Adjust pH
  - 8.5-9.5 optimal for all additives

Fix Your Water: Hardness and pH

Treat make-up water with:

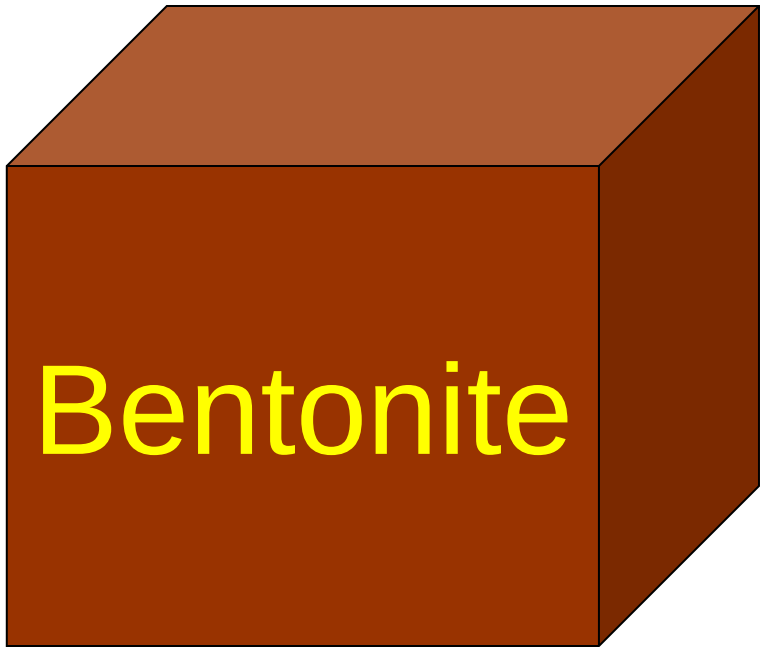
SODA ASH

0.5-2 lb/100 gallons

Fix Your Water: Salt

Find new source
of make-up water

2. CREATE SUSPENSION
The Backbone



Viscosifier

Builds suspension properties

and carrying capacity

Gellant

Filtration control

Bore hole stabilizer

Lubrication

Baroid bentonite products

- QUIK-GEL®
- BORE-GEL®
- AQUAGEL

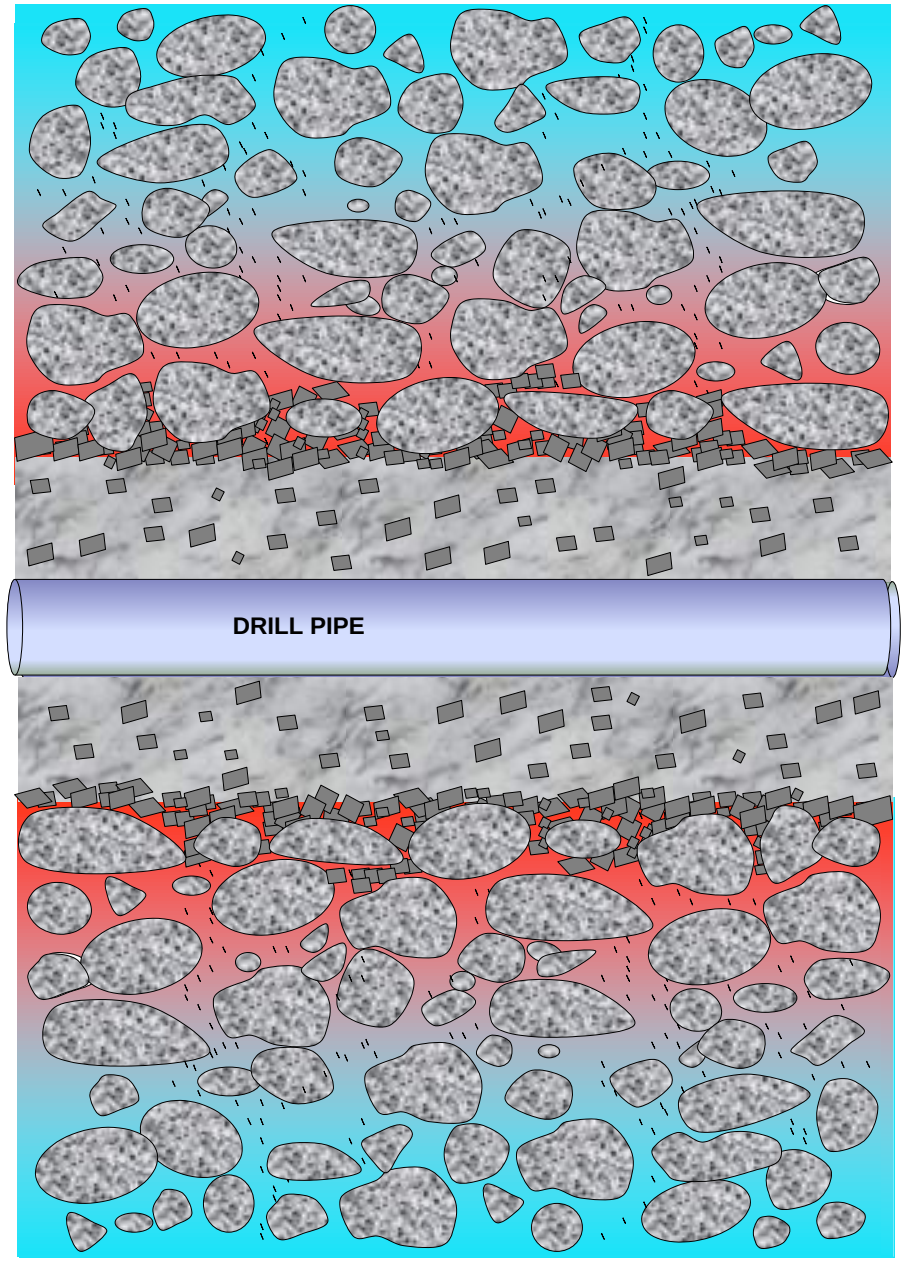
- Build the backbone of drilling fluid systems

3. CREATE A SHIELD AROUND THE BORE
Baroid PAC Products

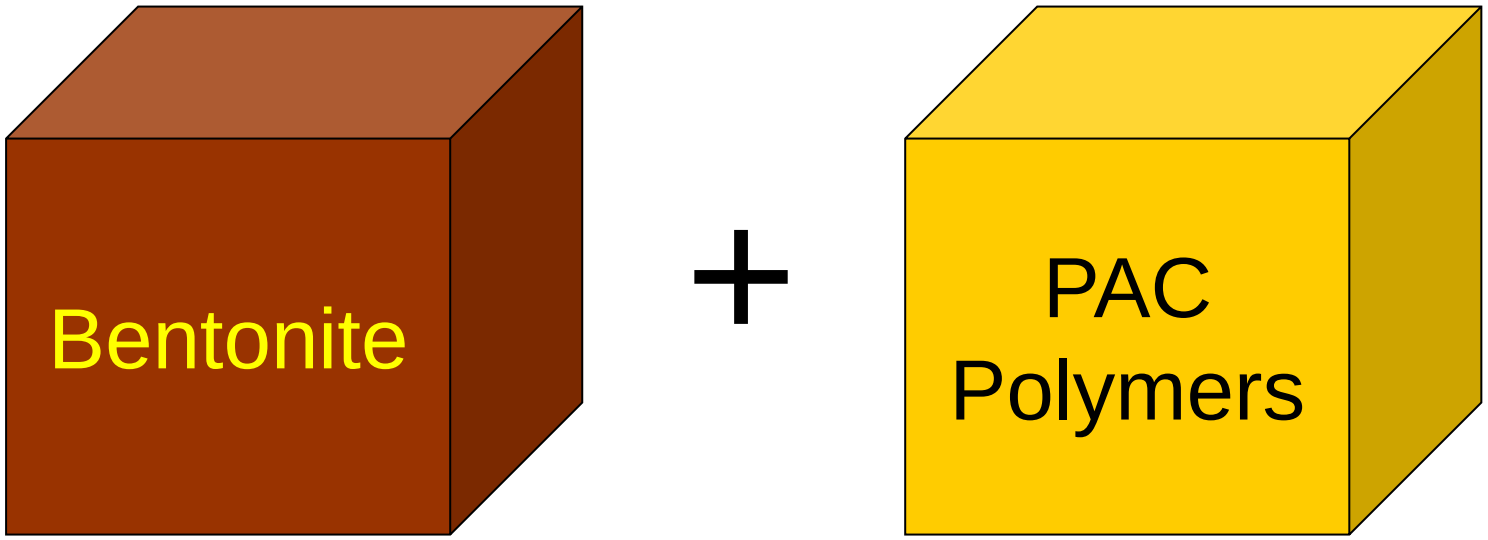
- ❖ QUIK-TROL® GOLD
- ❖ QUIK-TROL® GOLD LV

- Provide enhanced filtration control and improve filter cake
- Promotes borehole stability in water sensitive formations (sand, clay and shale)
- Disperse and hydrate effectively at low shear

Protect the bore



Improve Borehole Stability

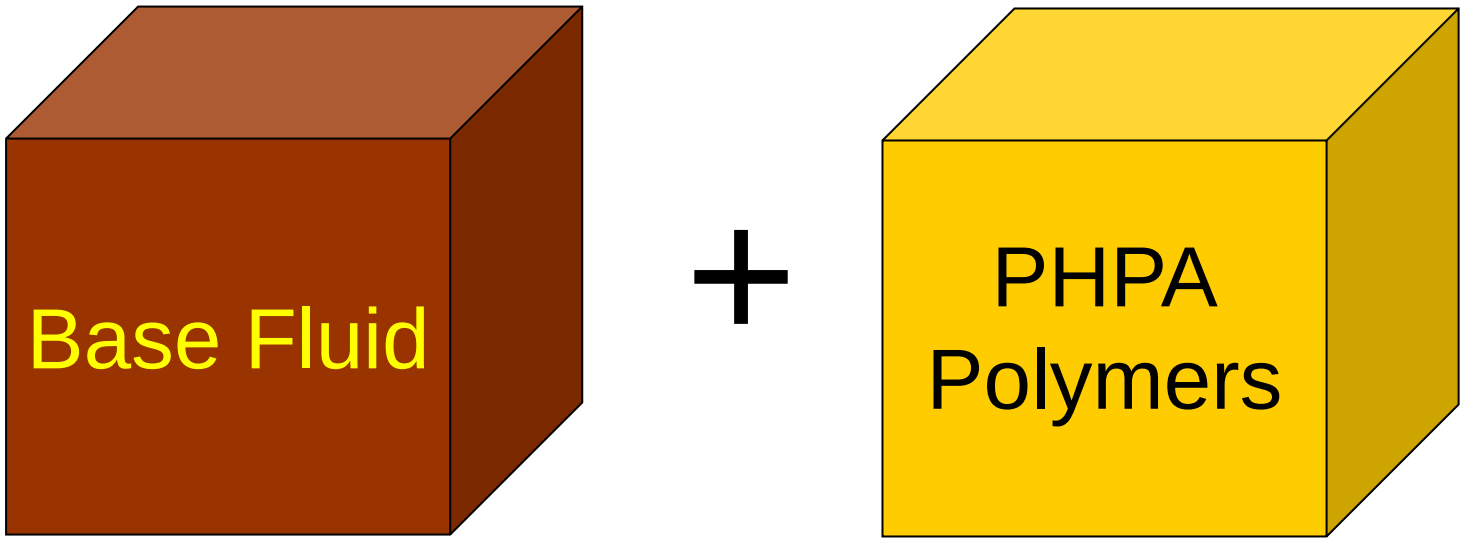


4. CREATE A SHIELD AROUND THE CUTTINGS
BAROID PHPAs

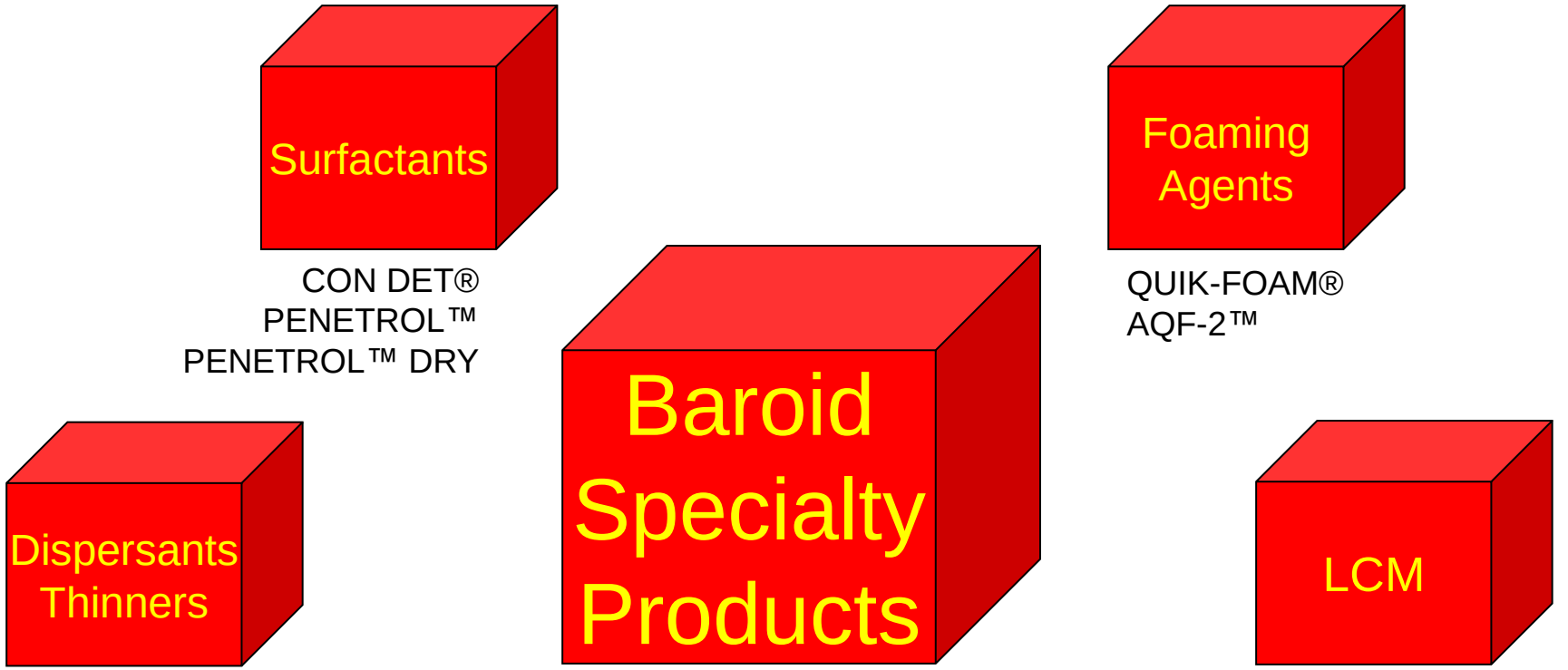
- EZ-MUD® GOLD
- EZ-MUD®
- QUIK-MUD® D50
- EZ-MUD® PLUS
- EZ-MUD® DP
- EZ-MUD® DP Gold

- Provide clay and shale inhibition

Provide Inhibition



5. ADDRESS SPECIAL NEEDS



Surfactants

- PENETROL®
- PENETROL® DRY
- CON DET®

- Prevent or remediate effects of sticky clay
- Reduce bit balling

Lost Circulation Materials

- N-SEAL™
- DIAMOND SEAL®
- FUSE-IT®

- Used to mitigate loss of whole fluid to the formation
- Used to fill/seal fractures, voids, highly porous formations

Flocculants/Coagulants

- SYSTEM FLOC-360®
- BARAFLOC

- Remove solids from mud system
- Lower mud density

Dispersants / Thinners

- AQUA-CLEAR® PFD
- Reduce viscosity
- Reduce carrying capacity
- Reduce gel strengths
- React with the formation as well as solids in the fluid

Foaming Agents

- QUIK-FOAM®
- AQF-2™

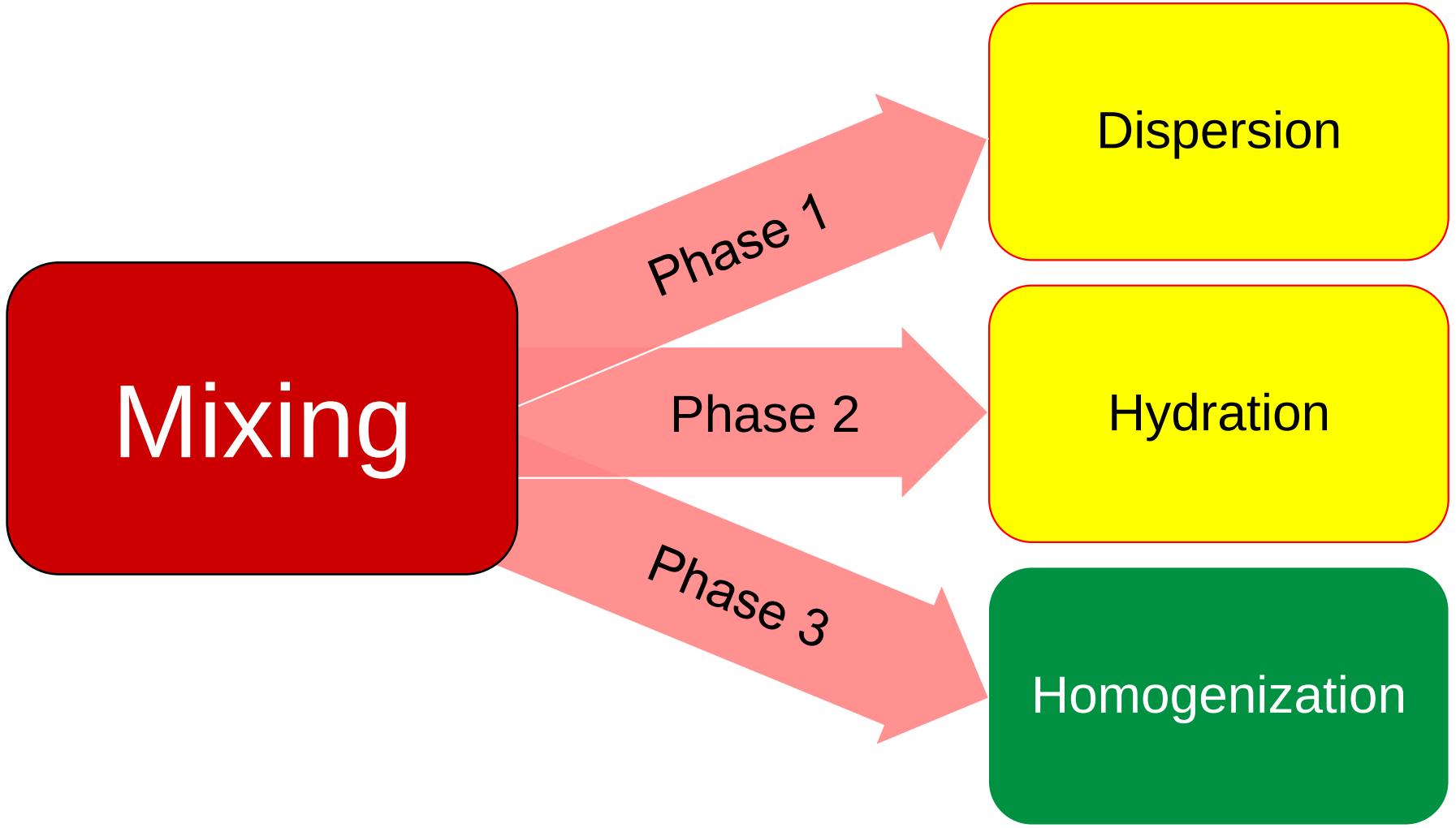
MIXING

Products only work for us when we activate them.

Importance Of Proper Mixing

- Activates the product's function
- Achieves desired fluid properties
- Complete utilization of drilling fluid additives
  - Maximizes yield and performance of drilling fluid additives
  - Eliminates potential for un-yielded products
- Biggest bang for your buck

Best Practices: 3 Phases of Proper Mixing



PHASE 1: Dispersion

- Products must be uniformly dispersed throughout the water phase of the fluid to provide for maximum hydration of the products
- Mixing Systems Must Produce “EFFECTIVE SHEAR”
- The Mixing Equipment is responsible for the introduction of high amounts of energy into the system to mix products effectively

Poor Mixing!

PHASE 2: HYDRATION

- Products need water to hydrate
- Mixing additives becomes a competition for free water
  - Therefore the products that require the most water are mixed first

1.) Soda Ash

2.) Bentonite

3.) Polymer(s)

Dry Polymers
Liquid Polymers
} PACs before PHPAs

4.) *Surfactants*

5.) *Thinners and LCM*

Time For Bentonite

- Bentonite requires time to hydrate
- It takes time for bentonite aggregates to separate into platelets
- Energy in the form of shear and agitation is needed to keep bentonite fully dispersed in the slurry during hydration

PHASE 3: Homogenization

- After dispersion and hydration, additional recirculation is required to achieve a uniform slurry
- Uniformly blends the hydrated products
  - Minimal for bentonite
  - Critical for polymers

Drilling Fluids

- Magic doesn’t exist
- One size does not fit all
- ***“Engineered fluid solutions to maximize wellbore value”***

THANK YOU