GEOTHERMAL DRILLING – AN INRODUCTION

CommTECH Course 2021 Online Edition
Sub Course (E/F/G/H) :

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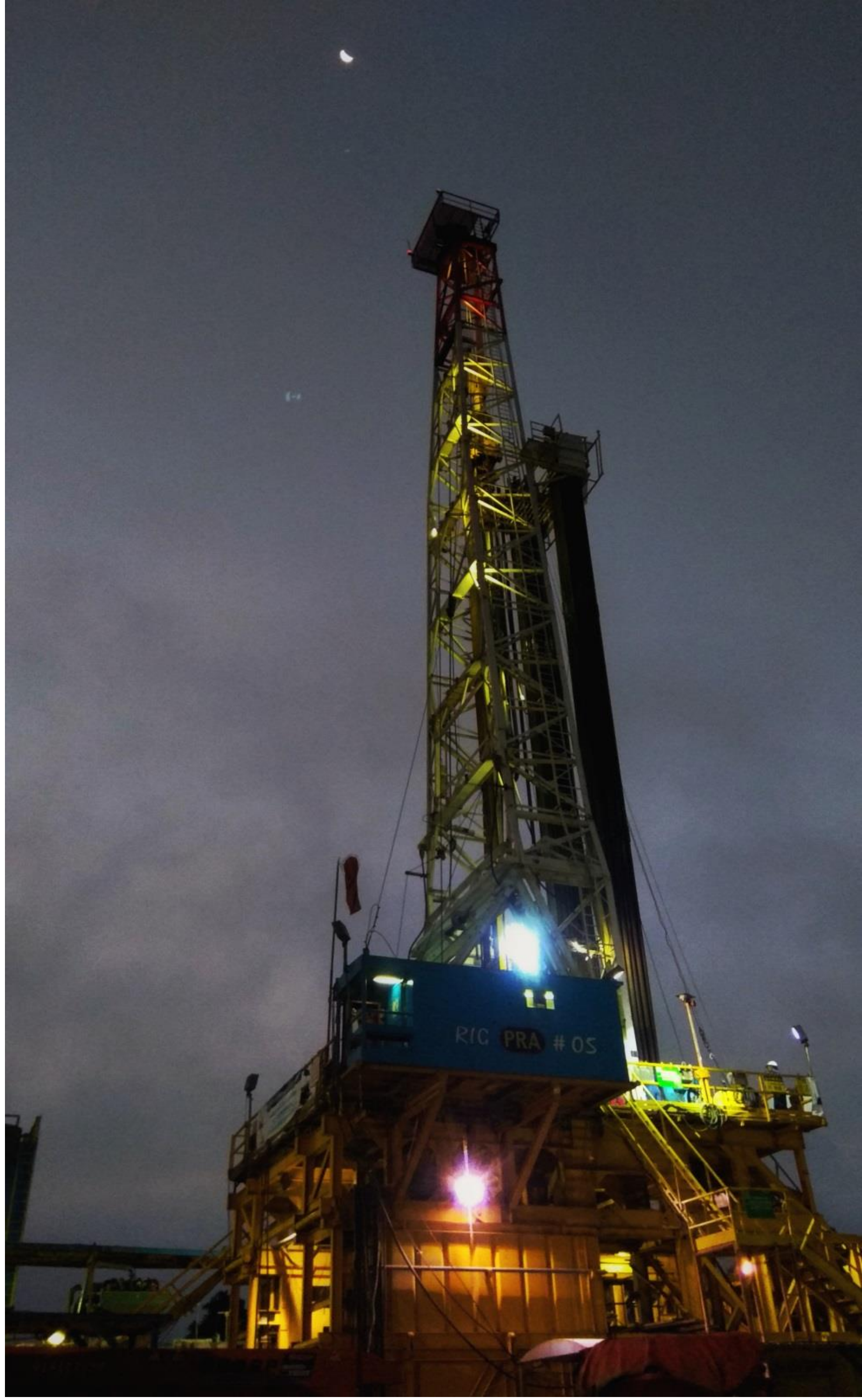
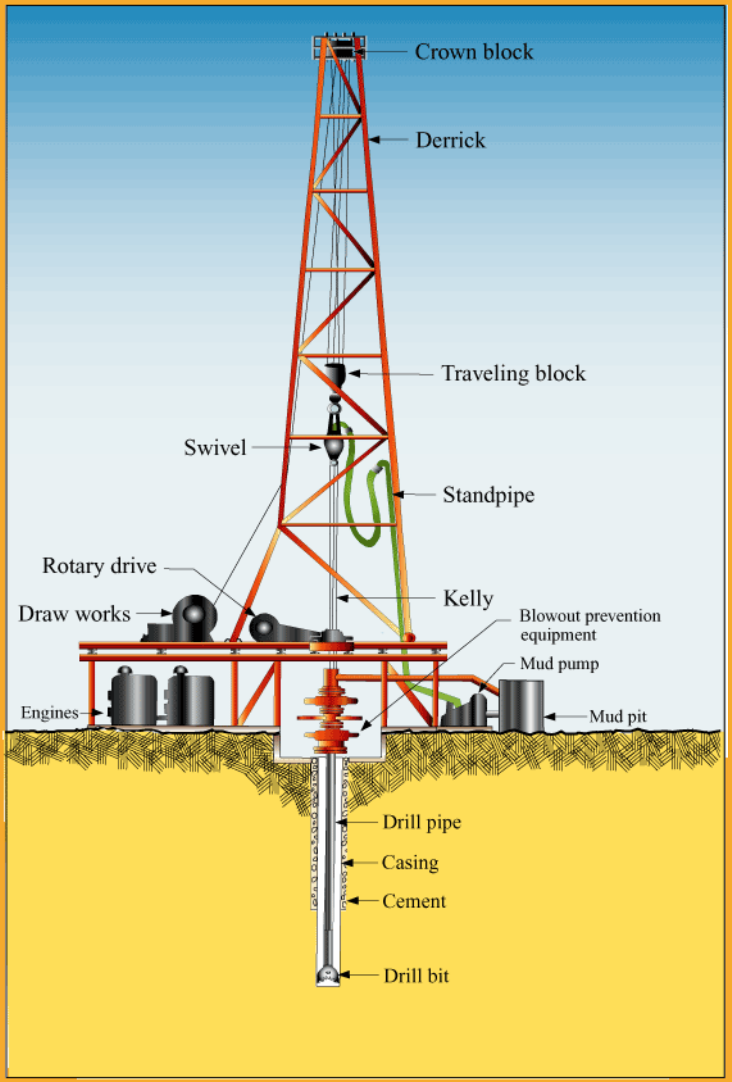
Surabaya - Indonesia

Content

- General Drilling Overview
- Drilling Project Team
- Geothermal Drilling Challenges
- Drilling Fluids for Geothermal Drilling



GENERAL OVERVIEW – DRILLING



ROTARY DRILLING PRINCIPAL

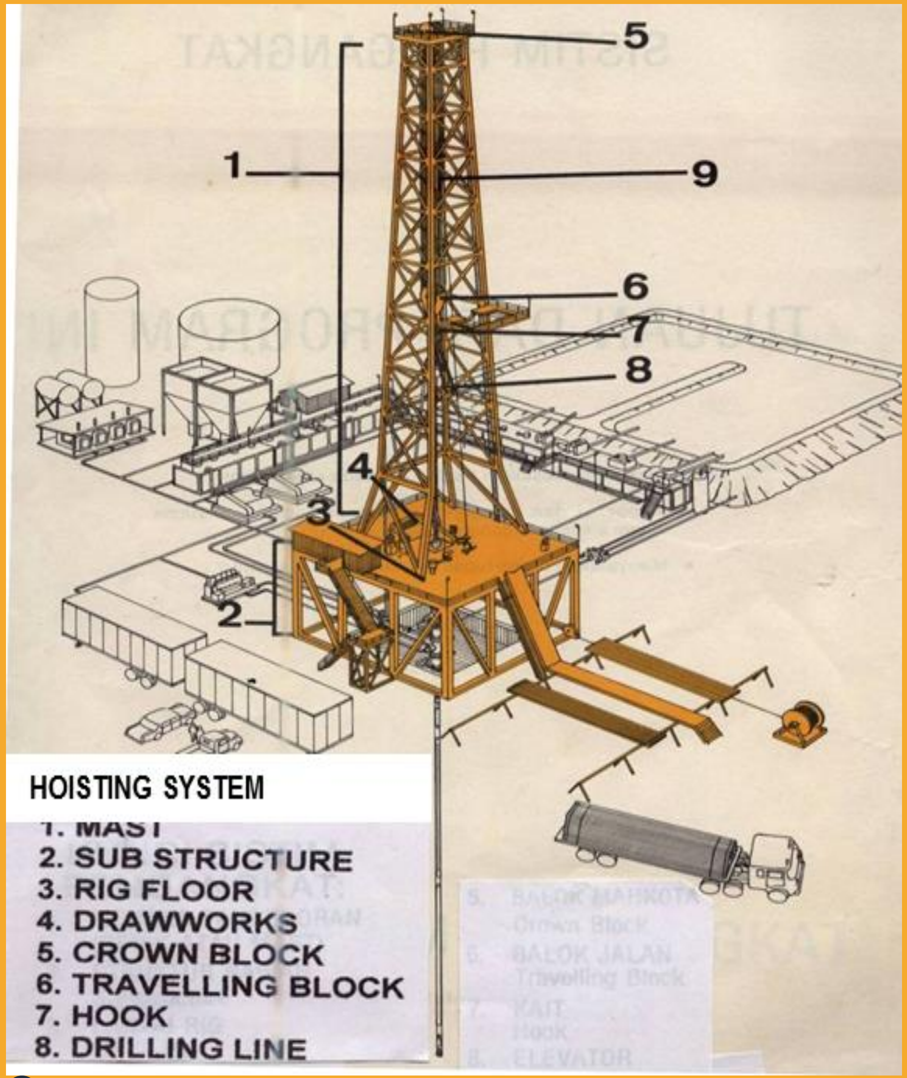
- Rotate the drill strings
- Remove the rock as drilling cuttings / solid
- Maintain the borehole / formation stability
- Control formation fluids
- Preservation of the wellbore (completion)

GENERAL OVERVIEW – DRILLING

DRILLING RIG SYSTEM

- Hoisting System
- Rotating System
- Circulating System
- Blowout Prevention System
- Power System

GENERAL OVERVIEW – DRILLING RIG



HOISTING SYSTEM

- Used for lifting / hoisting operation on the rig floor, especially for drill strings assembly.

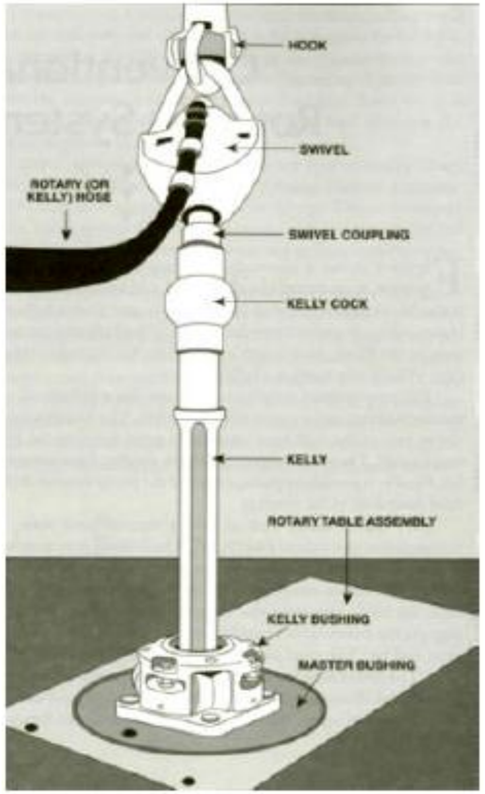
Consist of:

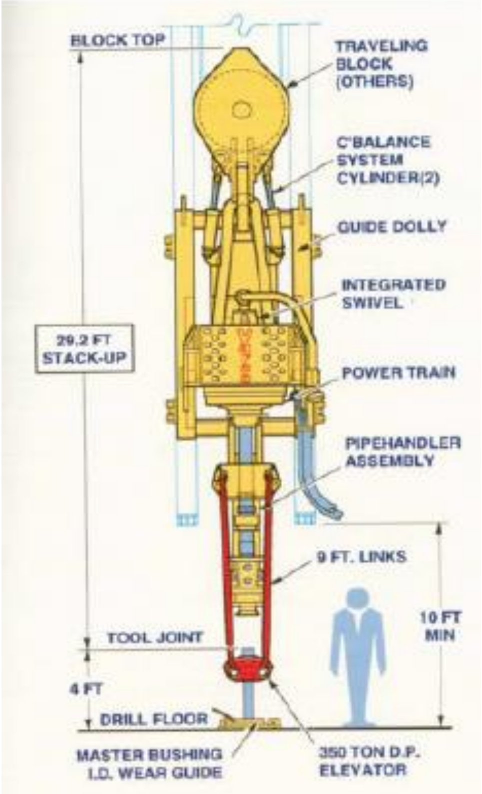
- Supporting Structure
  - Mast / Derrick
  - Sub-structure
- Draw work
- Overhead Tools
  - Block assembly
  - Drilling line

GENERAL OVERVIEW – DRILLING RIG

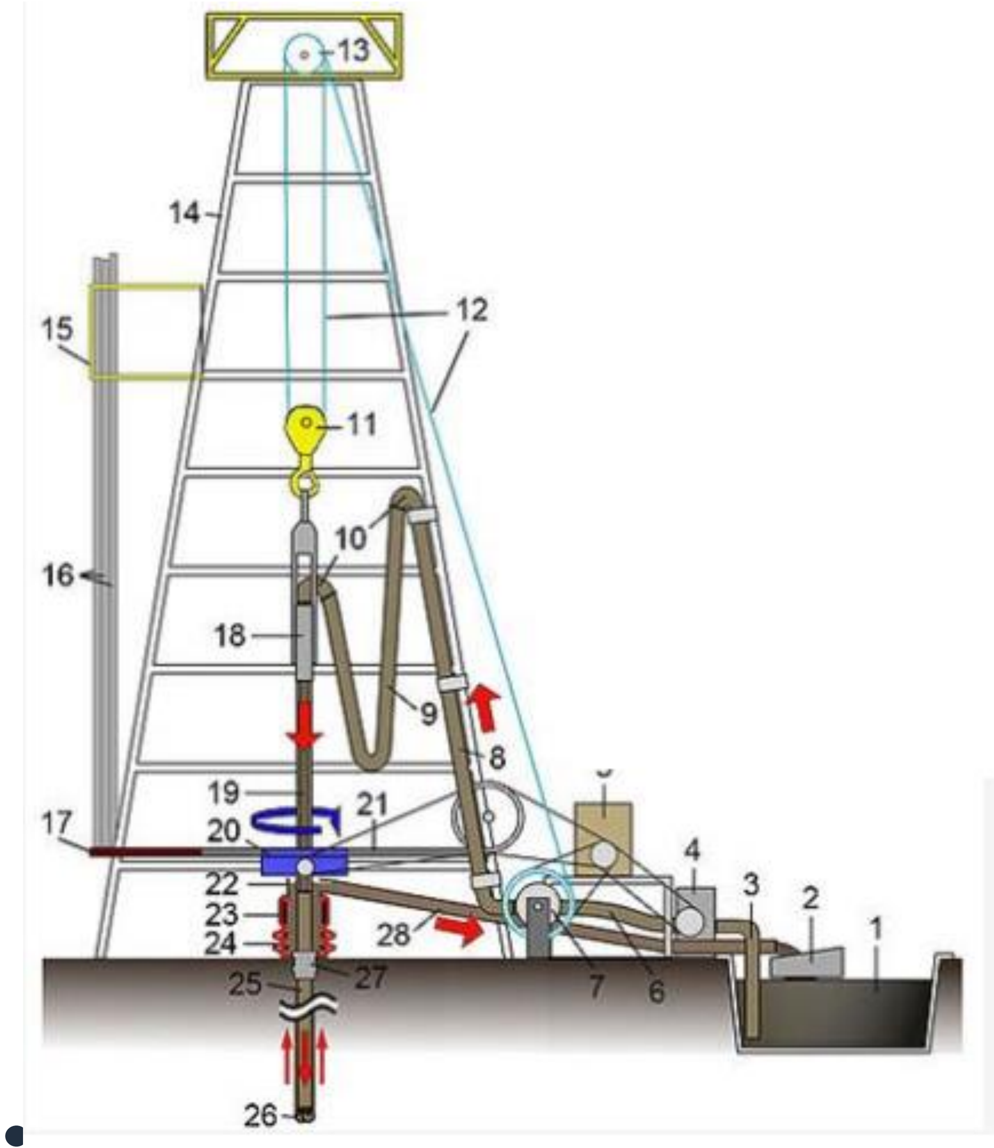
ROTATING SYSTEM

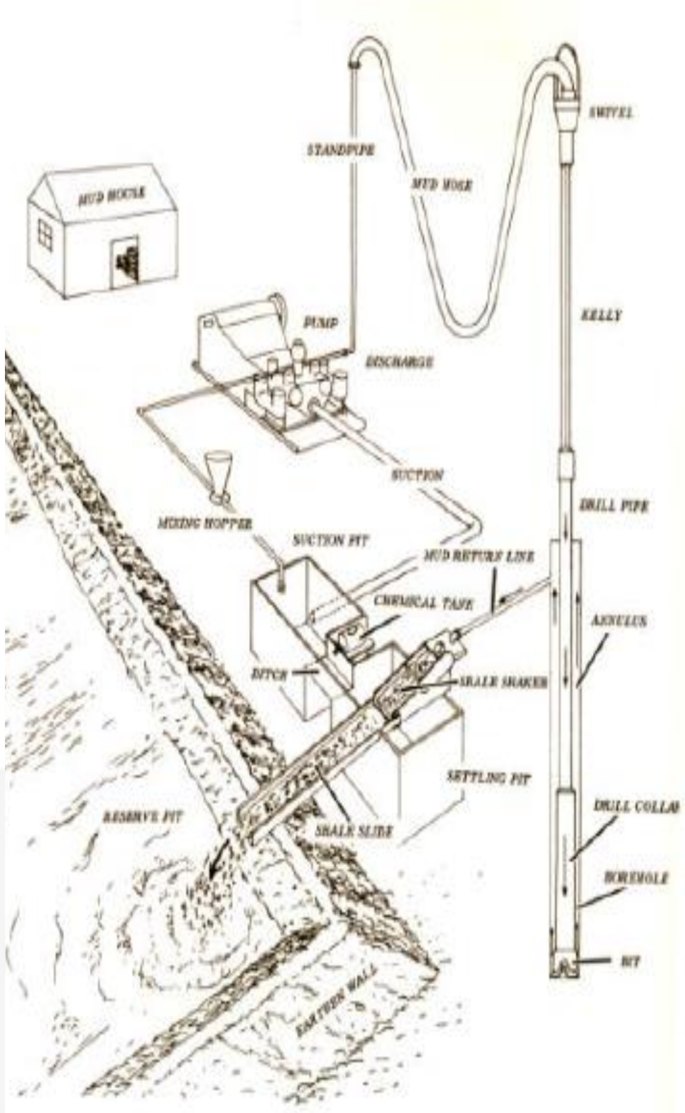
- Old Rig: Rotary Kelly Bushing
- Current : Top Drift





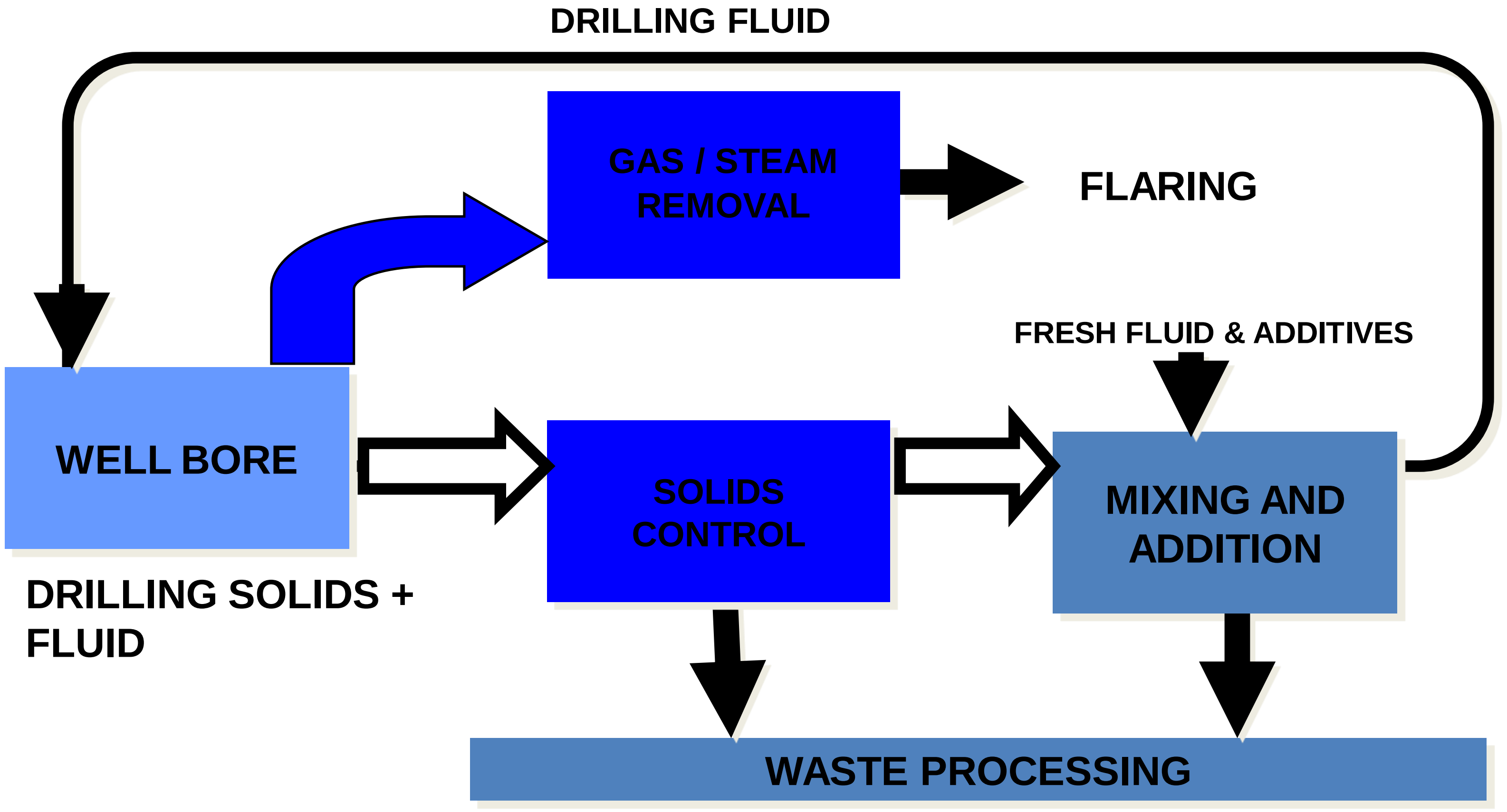
CIRCULATING SYSTEM



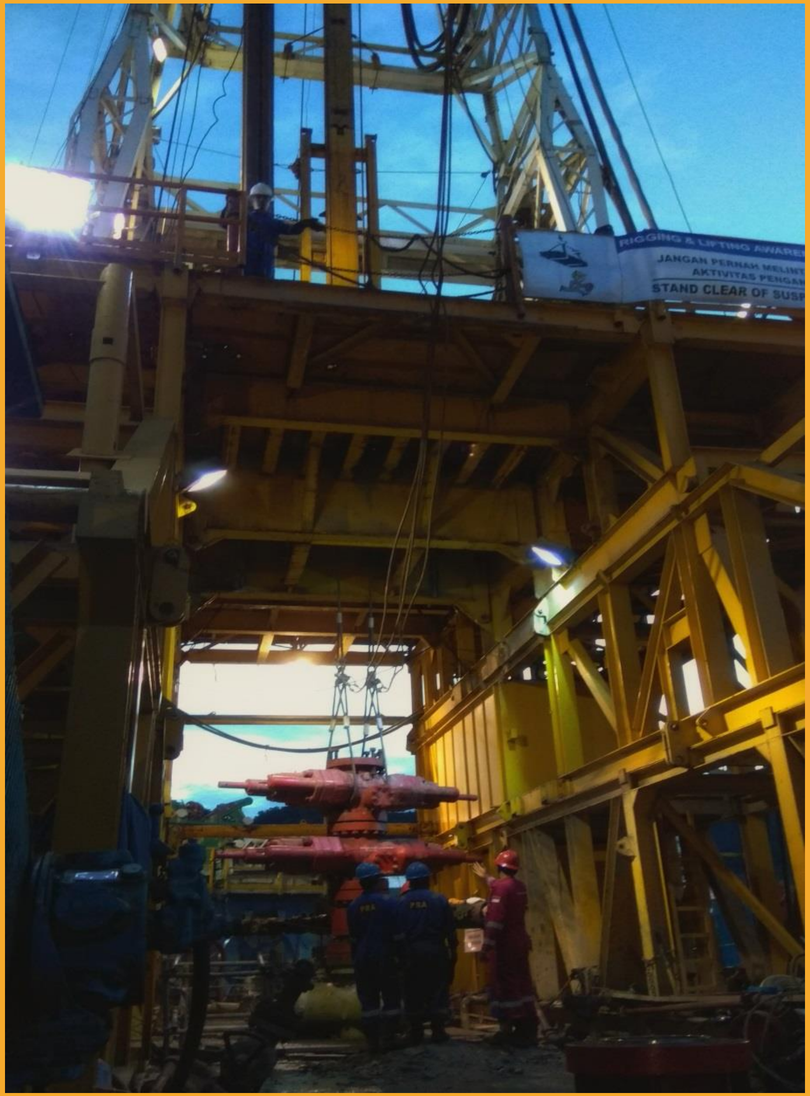


Suction pits
Suction line
Mud pumps
Discharge line
Stand pipe
Rotary hose
Drill Stem
Annulus
Return line
Settling tanks
Conditioning area

CIRCULATING SYSTEM



GENERAL OVERVIEW – DRILLING RIG



BLOWOUT PREVENTION SYSTEM

- Used to control kick / blowout by closing the wellbore rapidly for securing.

Consist of:

- BOP Stack
- Accumulator unit
- Choke line
- Kill line
- Choke manifold

TEAM OF DRILLING PROJECT

Company Personnel (Office + Site):

1. Drilling Manager
2. Drilling Admin
3. Drilling Specialist
4. Drilling Fluid Specialist
5. Drilling Superintendent
6. Sr. Drilling Engineer
7. Drilling Engineer
8. Completion Engineer
9. Drilling Accountant
10. Logistic Coordinator
11. Procurement
12. Civil Engineer
13. Day Drilling Supervisor
14. Night Drilling Supervisor
15. HSE Site Officer
16. Material Man

Services

1. Drilling Rig
2. Cement and Mud
3. Directional Drilling
4. Air Drilling
5. Mud Coller
6. Wellhead Installation
7. Drilling Personnel
8. Heavy Equipment
9. Drilling Waste Handling
10. VSAT
11. Drilling Report
12. Casing Handling
13. H2S Service
14. Mud Logging
15. Drill String Inspection
16. Hard Bending
17. Solid Control Services
18. Fishing Tool Services
19. Coring Services
20. E-Line & Explosive

Rig Personnel (Rig Site)

1. Toolpushers (Sr)
2. Toolpushers
3. Rig Superintendent
4. HSE Supervisor
5. Drillers
6. Assistant Drillers
7. Derrickman
8. Floorman
9. Roustabouts
10. Rig Mechanics/Electricians
11. Welders
12. Storekeepers
13. Crane /Forklift Operators
14. Drivers/Helpers (truck/cars)
15. Catering
16. Security

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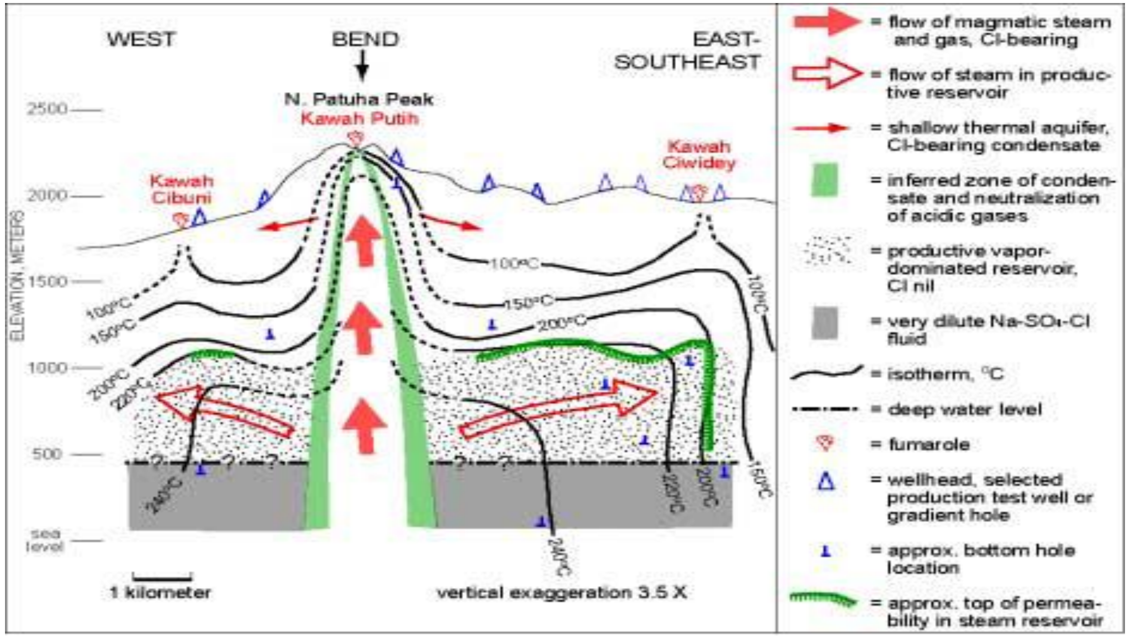
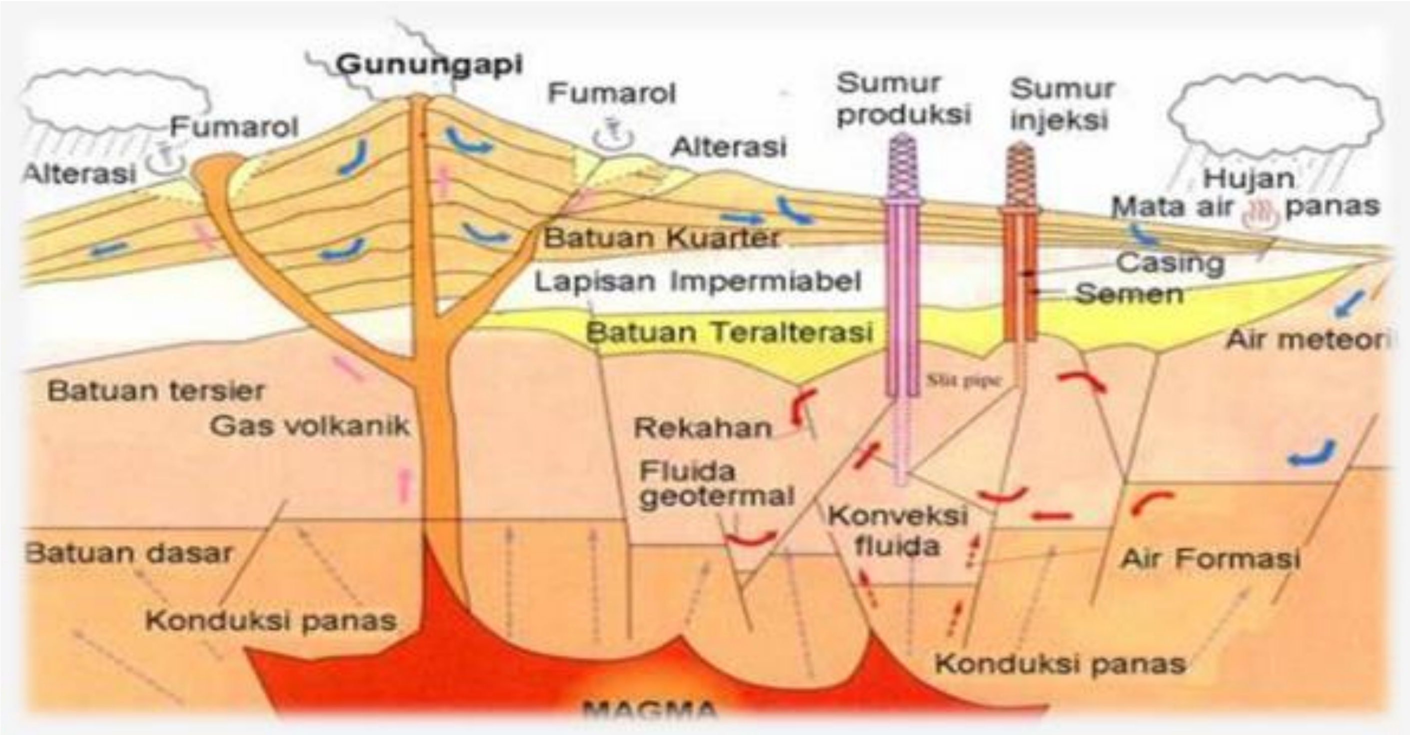
GEOTHERMAL DRILLING IN INDONESIA

- Location : Mostly on high terrain,
  Associate with strato-vulcano
- Target: High permeable reservoir zone
  Total loss circulation
- Directional well

Challange

- High Temperature
- Geology
- Geochemistry

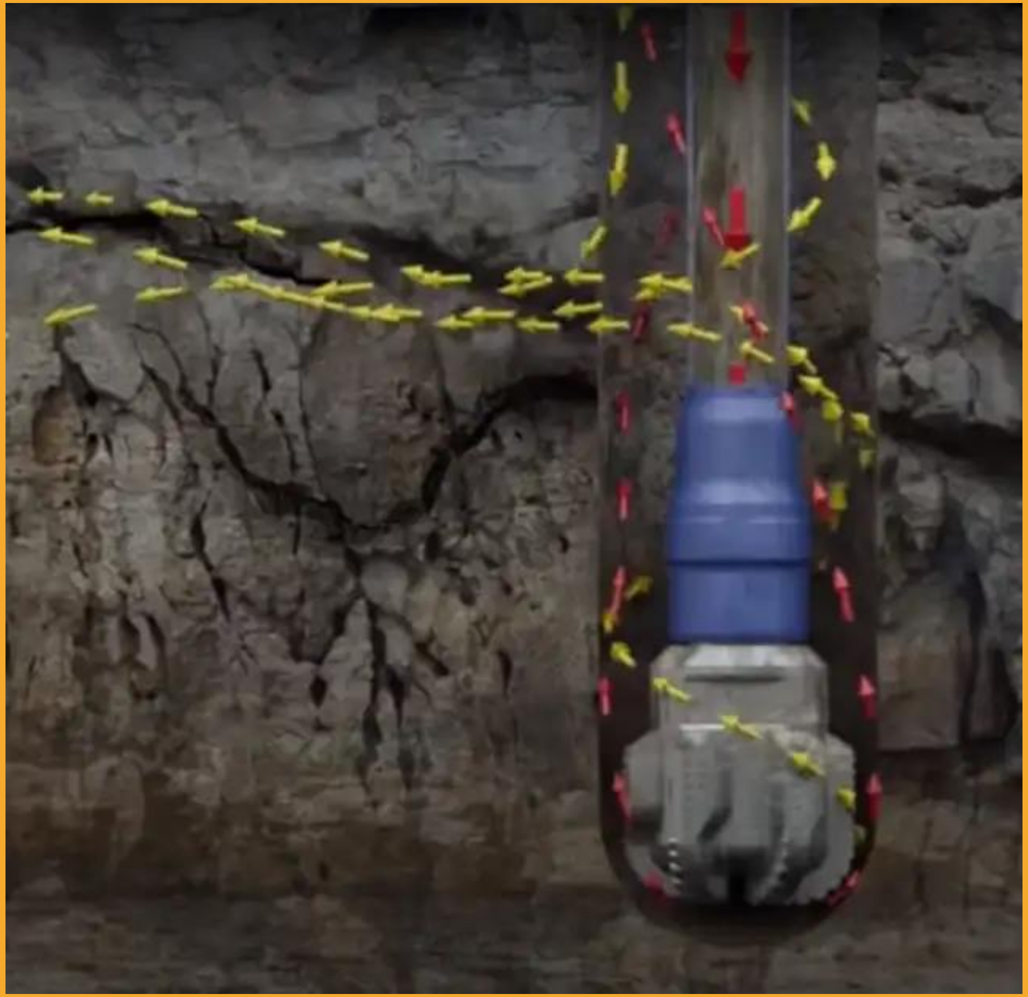




CHALLENGE - TEMPERATURE

➢ **Elevated Geothermal temperatures**

- Reduce drill bit and drilling tool performance
- Often precludes use of mud motors & MWD equipment (Oil & gas equipment typically rated to 150°C) – although some higher temperature ratings now appearing.
- Adversely effects drilling fluid and cement slurry properties.
- Reduces performance of BOP equipment.
- Increases potential for fluid to flash to steam – flowback, 'kick', or blowout.



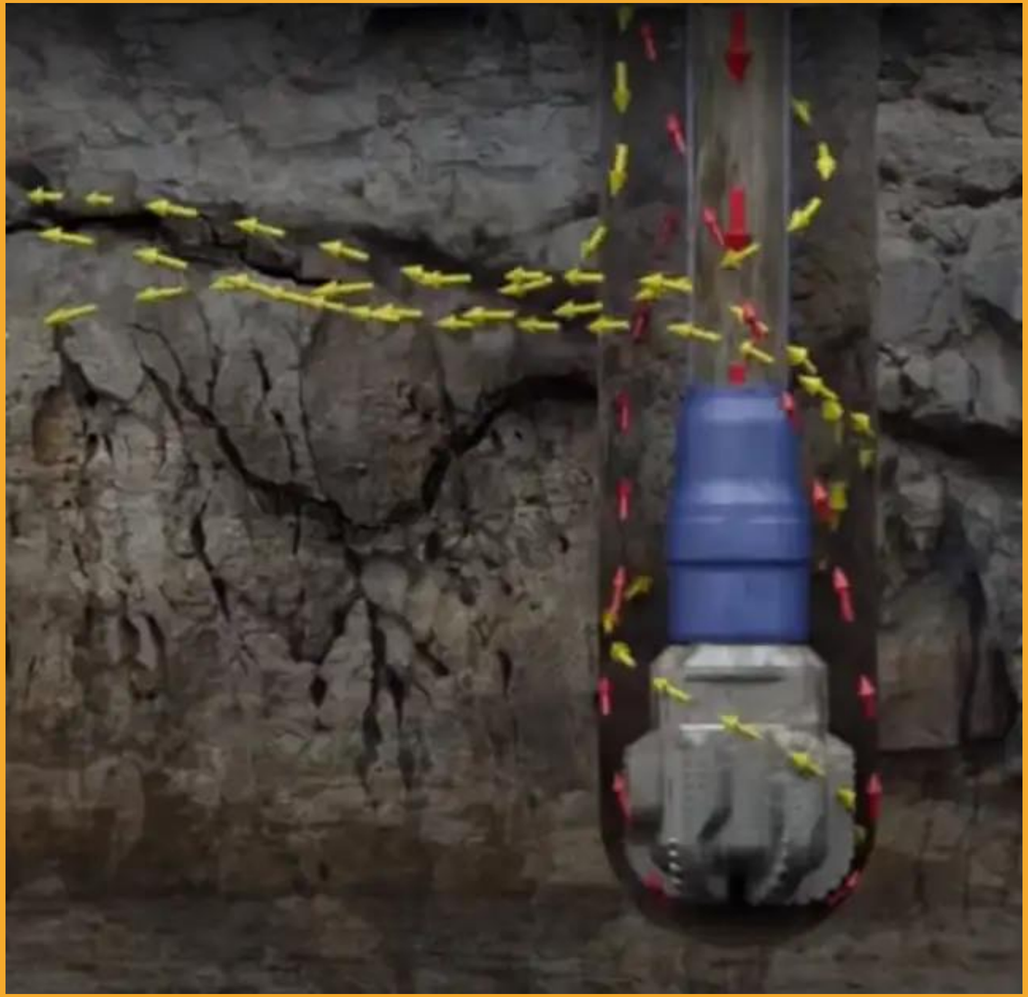
CHALLENGE - GEOLOGY

Geothermal systems are found in a wide variety of geological environments and rock types

- Pacific basin fields -predominantly rhyolitic or andesitic volcanism
- Iceland – widespread extensively fractured basalts
- Larderello, Italy – metamorphic rocks
- Geysers, California – fractured greywacke

Common denominator – highly permeable, fractured and faulted. Permeability – a fundamental prerequisite for a geothermal system to exist

- Typically permeability not only in reservoir structure, but in overlying formations as well



CHALLENGE - GEOLOGY

Under Pressured

- A characteristic of most geothermal systems -The static reservoir fluid pressure is less than that exerted by a column of cold water from the surface - the system is **"under pressured"**
- Static water level often 200 m to 400 m below surface.
- Drilling through ***permeable*** and ***under pressured*** zones – frequent and most often total loss of circulation of drilling fluid.
- Near surface formations often low bulk density pumices, ashes, breccias – permeable, non-consolidated, friable – with low fracture gradient – low resistance to blow out.

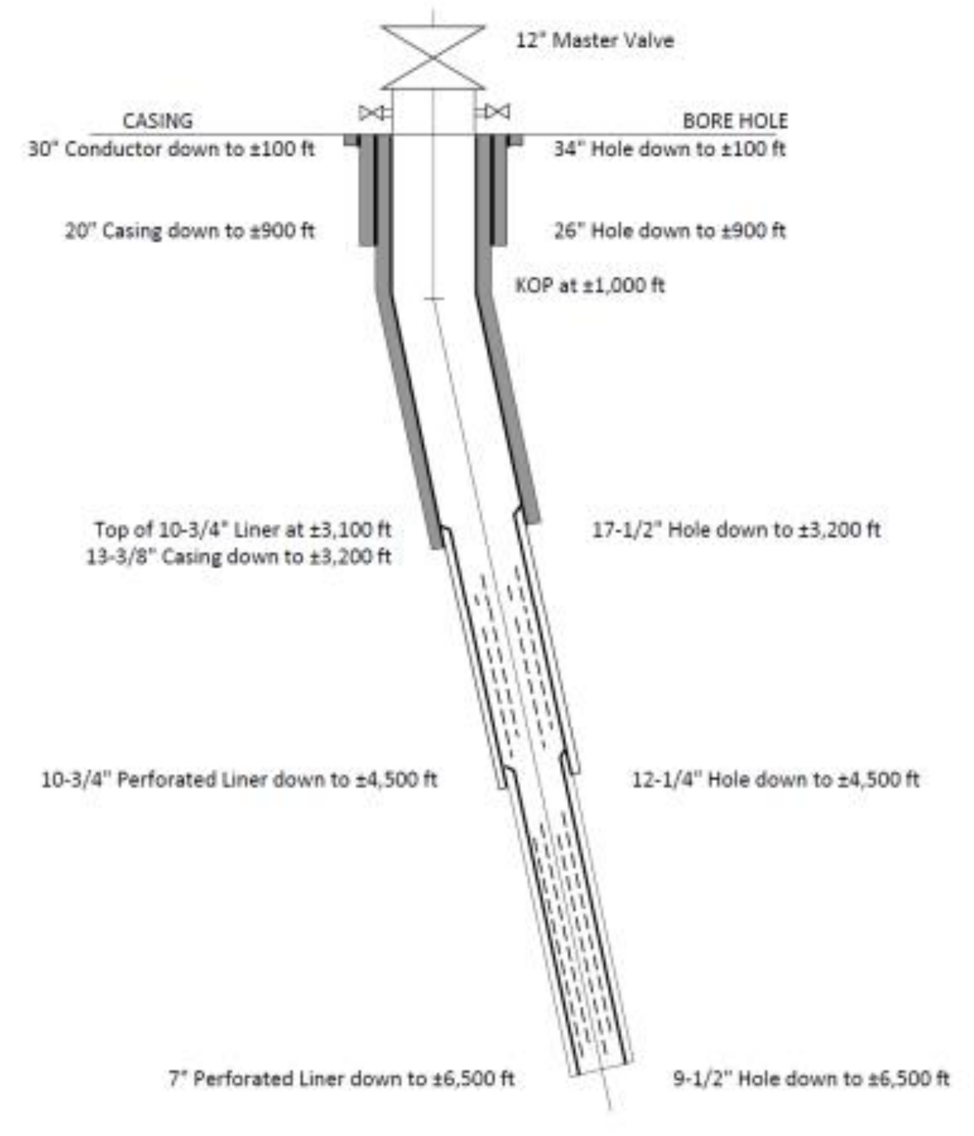
CHALLENGE - GEOCHEMISTRY

- Can contain varying concentrations of dissolved solids and gases.
- Can be highly acidic and corrosive.
- Can induce scaling.
- Dissolved gases mainly CO_2 – but also can contain significant quantities of H_2S – both can be high risk to personnel and induce failure in drilling tools, casing and wellhead equipment, also contaminate to drilling mud.
- Presence of dissolved solids and gases in the formation fluids imposes constraints on casing materials, wellhead equipment, casing cement slurry and mud formulations.

DRILLING PRACTICE

- Processes and equipment substantially same as developed for petroleum drilling
- Downhole conditions require different practices

SOME OF THE DIFERENCES



Well Design:

- Thermal efficiency of converting steam to electricity is low – (± 20%)
  - Large mass flows required – Large diameter casings

- "Standard" well – API 9 5/8" diameter production casing with 7" or 7 5/8" diameter perforated liner in 8½" open hole section

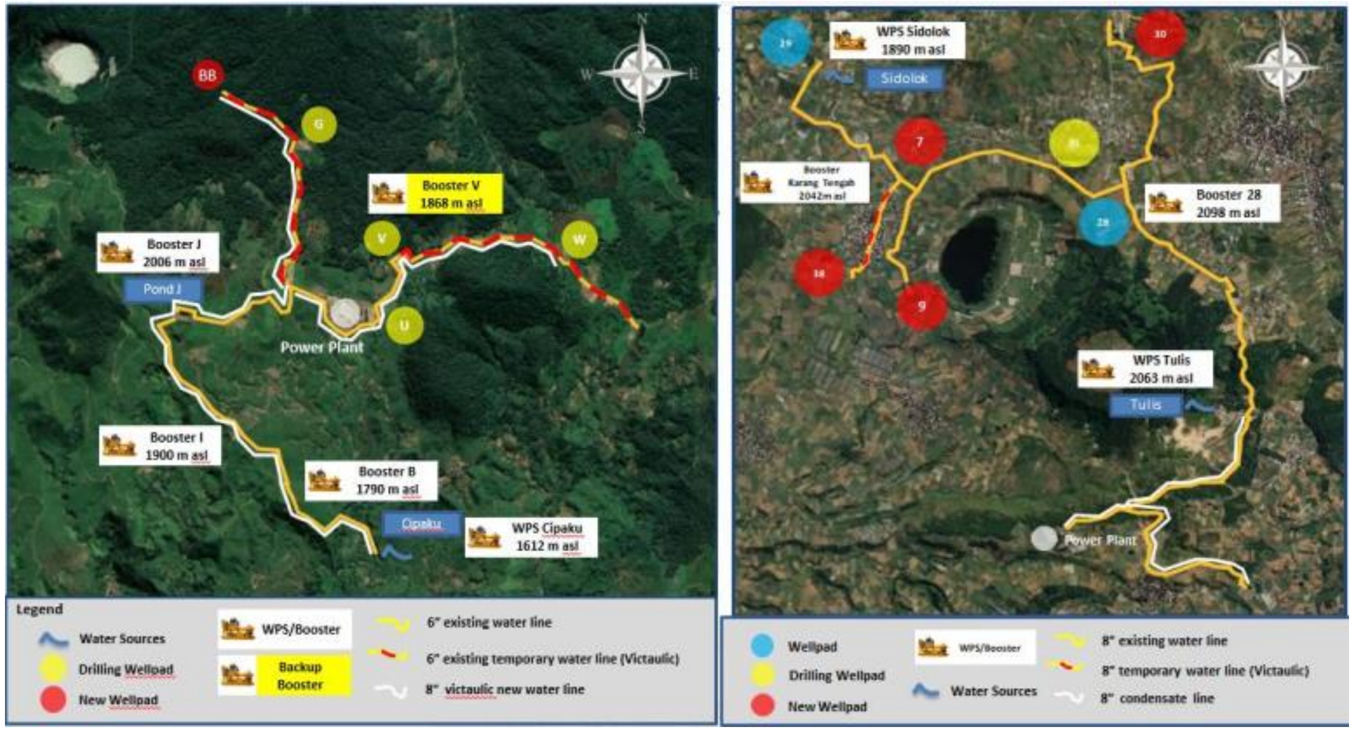
- "Large" diameter well –API 13 3/8" diameter production casing with 9 5/8" or 10¾" diameter perforated liner in 12¼" open hole section.

- Casing sizes for Anchor, Intermediate Surface and Conductor casings determined by geological and thermal conditions.

SOME OF THE DIFERENCES

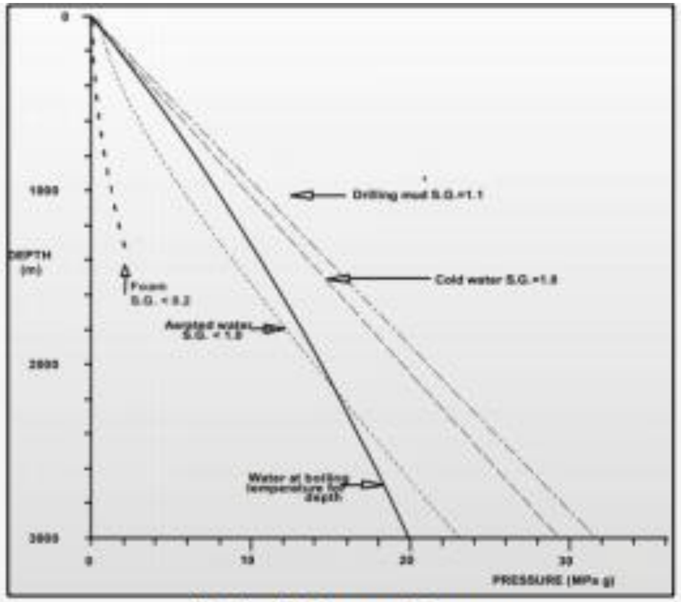
- Mud circulating system requires a fluid cooling unit
  - usually a forced draft cooling tower
  - or chilling unit

- Drilling water supply must be capable of providing at least 2000 lpm, preferably 3000 lpm continuously.
  - backup pumps and often dual are utilized pipeline

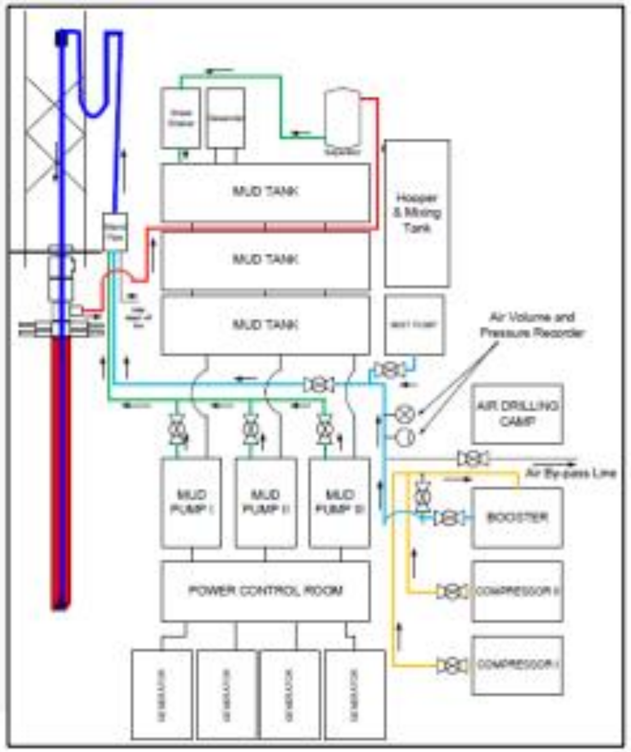


Aerated / Underbalanced Principal:

- Reduce the density of the drilling fluid by adding air (or with foam) to the fluid circulation system
- Therefore reduce the equivalent circulating density of drilling fluid to reach the underbalanced (or slightly overbalanced) pressure gradient from formation pressure
- For better hole cleaning at the Bit, BHA up to surface or into the highest feedzone, thus preventing stuck pipe problem and increasing rate of penetration at TLC condition



Underbalanced Pressure Profile with addition of Air



DRILLING FLUIDS

- Upper sections of well usually drilled with simple water based bentonite mud, treated with caustic soda to maintain pH.

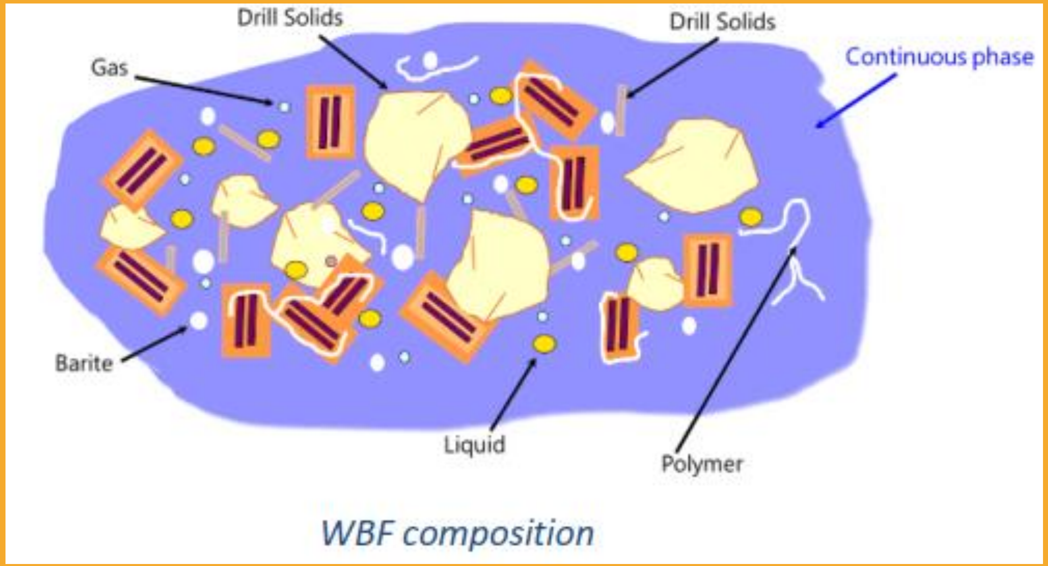
- As depth and temperature increases need to treat mud with dispersants and thinners.

- If permeability encountered - treat mud with LCM, attempt to plug losses with cement - otherwise drill ‘blind’ with water or with aerated water - washing cuttings into the formation.
  - In production section – “mud” is NOT used - formation damage. Traditionally drilled ‘blind’ with water with mud or polymer sweeps.
  - Possibly with aerated water - ‘balanced’ conditions.

DRILLING FLUIDS FUCTION

Drill cuttings being removed from well

1. Control formation pressure
2. Maintain wellbore stability
3. Seal permeable formation
4. Minimize formation damage
5. Cool, lubricate, and support the bit and drill strings
6. Transmit hydraulic energy to downhole tools and bit
7. Facilitate formation evaluation
8. Control corrosion
9. Suspend and release cuttings
10. Remove cutting from the well



Drilling fluids compositions consists of two phases:

a) **Continuous phase:** represents the base fluid.
b) **Discontinuous phase:** represent the additives that can be added to the fluid.

WATER BASE MUD COMPOSITION

➢ Example: WBM Formulation 26" Hole section

PRODUCTS	Product Description	Product Function
Caustic Soda	Caustic Soda	Alkalinity source / pH control
BARAZAN D	Xanthan Gum	Viscosifier
Bentonite	Sodium Montmorilonite	Viscosifier and Filtration Control
DEXTRID LTE	Potato Starch	Filtration Control
KCl	Potassium Chloride	Clay Inhibitor
Barite	Barium Sulfate	Weighting Agent
Zinc Carbonate / SOURSCAV	Zinc Carbonate	H2S Scavenger

➢ Example: WBM Formulation 17.5" Hole section

PRODUCTS	Product Description	Product Function
Caustic Soda	Caustic Soda	Alkalinity source / pH control
BARAZAN D	Xanthan Gum	Viscosifier
KCL	Potassium Chloride	Cay Inhibitor
Bentonite	Sodium Montmorilonite	Viscosifier and Filtration Control
DEXTRID LTE	Potato Starch	Filtration Control
PAC L	Polyanionic	Filtration Control
Barite	Barium Sulfate	Weighting Agent
Zinc Carbonate	Zinc Carbonate	H2S Scavenger
Fracseal F/M	LCM	LCM

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LPLT Assembly

HPHT Assembly

Filterpresses used for WBF testing

Rheometer

DRILLING FLUIDS PROPERTIES

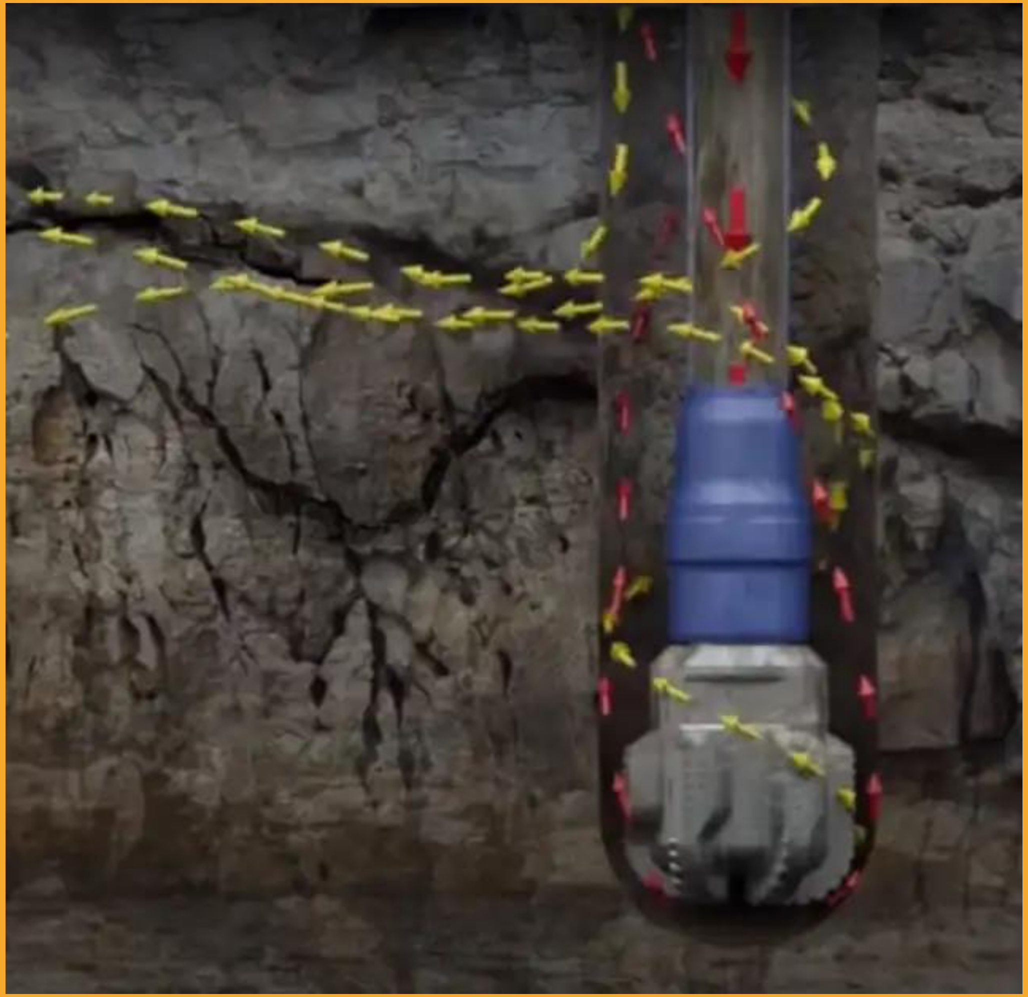
Physical and Chemical properties of WBF systems

Physical Properties

- Mud weight (density)
- Rheological properties
  - Funnel viscosity
  - Plastic viscosity
  - Yield point
  - Gel strength
- Solids analysis
- Filtrate
  - API (ambient temperature, 100 psi)
  - API (high temperature, high pressure)
- Cation Exchange Capacity (CEC) or Methylene Blue Capacity (MBC)

Chemical Properties

- pH
- Mud alkalinity (Pm)
- Filtration Analysis
  - Alkalinity (Pf/Mf)
  - Chloride
  - Calcium Hardness
  - Total Hardness



POTENTIAL DRILLING HAZARD RELATED TO DRILLING FLUIDS

Lost Circulation

Loss Severity	% of Loss Rate	Typical Formations
A. Total Lost Circulation	90% - No returns	Cavernous/large fractures
B. Severe	20%-90% 65 bbls/hr or more	Large sections of unconsolidated sands/ fractures.
C. Partial	10-20% - 20-65 bbls/hr	Unconsolidated sands and gravel: small open fractures
D. Seepage	<10% 1-20 bbls/hr	Porous and permeable shell beds/reef deposits. It should be expected to lose 2.0 bbls of mud per bbl of cuttings drilled based on average cuttings retention of 1.5 bbl/bbl and .5 bbl/bbl to the formation.

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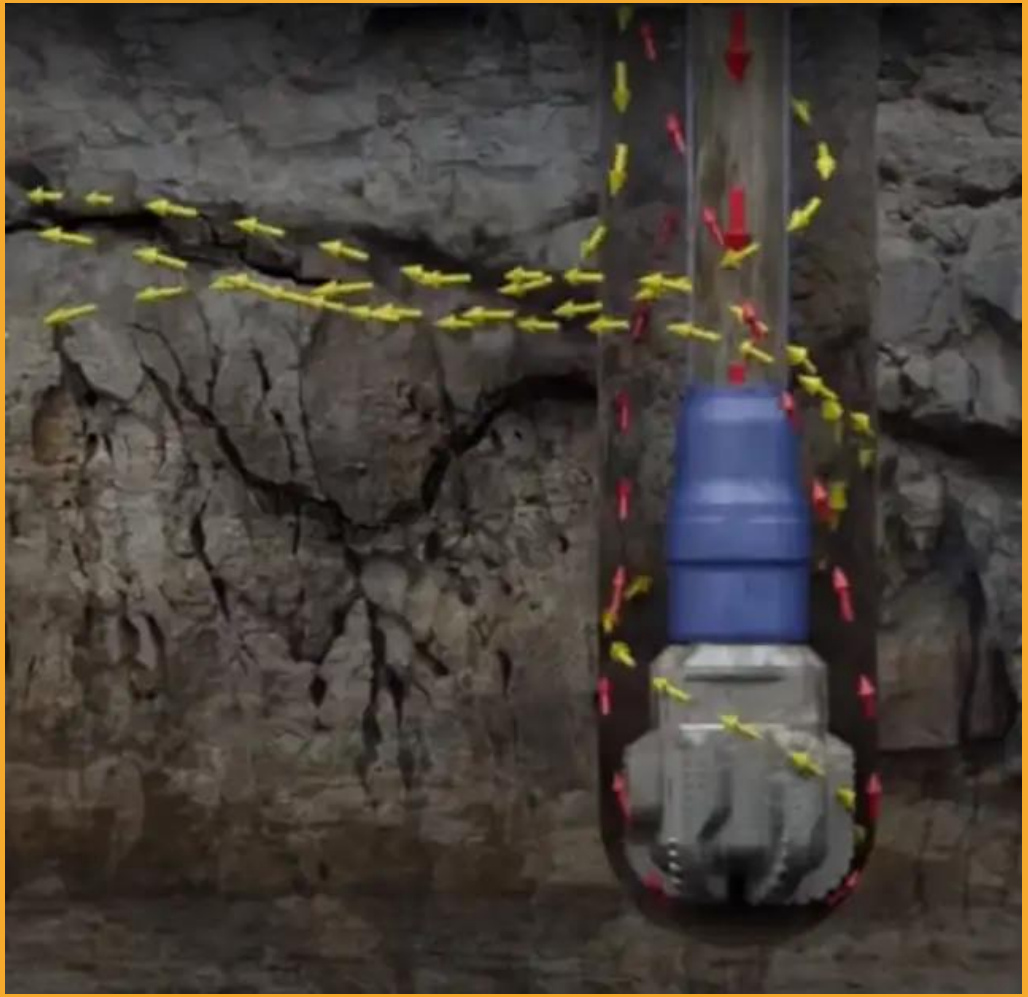
POTENTIAL DRILLING HAZARD RELATED TO DRILLING FLUIDS



Lost Circulation - Solution

a) Immediately fill the backside with water (if necessary) to stabilize the hole and to calculate the fracture closure stress.
b) Lower ECD by reducing flow rate.
c) With well control in mind, reduce the MW as much as possible; approval required from Drilling Supervisor.
d) Keeping the backside full, spot the following pill across the loss zone, pull above pill and circulate slowly.
e) Soak 15 minutes and then wash down to TD while monitoring losses.

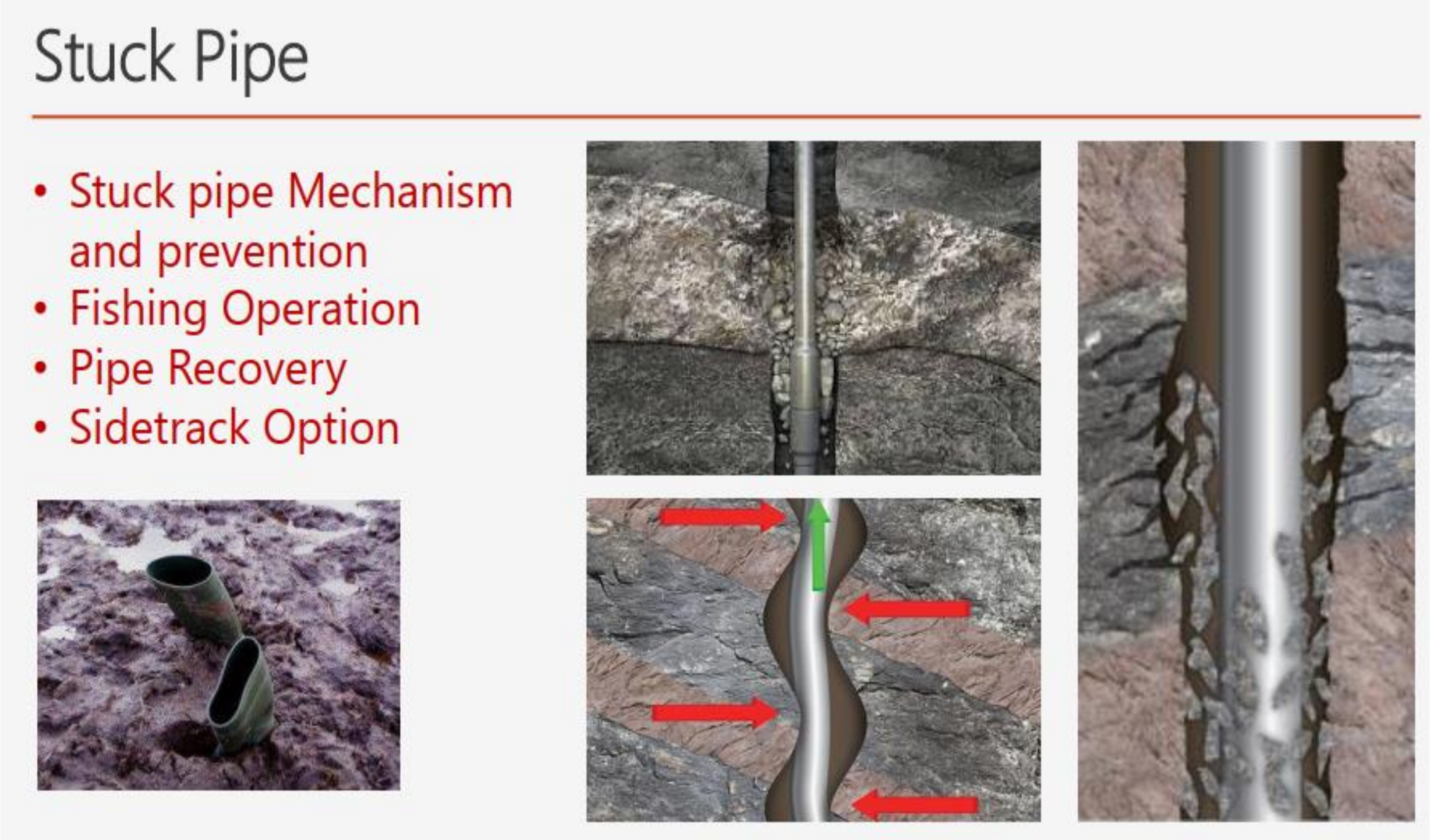
FRACSEAL FINE	10 ppb
FRACSEAL MEDIUM	10 ppb
KWIKSEAL FINE	20 ppb
KWIKSEAL MEDIUM	20 ppb
KWIKSEAL COARSE	10 ppb

Pill volume:

12 ¼" section: 95 – 125 bbl
17 ½" section: 160 – 190 bbl Pill volume:

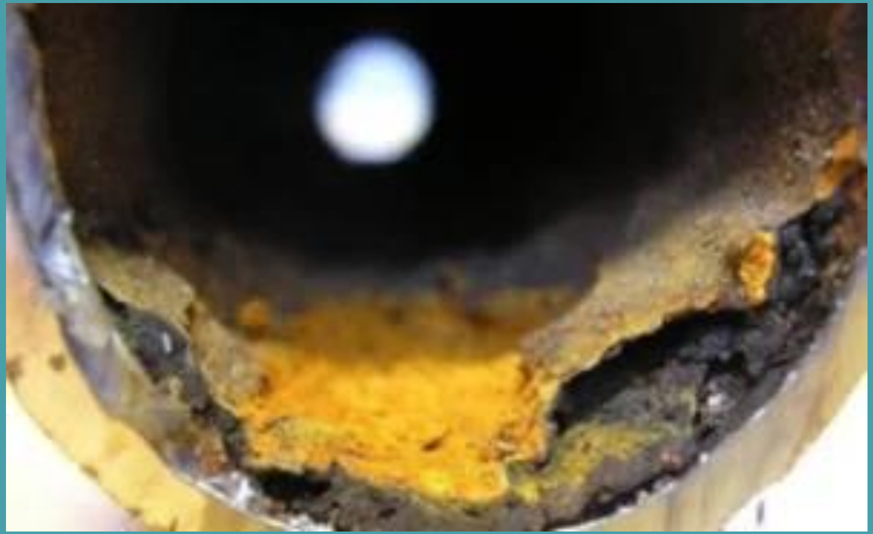
f) If Losses not reduced, consider to apply severe to Total Lost treatment as below.

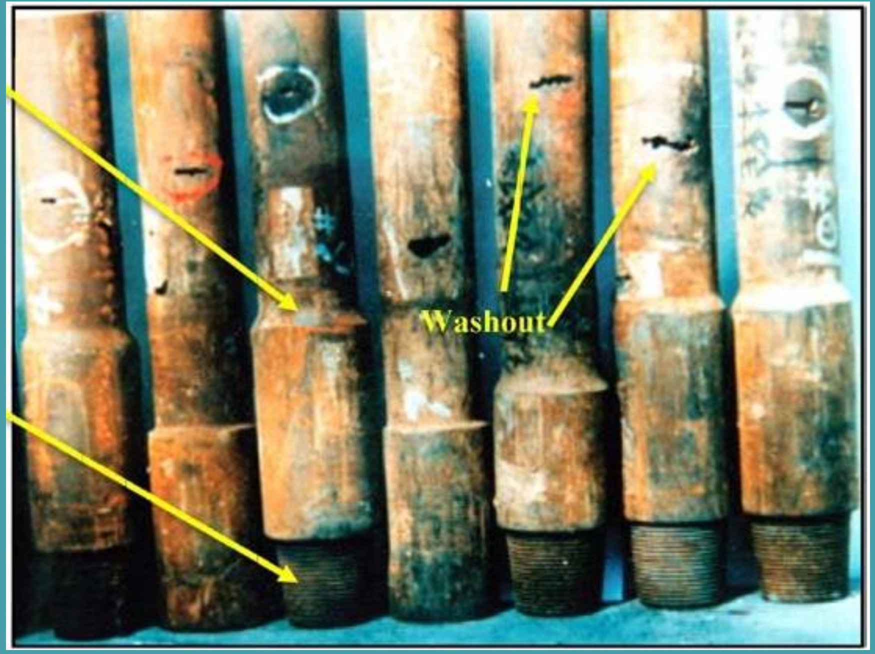
- Cement plug
- Blind drilling using aerated mud



Fluids Solution

- Control ROP and use adequate circulating rate
- Provide good hole cleaning
- Pump viscous sweep regularly
- Pump spotting pills for releasing stuck pipe





CORROSION

Solution

- Corrosion protection with pH control by adding caustic soda or lime.
- Add oxygen scavanger (BARASCAV-L / OXYGON)
- Add filming / coating agent
  - BARACOR 100
  - BARAFILM

ACID GAS CONTAMINATION

- Carbon dioxide (CO2) and hydrogen sulfide (H2S) are often found as components of natural gas.

- Identification
  - Drop on density
  - Alkalinity and pH decreases
  - API and HT-HP filtration increase
  - Decrease in calcium
  - Rheology Increases
- Recommended Treatment
  - **Add an acid gas scavenger**
    - Replenish alkalinity with lime to adjust pH to >10
    - Add starch or polymers to reduce fluid loss.
    - Add water for dehydration.


DISCUSSION

Terima Kasih

Thank you