Drilling Problems

CAUSES & SOLUTIONS

OPA Energy

Meet Your Instructor

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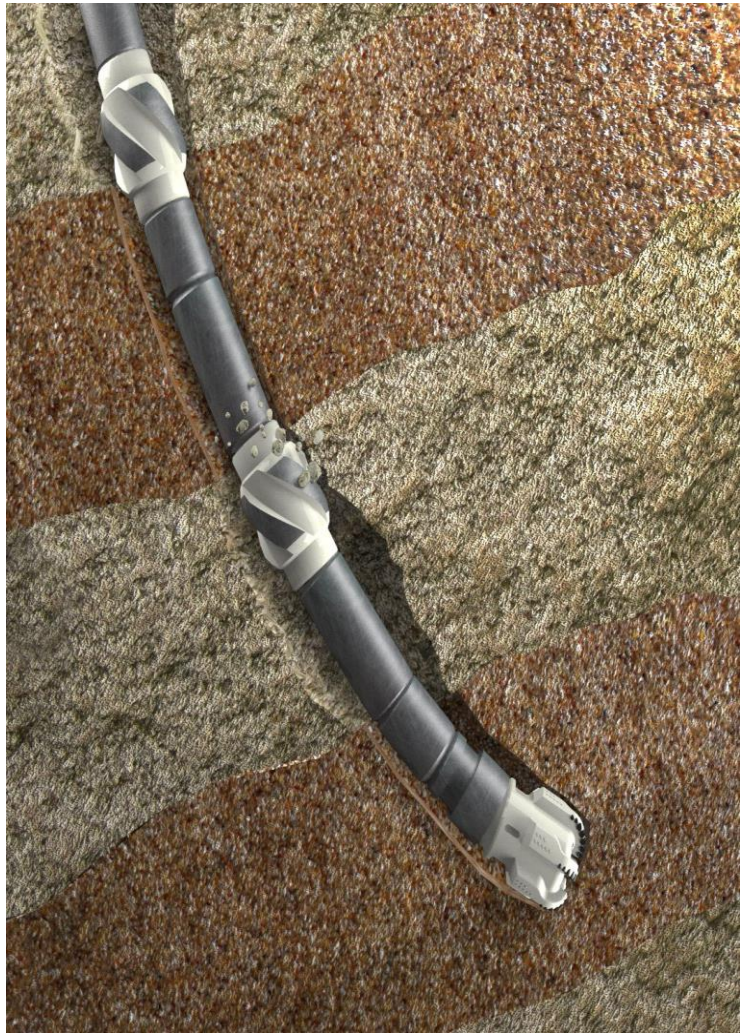
Agenda

- Stuck Pipe
- Downhole Losses
- Bit Balling
- String Washout
- Twist-off
- Nozzle Plugging
- Drillstring Vibrations
- Ballooning
- Well Control Problems

Stuck Pipe Mechanism



1 Mechanical Sticking

The pipe is physically blocked or trapped and cannot be moved (rotated or pulled) due to mechanical interference.

2 Differential Sticking

The drill string is held against the wellbore wall by pressure differential, especially when the wellbore pressure exceeds formation pressure.

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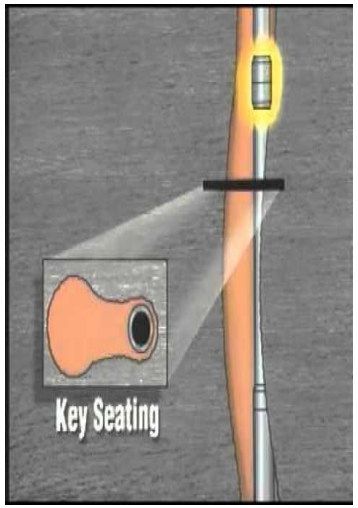
Mechanical Sticking



Pack-off

Cuttings Accumulation

Wellbore Geometry

Keyseating
Ledge Sticking
Tight hole

Formation Instability

Bridging/Caving
Swelling/Sloughing
Salt Healing

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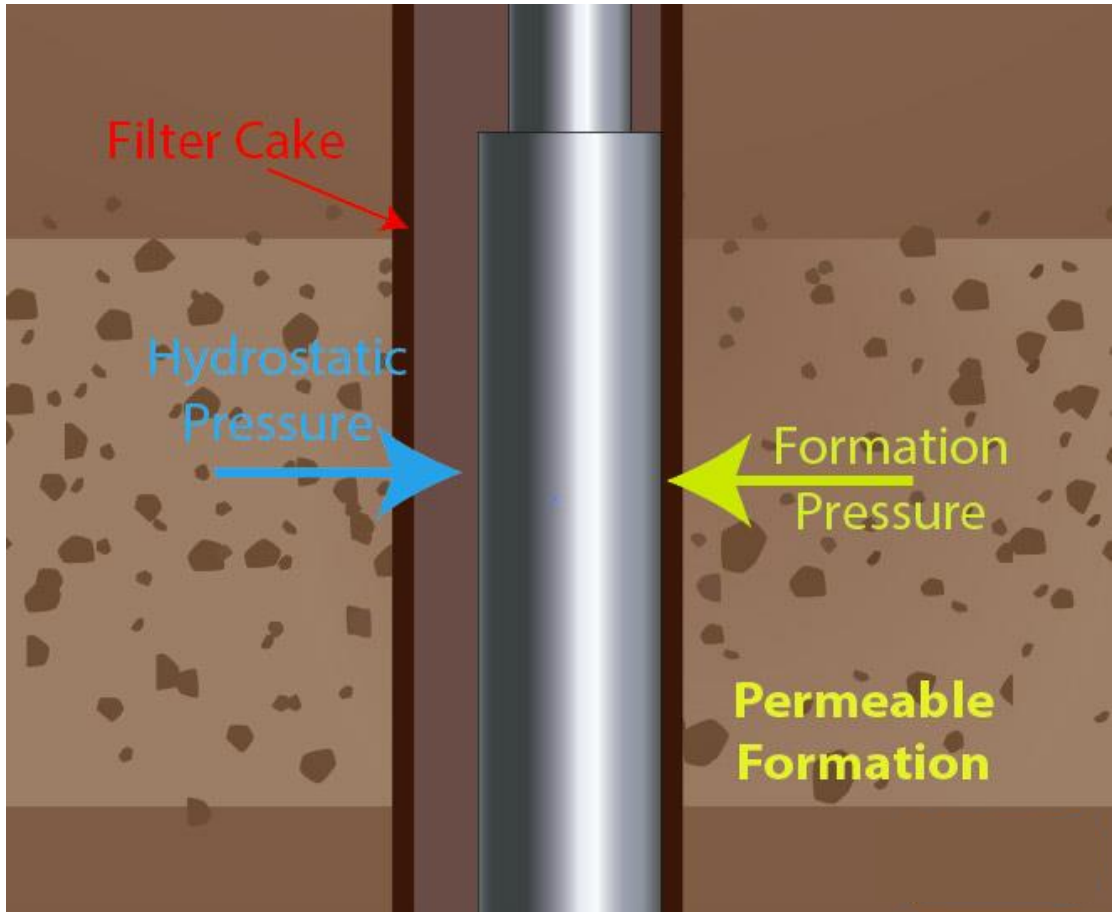
Differential Sticking



Factors Affecting Differential Sticking

- Overbalance: Hydrostatic pressure (mud weight + TVD) Vs pore pressure
- Contact Area: Spiral vs Slick DC
- Time: $F_{pull} = \Delta P \times A \times \mu(t)$
  Where $\mu(t)$ is coefficient of friction

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Stuck Pipe Diagnosis

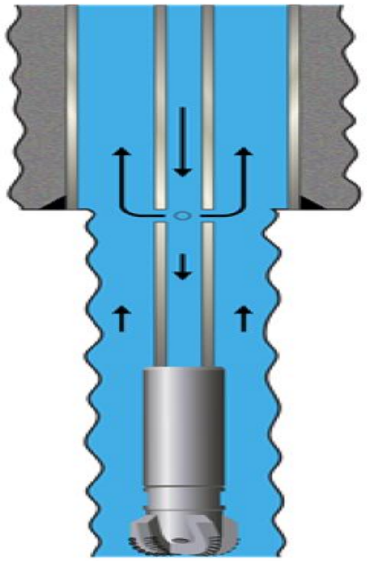
	Movement (after)	Circulation	Movement (before)	Reason
Pack-off	No	No or limited	No	Poor Hole Cleaning
Wellbore Geometry	No	Yes or limited	Yes	Severe dogleg Hard/soft formations Under-gauge bit
Formation Instability	No	No or limited	-	Reactive shale Insufficient Mud Wt Creeping effect
Differential Sticking	No	Yes	No	High Overbalance Thick filter cake

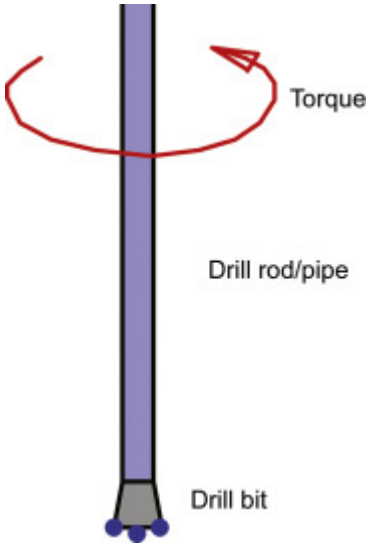
Note

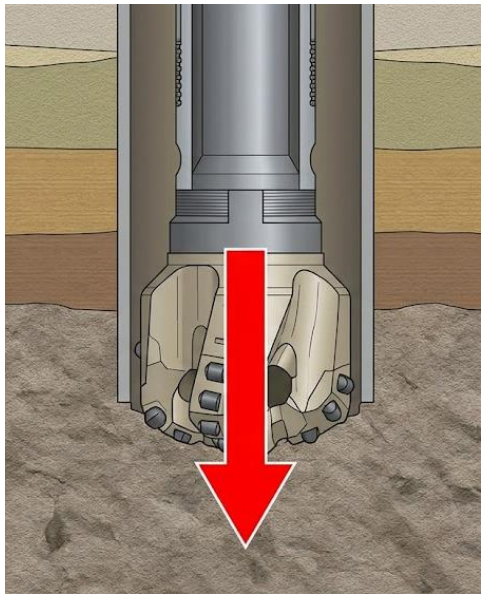
Stuck Pipe freeing worksheet can be used as an estimate of the type of stuck based on simple calculations.

Stuck Pipe Prevention

Drilling Parameters

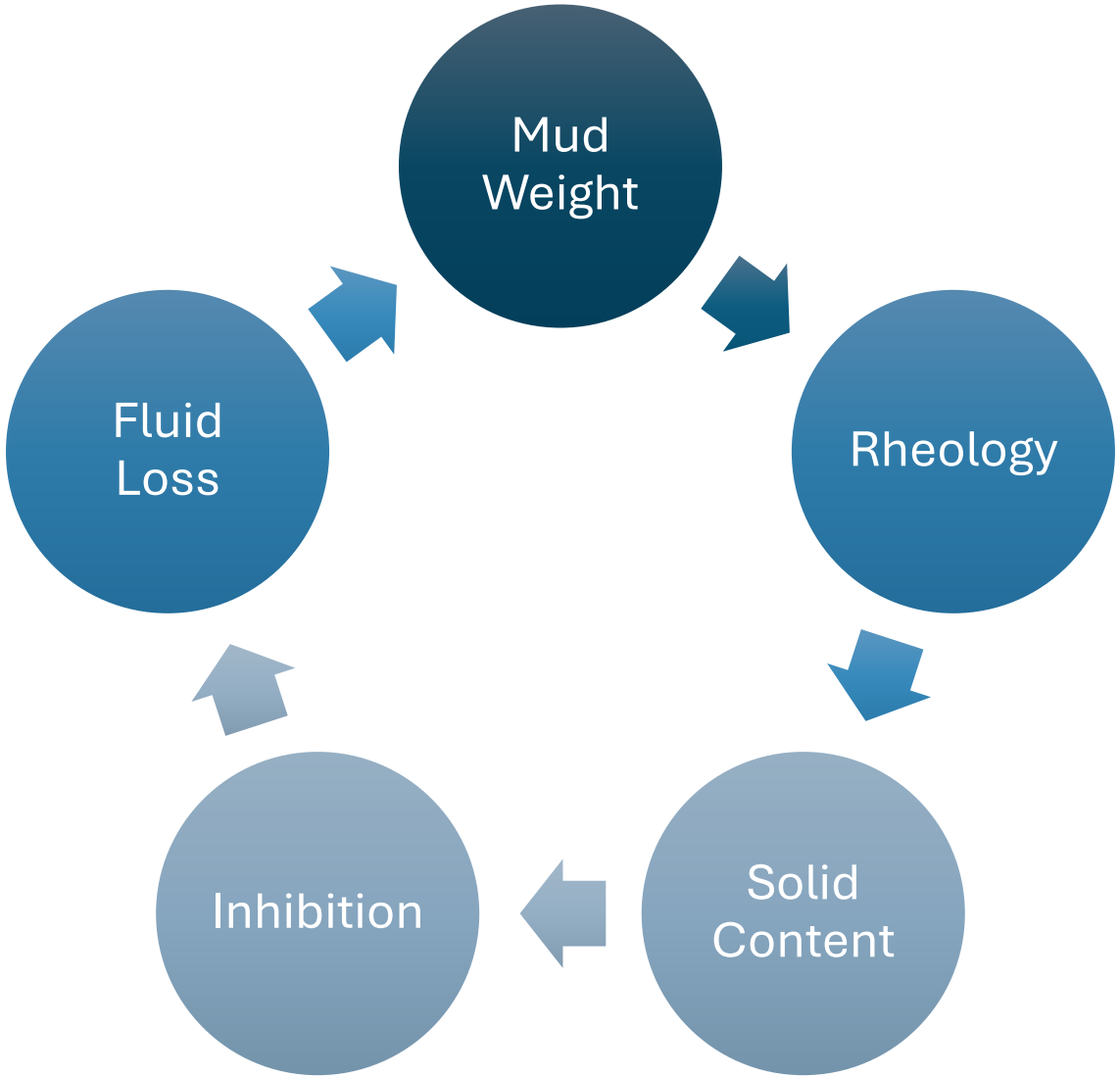






GPM ..... RPM ..... ROP

Mud Properties



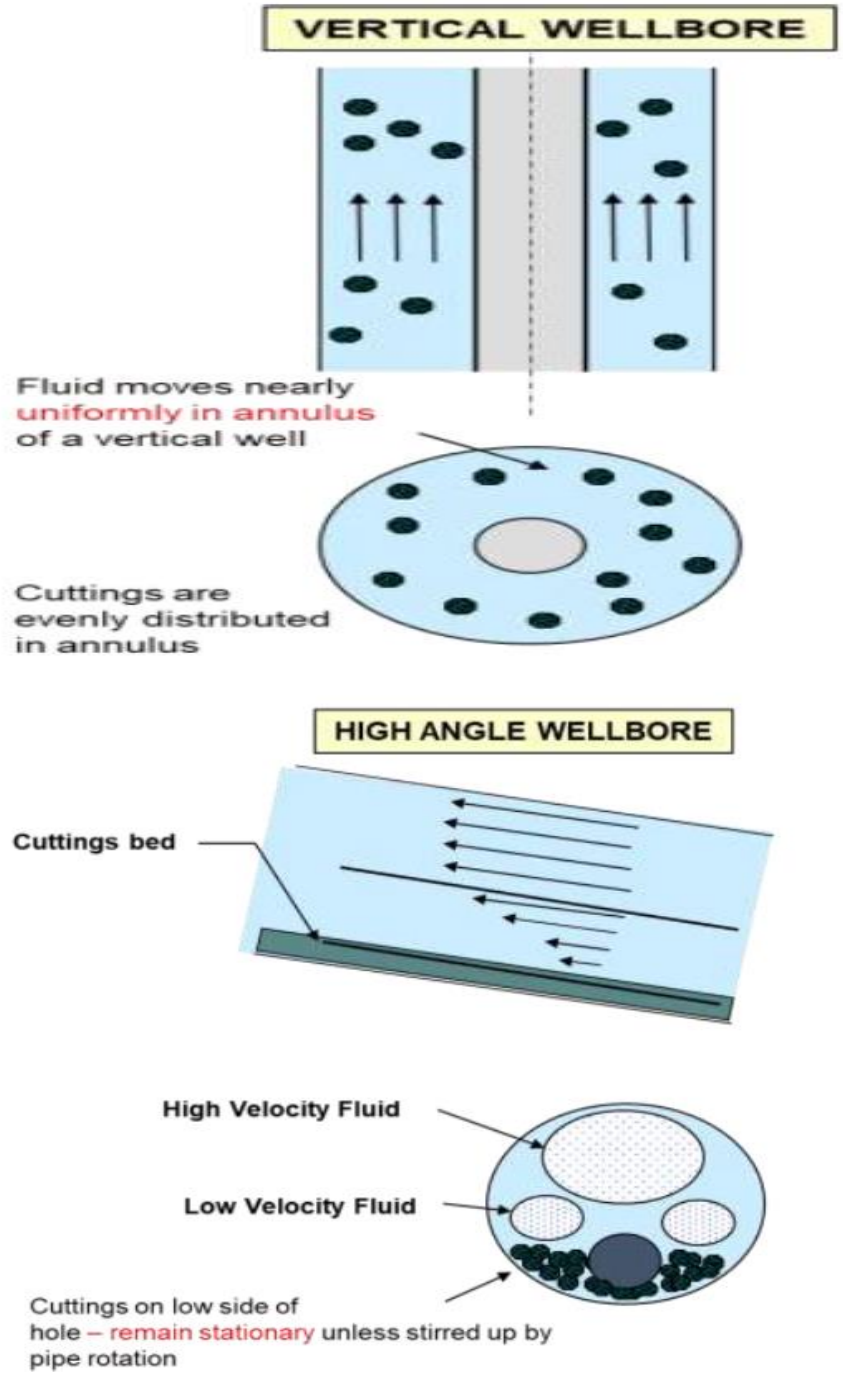
Cleaning Sweeps

Cuttings behave differently depending on well angle:

- **Vertical and slightly inclined wells (0° - 30°):** Hi-Vis Sweeps
- **Highly inclined and horizontal wells (30° - 90°):** Tandem Pills

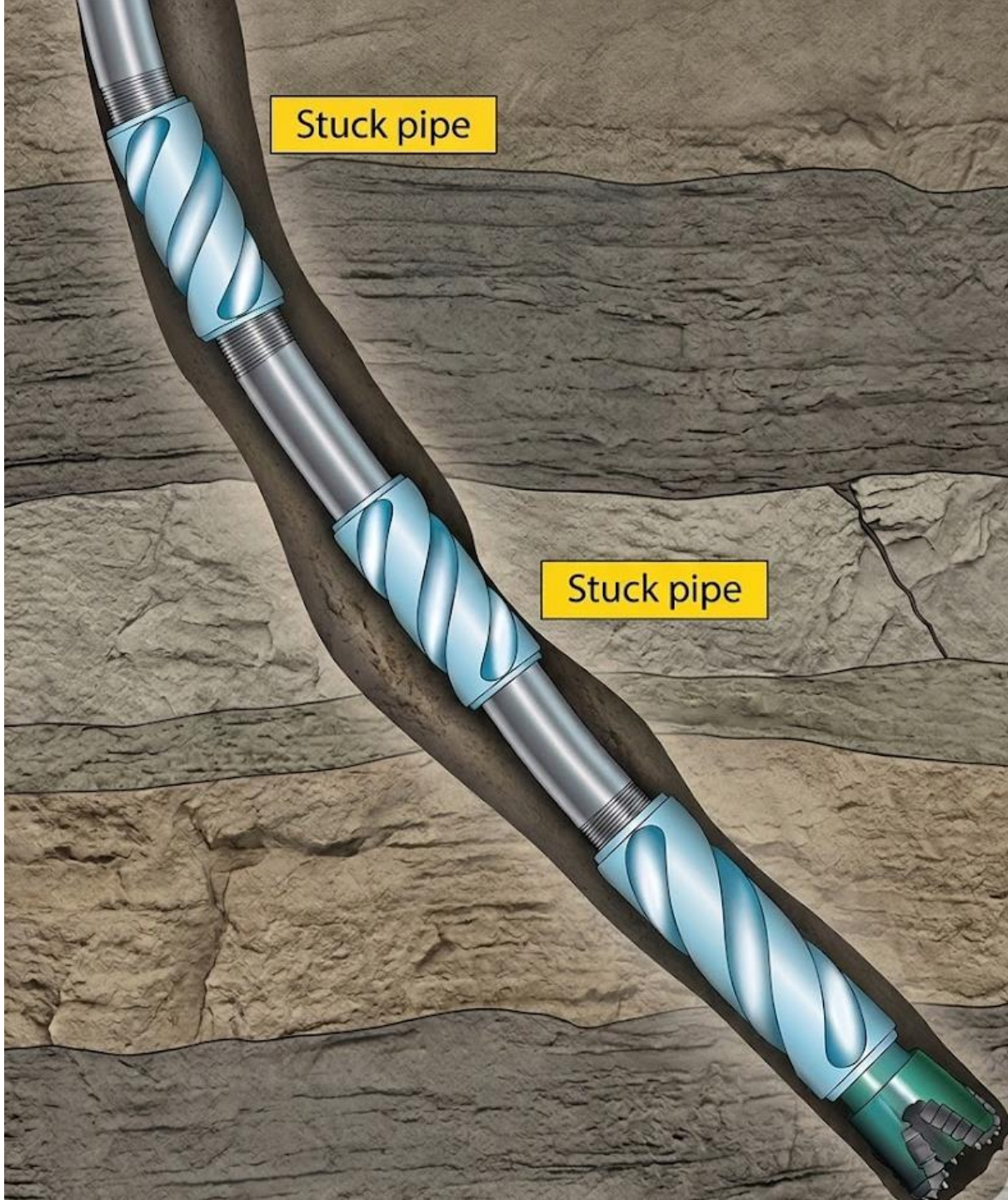
Tandem pills consist of two consecutive sweeps:

- **Low Vis Sweep:** To disturb cutting bed through turbulent flow.
- **High Weighted Pill:** To carry cuttings through buoyancy effect.



BHA Design & Stiffness

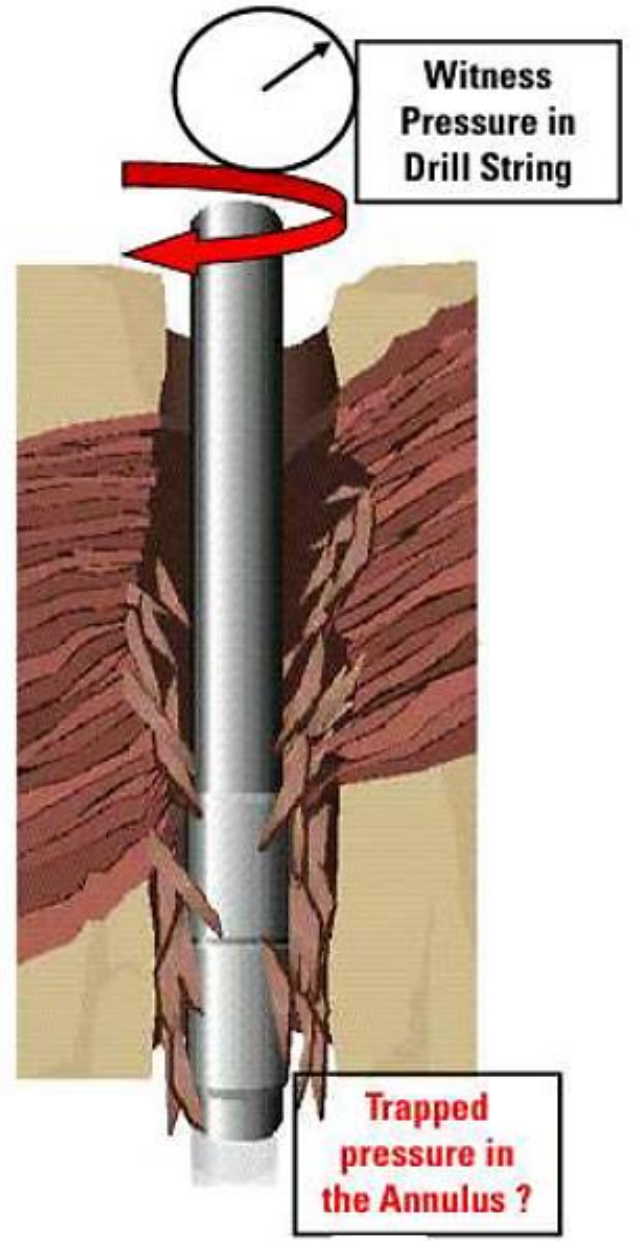
- Drill collars can be slick or spiral
- Slick drill collars gives higher stiffness and weight
- Spiral drill collars reduce differential sticking tendency
- If different stiff BHA is run into a previously drilled hole, it may get jammed into the hole.
- Reamers help prevent stuck pipe by improving the wellbore condition and reducing spots where the drillstring can get trapped.



Troubleshooting

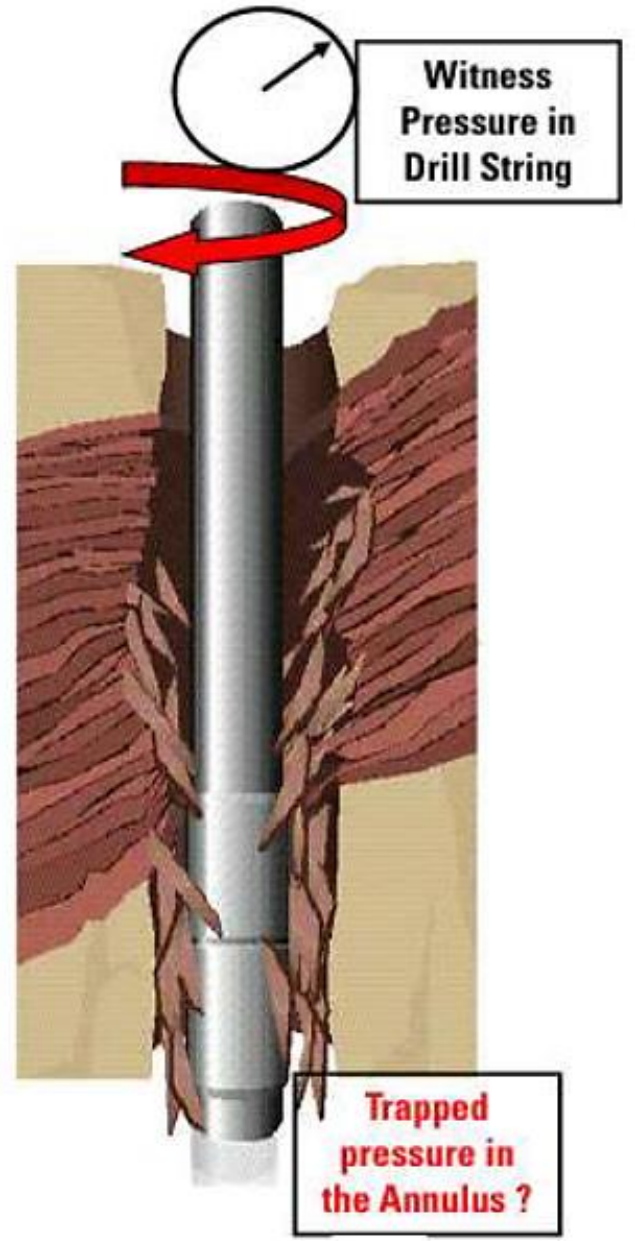
Packoff

- Stop pumps when seeing signs of packing off
- Bleed off any trapped pressure in the drill string.
- Establish circulation. Use a low pumping pressure (200-400 psi) or leave a low trapped pressure as a witness pressure in the DS.
- Do not exceed the fracture pressure at any point in the well.
- Put string weight to its neutral value & mark pipe.
- Work the string against the direction of the string before the stuck event.



Working the String

- Start jarring down / up and increase gradually to the maximum allowable limit.
- Maximum allowable limit while working up is 80% of the maximum tensile strength of the weakest component.
- Maximum allowable limit while working down is 100% of the Slack-off weight.
- Torque up to maximum torque while working down.
- Never apply torque while working up to prevent back-off / twist-off.
- If decision is to back-off / sever the string, work the string in the opposite direction first.

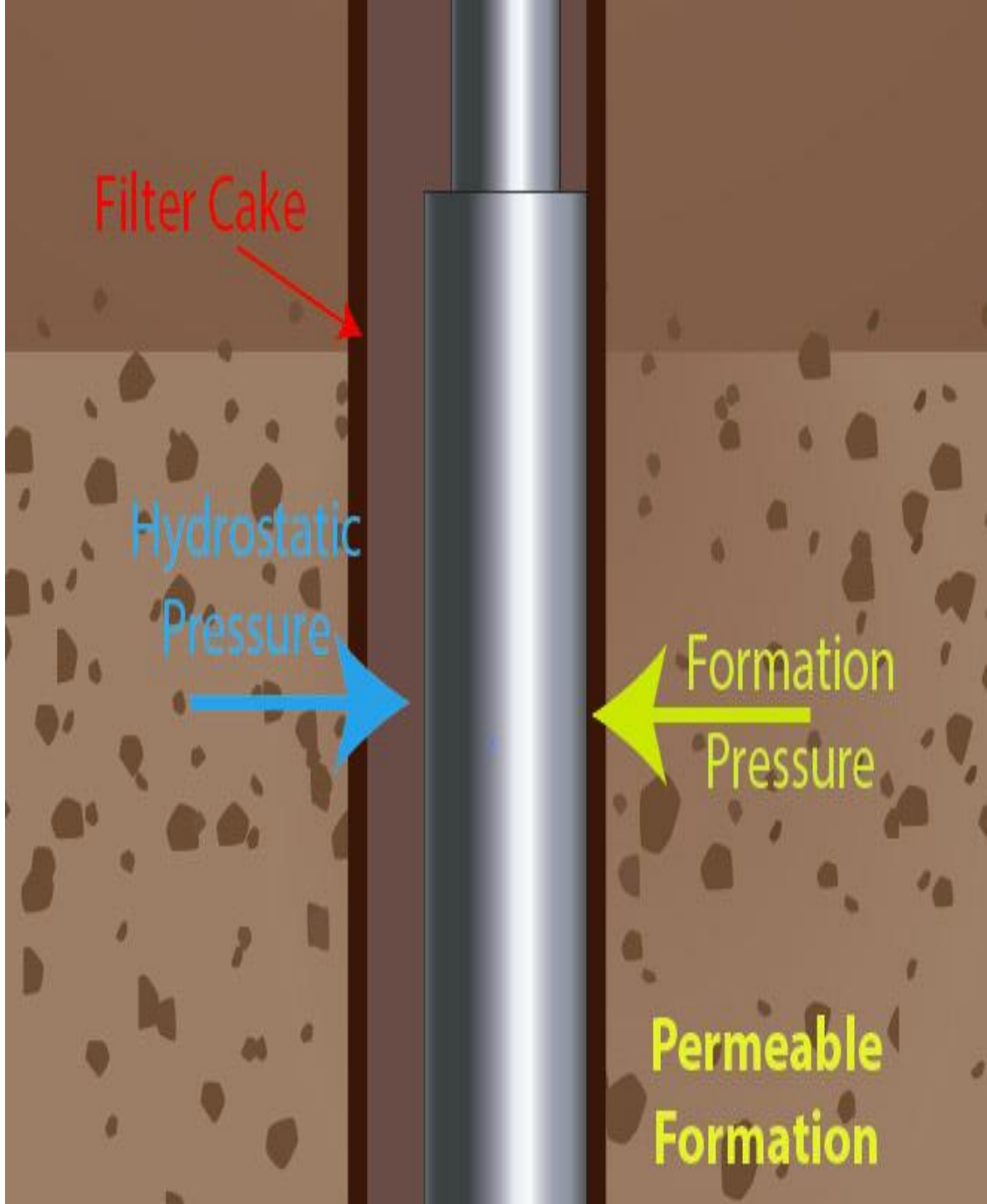


Mechanical Stuck

- Same procedures as in case of packoff.
- **If stuck in limestone or chalk:** spot acid pill in the annulus, around the BHA. Give soak time and work pipe
- **If stuck in salty formation:** spot freshwater pill in the annulus around the BHA. Give soak time and work pipe.

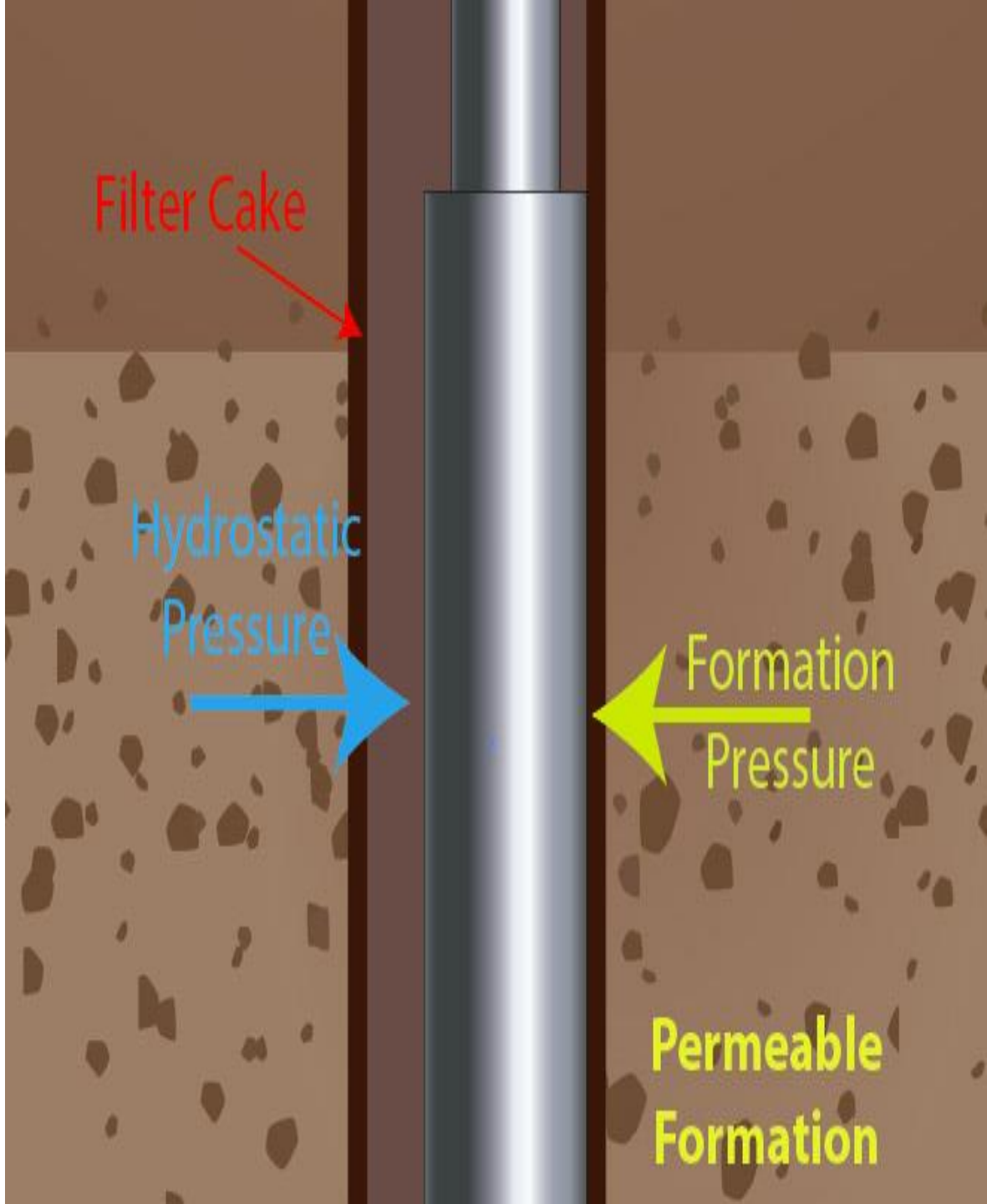
Differential Stuck

- Full circulation is already established.
- Use a low or a reasonable flow rate to reduce ECD.
- Slack off the string weight while holding torque on surface pipe. Do not exceed maximum allowed torque.
- Pick up to just above the free weight (slight tension)
- Repeat the previous steps while jarring.



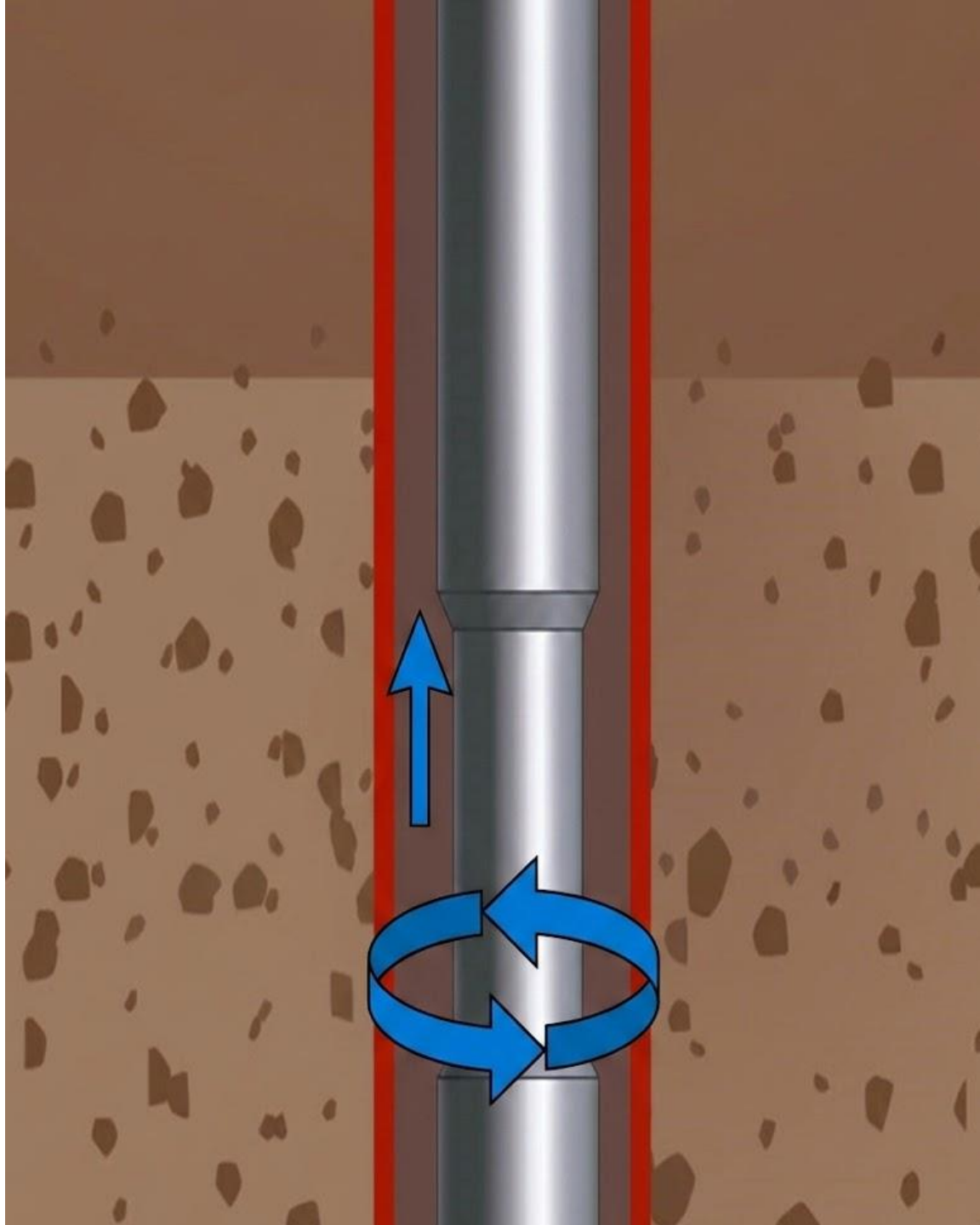
Differential Stuck

- Pump and displace a "pipe free pill" to the annulus and spot it around the BHA.
- Give the pill a soaking time and displace it to the annulus
- Do not extend soak time.
- If the pill is ineffective, consider reducing the MW to a safe value (pay attention to Well Control and Hole stability).
- If all attempts failed, make trials to work the string up. Don’t apply torque.



If String is Free

- Circulate at maximum rate, rotate and work the string
- Ream / backream the hole section
- Circulate the hole clean / condition mud properties
- Continue with normal operations

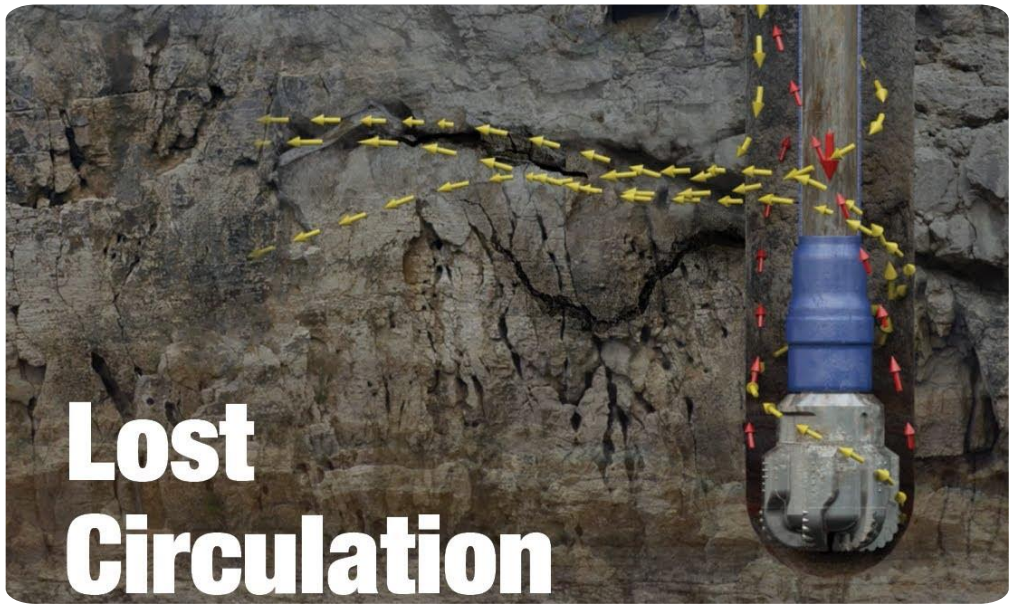


If String is Not Free

- Run free point indicator to identify the stuck point
- Back-off the string above the stuck point.
- If couldn’t, a severance tool may be used.
- Perform fishing operations to retrieve the stuck part.
- If couldn’t, milling operation can be handy.
- Sidetrack if recovery is unsuccessful.

Downhole Losses

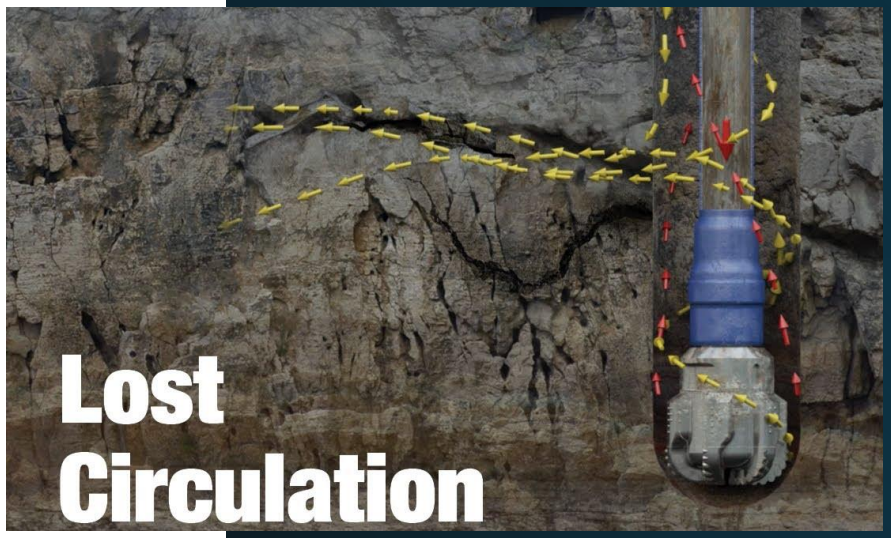
Types of Losses



- **Seepage losses:** Minor fluid loss into porous formations (less than 20 BPH).
- **Partial losses:** Indicates moderate fractures or higher permeability zones (20:100 BPH).
- **Severe losses:** Signals large fractures or high permeability thief zones (higher than 100 BPH).
- **Complete losses:** No fluid returns to the surface, indicating caverns and larger fractures.

Causes of Losses

- Naturally, fractured formations
- Induced fractures from high ECD (equivalent circulating density)
- Vugs or cavernous zones
- High permeability sands, especially unconsolidated ones



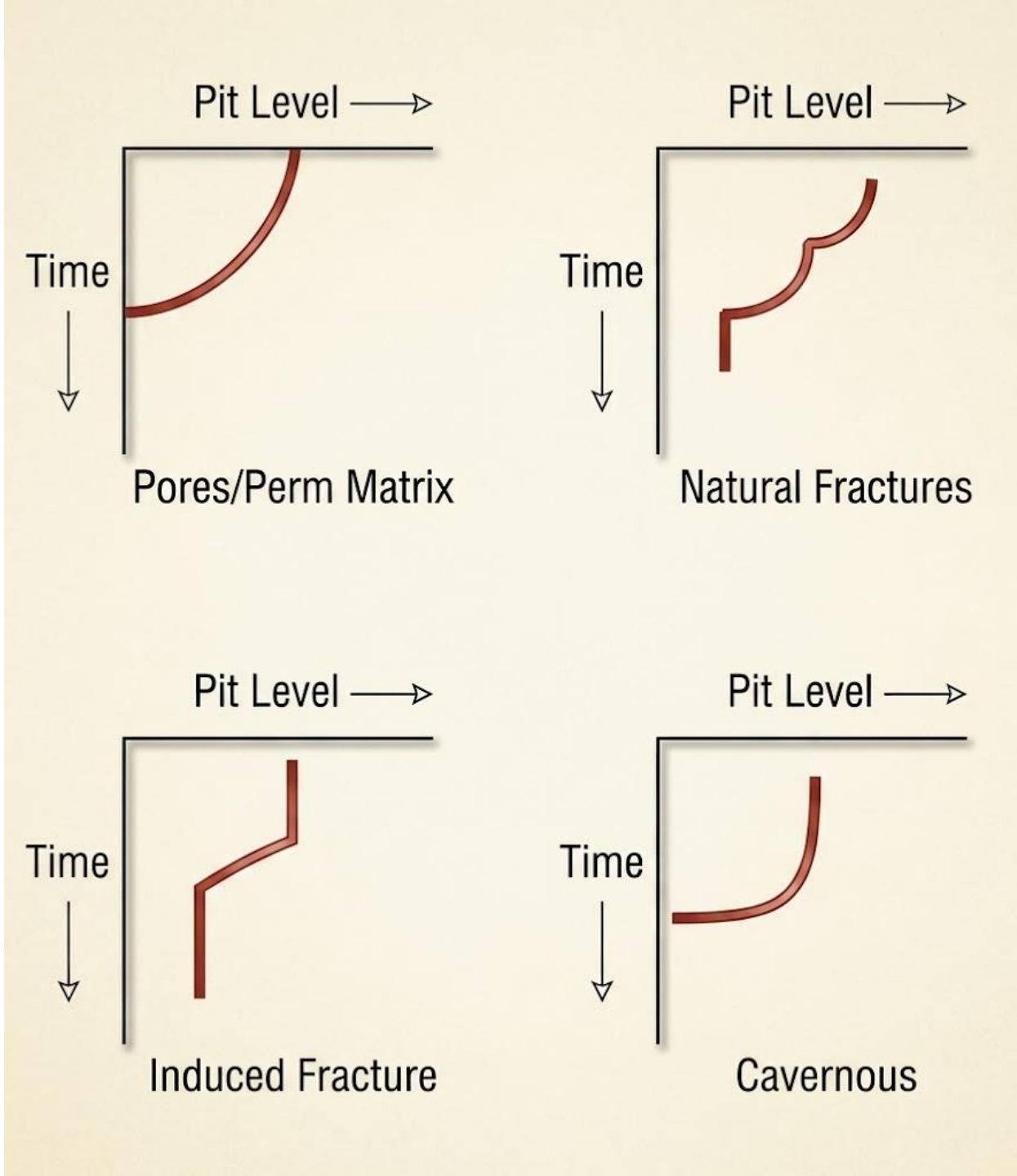
Consequences of Losses

Downhole losses could be considered the worst drilling problem as it can cause most of drilling problems, the below drilling problems can be consequences of downhole losses

- Kick or blowout due to underbalanced condition
- Stuck pipe or pack off
- Wellbore instability
- Excessive non productive time (NPT)

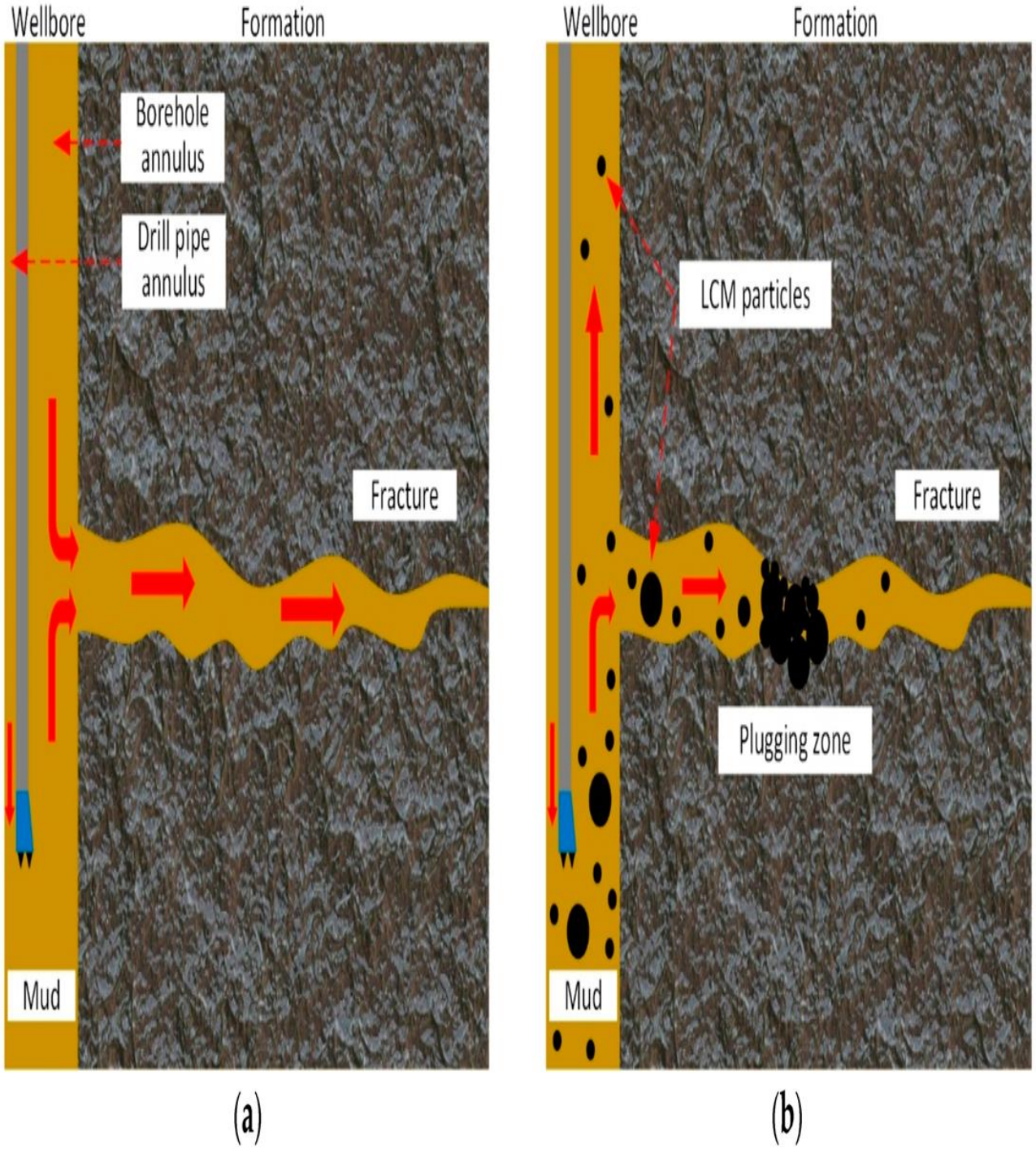
Losses Detection

- Drop in mud pit volume
- Decrease in pump pressure
- Visible losses at the flowline
- Decrease in flow return in partial and severe losses
- No Return in case of complete losses.



Mitigation & Treatment

- **Reduce ECD:** By reducing mud weight, flow rate, mud viscosity, ROP, and using MPD if possible.
- **Use LCM:** Granular, fibrous, flaky, and blended.
- **Cement plugs & advanced pills:** for severe or total losses.



Bit Balling

Bit Balling

- Bit balling is a drilling issue where sticky formations (usually clays or shales) accumulate and pack around the drill bit
- This causes blocking cutters and nozzles, severely reducing drilling efficiency
- Once bit balling happens, it is very hard to cure it, and in most cases a trip to the surface must be done to clean the bit.



Causes of Bit Balling

- Highly reactive Hydrophilic formations like Dabaa Shale.
- Inadequate mud properties– especially poor inhibition or insufficient cleaning
- Poor hydraulics– insufficient jet velocity to clean the bit
- Wrong Drilling practice
- Wrong Bit selection: Junk slot area and cutter spacing.

Bit Balling Indicators

- Decrease in drilling torque.
- Sharp drop in ROP.
- Increase in pump pressure.

How to Prevent

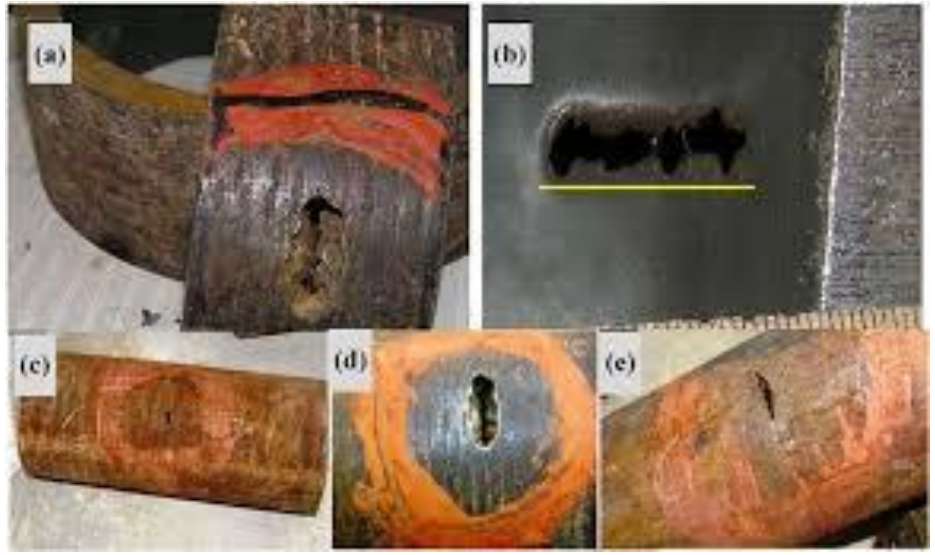
- Use inhibitive mud systems (KCl or oil-based muds).
- Optimize bit hydraulics (increase flow rate or nozzle velocity)
- Add surfactants or bit lubricants to discourage sticking
- Maintain high rotary speed and moderate WOB to reduce sticking time

Troubleshooting

- Pump anti-bit balling sweeps:
    - **Lignosulphonate: deflocculates aggregated clay.**
    - **Caustic pill: erode balling**
    - **LCM pill: erode balling**
    - **Detergent: reduces adhesion of clay to bit**
- Perform wiper trip to nearest sand interval and apply maximum RPM and jerk string to get bit clear
- Pull out of hole to clean / replace bit

String Washout

String Washout



- A drill string washout refers to a situation where a small hole or rupture develops in the drill string
- This allows drilling fluid (mud) to escape into the borehole instead of circulating through the bit as intended.
- A string washout may eventually develop into a full twist-off.

Causes of Washout

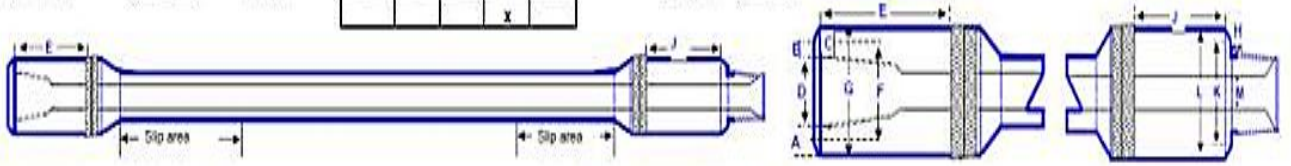
- **Erosion:** Continuous flow of abrasive drilling fluids can erode weak spots
- **Corrosion:** Chemical reactions over time weaken the pipe walls.
- **Mechanical Damage:** Physical wear or damage from rough handling or downhole obstructions.
- **Defective Tool Joints or material:** Poorly made or worn-out connections and material.

How to Avoid

- **Check the** inspection report for whole BHA and drill pipe.
- Use an appropriate T&D model during well trajectory planning.
- Good selection for the BHA.
- Mitigate drill string vibrations.
- Provide WWI so as not to exceed the limitation of the material downhole.

PIPE OD	PIPE GRADE	WEIGHT LBS/FT	NOM. WALL THICKNESS	THREAD CONNECTION	RANGE
5"	G-105	19.50	0.362	NC 50	II

Specification: DS 1 — Category: 1 | 2 | 3 | 4 (X) | 5 — Hard Band: X



	TUBE							BOX TOOL JOINT							END AREA		PIN TOOL JOINT				END AREA			Remarks
		ID						Shoulder	Minimum	COUNTERBORE		Tong	Bevel	Hard	Box	Box	Pin Neck	Tong	Bevel	Hard	PIN	PIN	Pin	
ID No	OD Condition	Coating Condition	EMI	OD Gauge	Remain Wall Thick	Final Class	Width A	Seal B	Depth C	Diameter D	Space E	Diameter F	band	OD G	Cond	Length H	Space J	Diameter K	band	OD L	ID M	Cond	
157	OK	2	OK	OK	0.374	P	5/8	5/16	5/8	5 5/16	8 1/4	6 1/16	OK	6 5/8	OK	3/8	9	6 1/16	OK	6 5/8	3.1/4	OK	NIL
401	OK	2	OK	OK	0.377	P	5/8	5/16	5/8	5 5/16	8 3/8	6 1/16	OK	6 5/8	OK	3/8	9	6 1/16	OK	6 5/8	3.1/4	OK	NIL
213	OK	2	OK	OK	0.370	P	5/8	5/16	5/8	5 5/16	8 1/4	6 1/16	OK	6 5/8	OK	3/8	9	6 1/16	OK	6 5/8	3.1/4	OK	NIL
544	OK	2	OK	OK	0.381	P	5/8	5/16	5/8	5 5/16	8 1/4	6 1/16	OK	6 5/8	OK	3/8	9	6 1/16	OK	6 5/8	3.1/4	OK	NIL
536	OK	2	OK	OK	0.377	P	5/8	5/16	5/8	5 5/16	8 1/4	6 1/16	OK	6 5/8	OK	3/8	9	6 1/16	OK	6 5/8	3.1/4	OK	NIL
431	OK	2	OK	OK	0.374	P	5/8	5/16	5/8	5 5/16	8 1/2	6 1/16	OK	6 5/8	OK	3/8	9	6 1/16	OK	6 5/8	3.1/4	OK	NIL
300	OK	2	OK	OK	0.374	P	5/8	5/16	5/8	5 5/16	8 1/2	6 1/16	OK	6 5/8	OK	3/8	9	6 1/16	OK	6 5/8	3.1/4	OK	NIL
633	OK	2	OK	OK	0.374	P	5/8	5/16	5/8	5 5/16	8 1/4	6 1/16	OK	6 5/8	OK	3/8	9	6 1/16	OK	6 5/8	3.1/4	OK	NIL
470	OK	2	OK	OK	0.377	P	5/8	5/16	5/8	5 5/16	8 3/8	6 1/16	OK	6 5/8	OK	3/8	9	6 1/16	OK	6 5/8	3.1/4	OK	NIL
548	OK	2	OK	OK	0.374	P	5/8	5/16	5/8	5 5/16	8 1/4	6 1/16	OK	6 5/8	OK	3/8	9	6 1/16	OK	6 5/8	3.1/4	OK	NIL
Minimum							11/32		9/16		8 1/8	5 53/64		6 3/32			4 37/64	5 53/64		6 3/64			
Maximum										5 3/8		6 5/64						6 5/64			3.25/32		

Box Recut		Box Reface		Hard Band Damage		Prime Joints	10
Pin Recut		Pin Reface		Class II		Scrap	

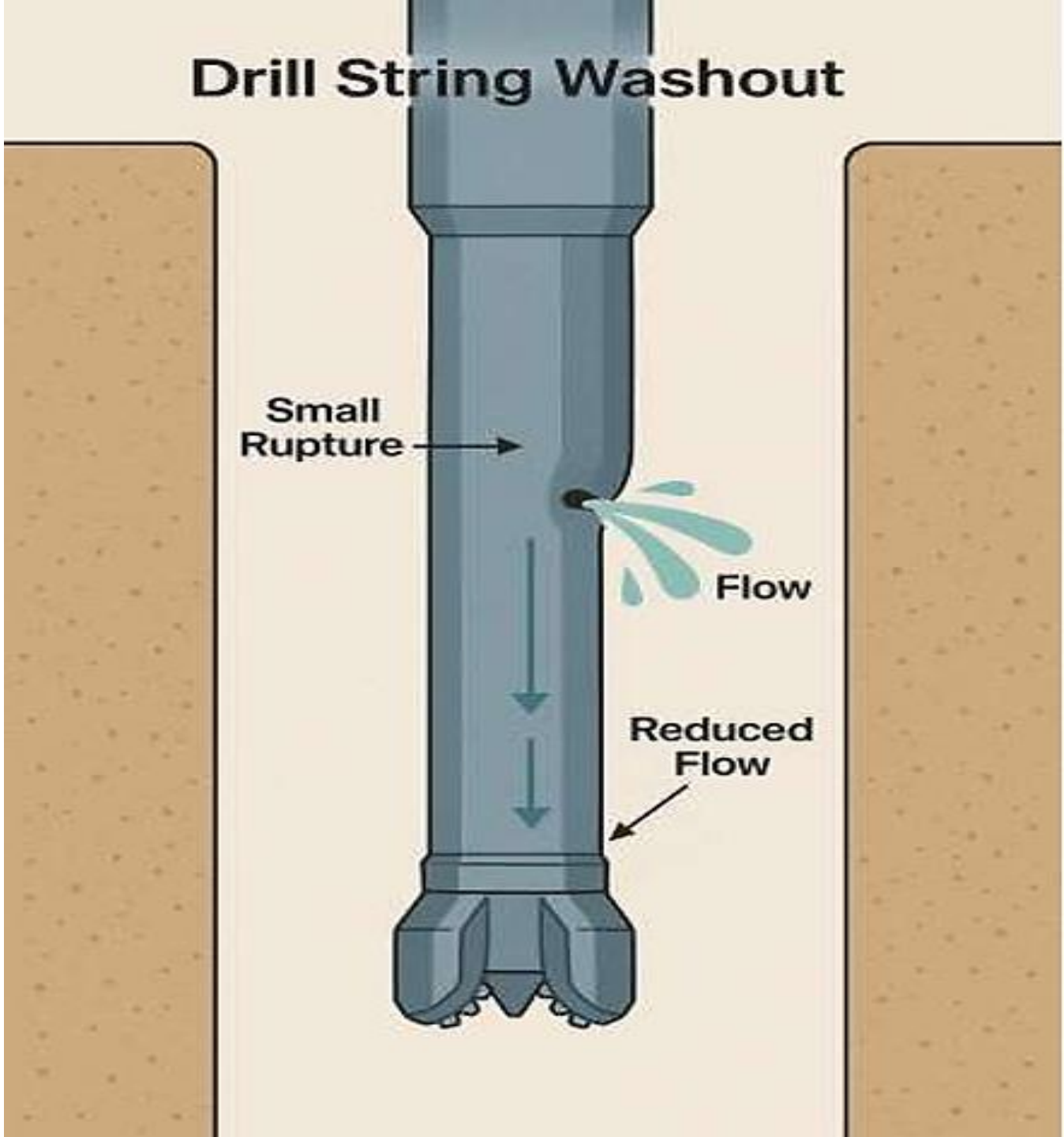
CUSTOMER SIGNATURE

DATE

KRISHNA PRASAD

How to Detect

- Sudden drop in pump pressure with no change in flow rate.
- Reduced bit performance or rate of penetration (ROP)
- Increase in return flow rate at the surface.
- MWD impeller speed decreasing.
- PWD detects anomalies in pressures.



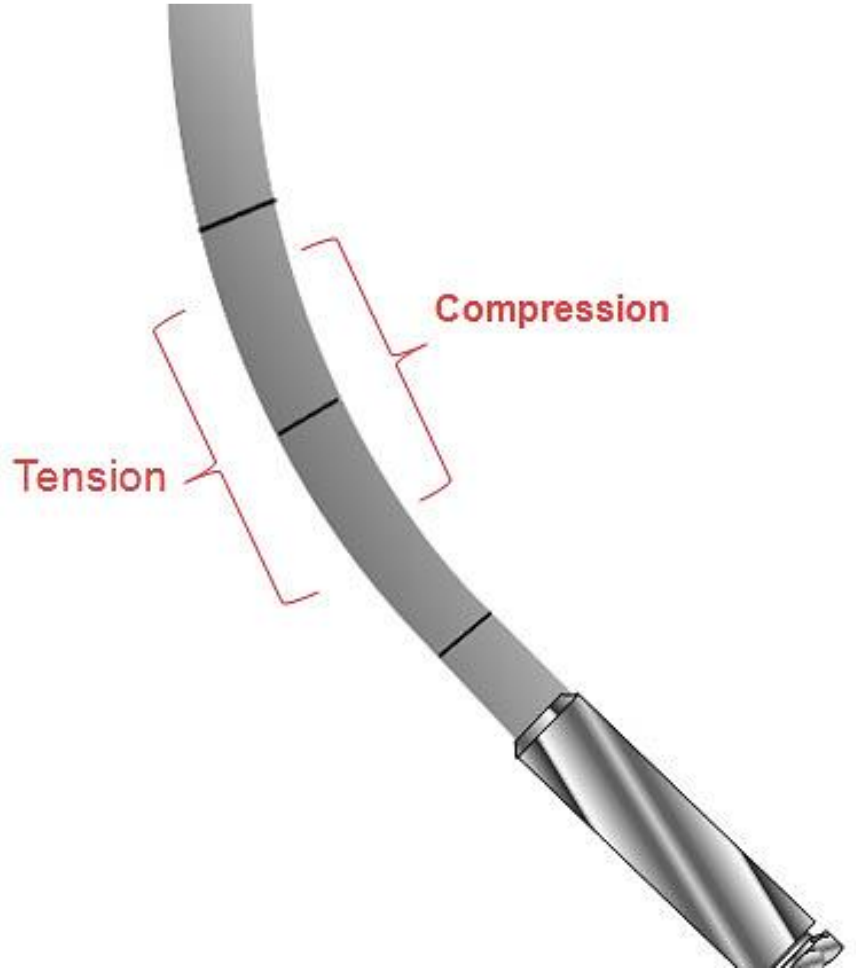
Troubleshooting

- Stop rotation and pick string off bottom.
- Decrease flow rate to avoid situation escalation.
- Check surface equipment to confirm pressure drop is Downhole.
- Check MWD tools readings.
- Continue investigation and if Washout is confirmed.
- POOH without slugging pipe (POOH wet).

String Twist-off

String Twist-off

- The drill string physically separates or breaks apart
- Causes expensive downtime and fishing operations
- The retrieved part provides crucial information for further fishing operations.



Causes of Twist-off

- Fatigue failure due to repeated stress cycles (especially in Build up sections).
- Over-torquing during drilling or reaming operations.
- Washout weakening the pipe wall before failure.
- Corrosion and erosion, often in older or reused pipes.
- Improper connection makeup, resulting in weak tool joints.
- Severe lateral & Stick-slip vibrations

How to Avoid

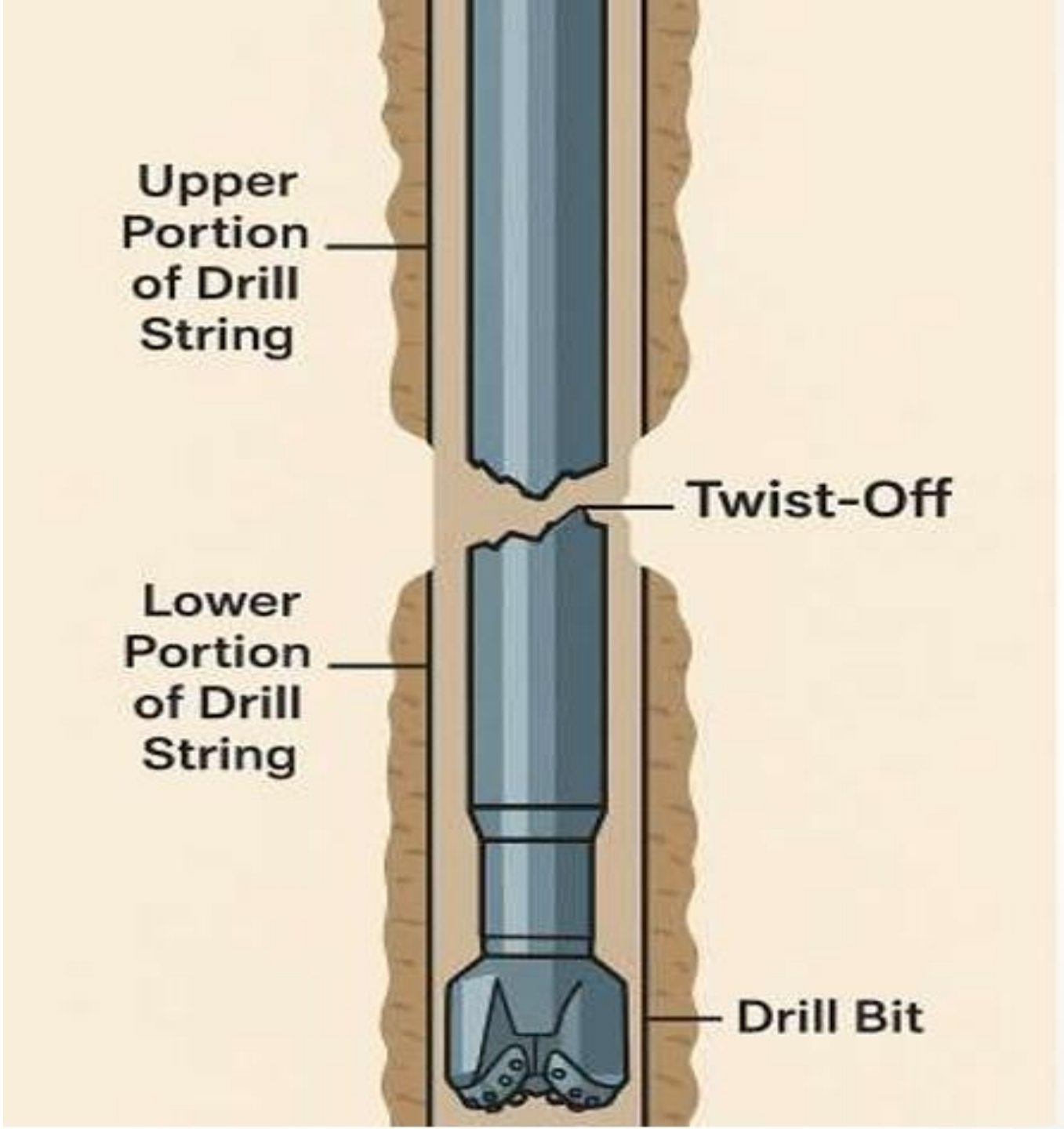
- **Check the** inspection report for whole BHA and drill pipe.
- Use an appropriate T&D model during well trajectory planning.
- Good selection for the BHA.
- Mitigate drill string vibrations.
- Provide WWI so as not to exceed the limitation of the material downhole.
- Apply correct makeup torque

How to Detect

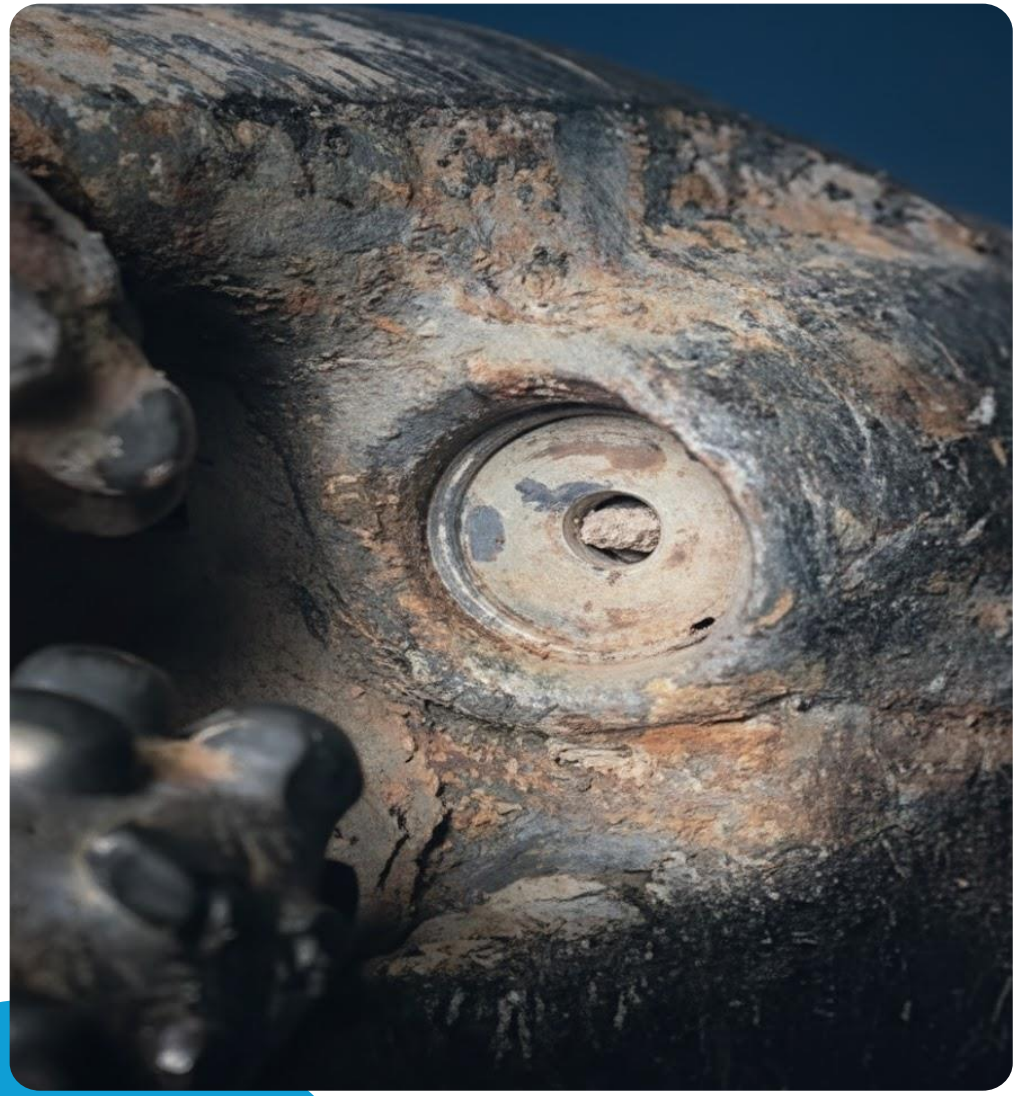
- Sudden loss of weight-on-bit (WOB).
- Sudden drop in torque.
- Sudden drop in pumping pressure.
- Sudden drop in ROP
- PWD detects anomalies in pressures.

Troubleshooting

- Preparation for fishing before POOH
- Do not circulate on top of fish to avoid cutting accumulation
- Spot a high vis on top of fish
- Time is an enemy, trips must be fast before the formation begins to swell or slough off around the fish.



Nozzle Plugging



Nozzle Plugging

- Occurs when solids block the nozzles in a drill bit, restricting or cutting off the flow of drilling fluid through the bit.
- This reduces cleaning, cooling, and cutting transport efficiency at the bit face.
- Causes poor ROP, overheating, or even bit damage.

Causes of Nozzle Plugging

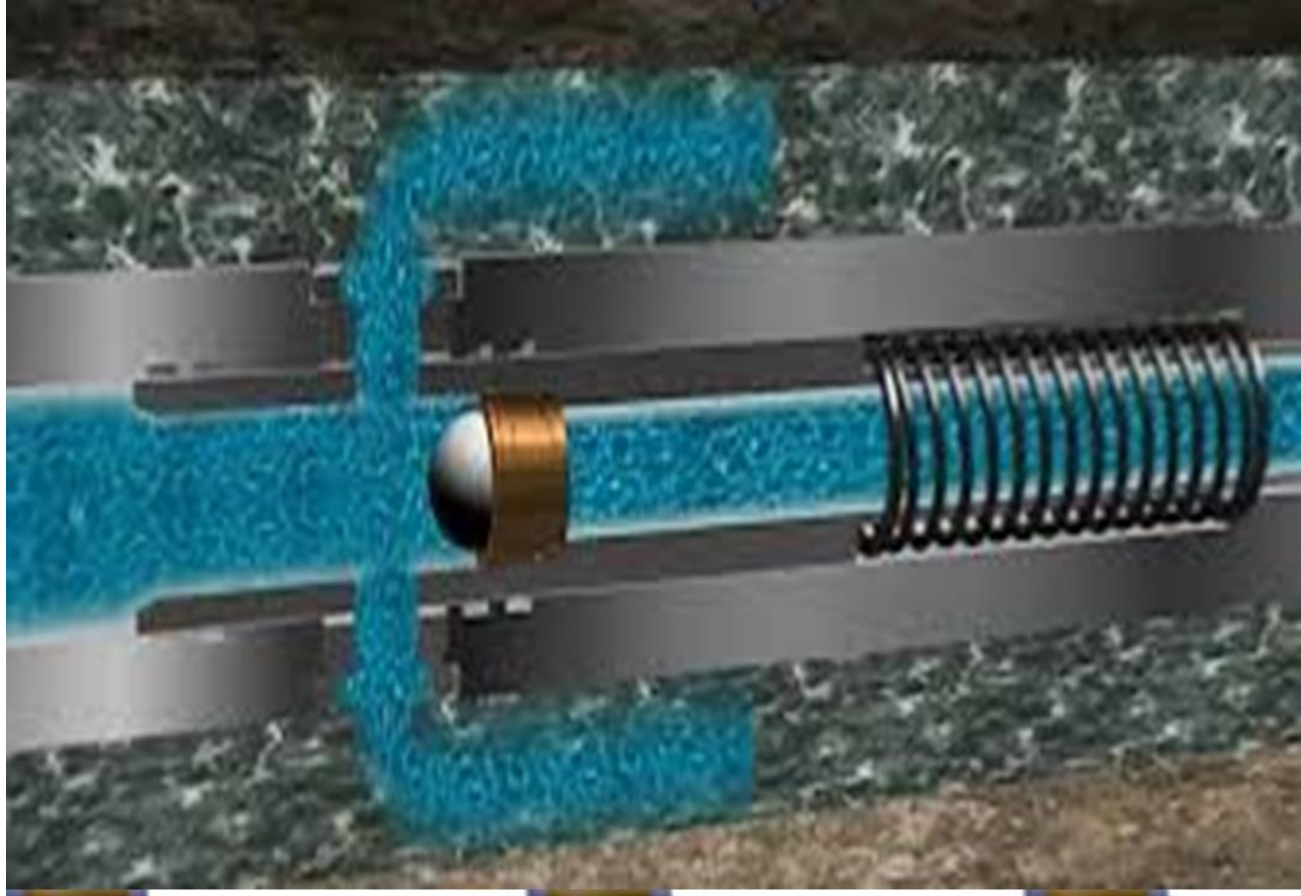
- Oversized solid particles in the mud (e.g., formation cuttings, lost circulation materials).
- Drilling junk or metal fragments in the mud.
- Improper nozzle size selection relative to fluid type and solids content.
- Poor mud conditioning or solids control system issues.

How to Prevent

- Use adequate solids control equipment (shakers, desanders, desilters).
- Ensure LCMs are compatible with nozzle size.
- Use muds with appropriate viscosity to suspend solids.
- Select nozzles large enough to allow solid passage when LCMs are used.

Circulating Sub (PBL)

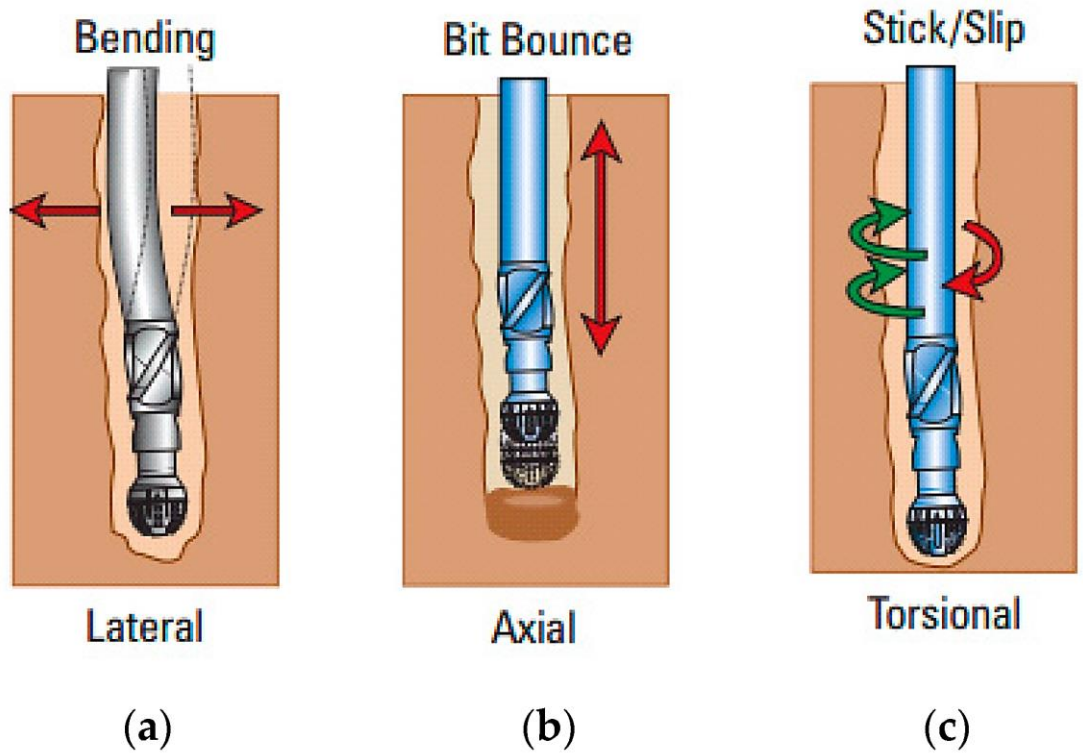
- Short for Pressure-Bypass Locking Sub
- Re-closeable multi-cycle circulating tool used in drilling operations.
- Allows to bypass the normal flow path (through the bit) and open side ports in drill string while downhole.
- Used to pump high-volume of coarse-material fluids like Lost Circulation Materials (LCM) or spacers, especially when these would otherwise plug nozzles, motors, or MWD tools



Vibrations

Vibrations

- Drill string vibrations are mechanical oscillations that occur during drilling.
- Types of vibrations:
  - Axial (bit bounce)
  - Lateral (Bit whirl)
  - Torsional (stick-slip)

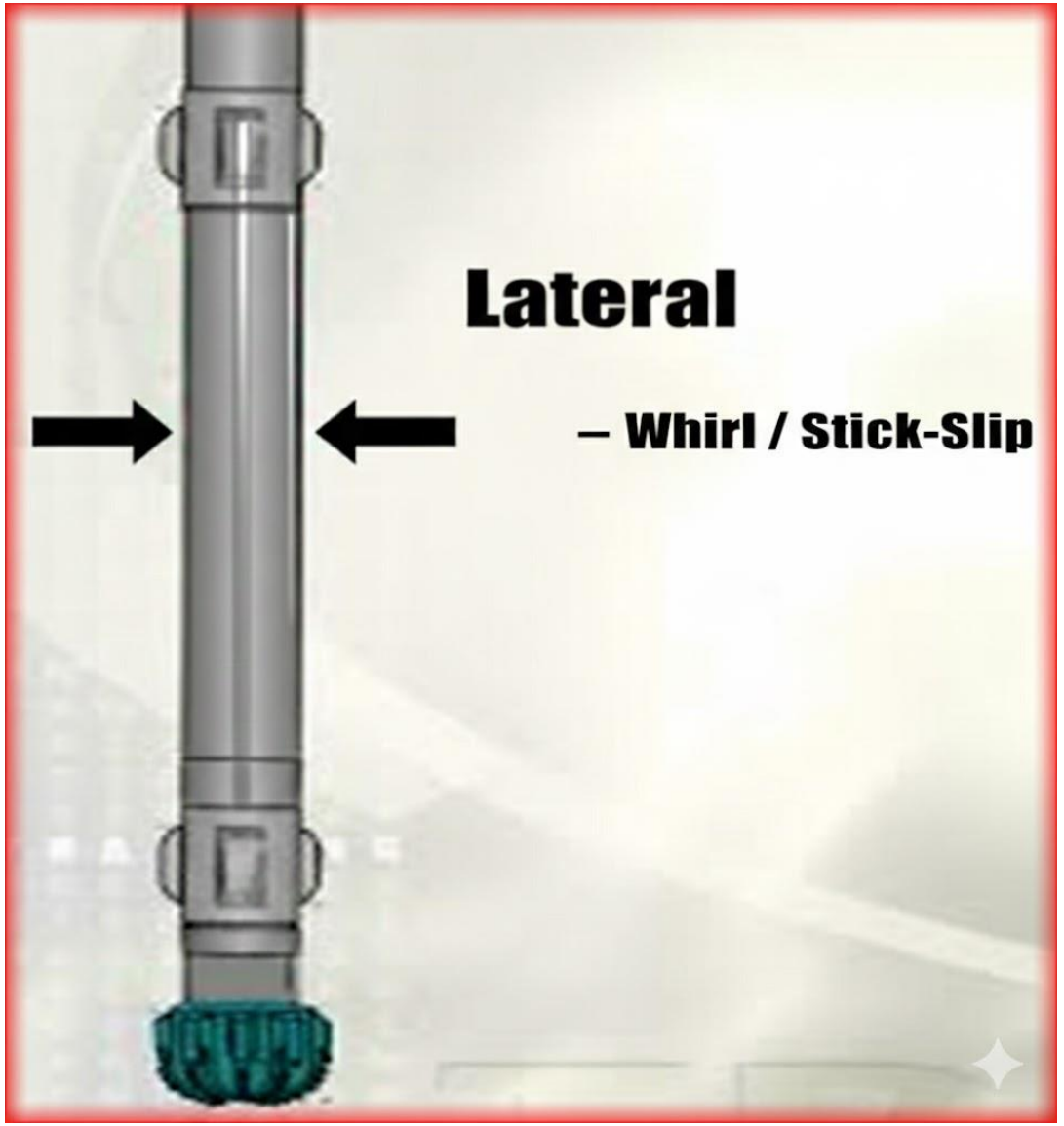


Axial Vibrations (Bounce)

- Up-and-down movement along the string's axis, where bit loses contact with formation and slams back down
- Indicated by erratic WOB
- Causes bit damage.
- Increase WOB and decrease RPM

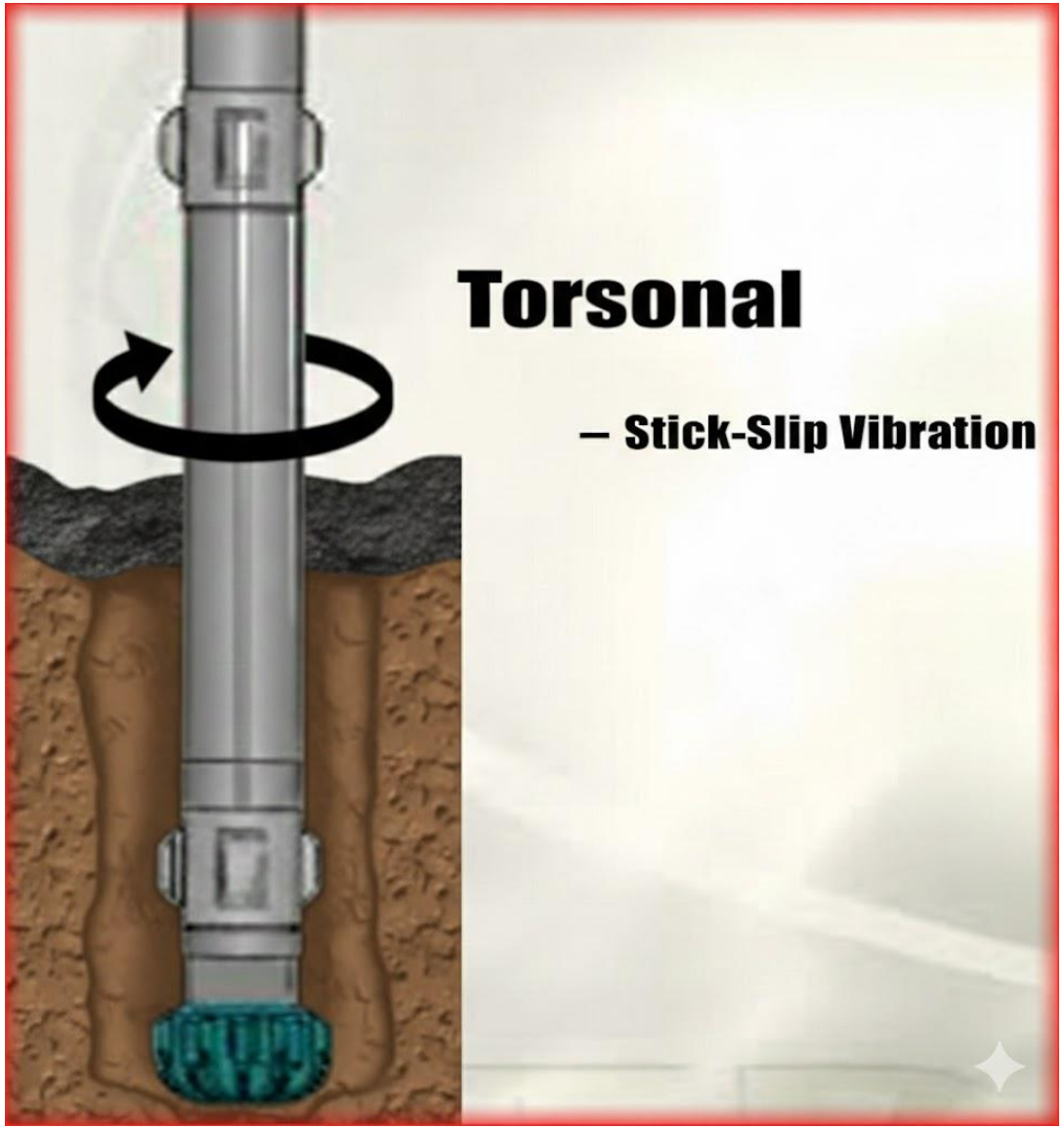
Lateral Vibrations (Whirl)

- Side-to-side motion, causing drill string to contacts the borehole wall.
- Causes hole washout, BHA damage, and possible twist-off.
- Increase WOB and decrease RPM



Torsional Vibrations

- Twist and release (stick slip) of the drill string.
- Identified by sharp torque fluctuations.
- Causes twist-offs, tool failures, and non-uniform hole patterns.
- Decrease WOB and increase RPM
- Not common in surface holes.



Ballooning Effect

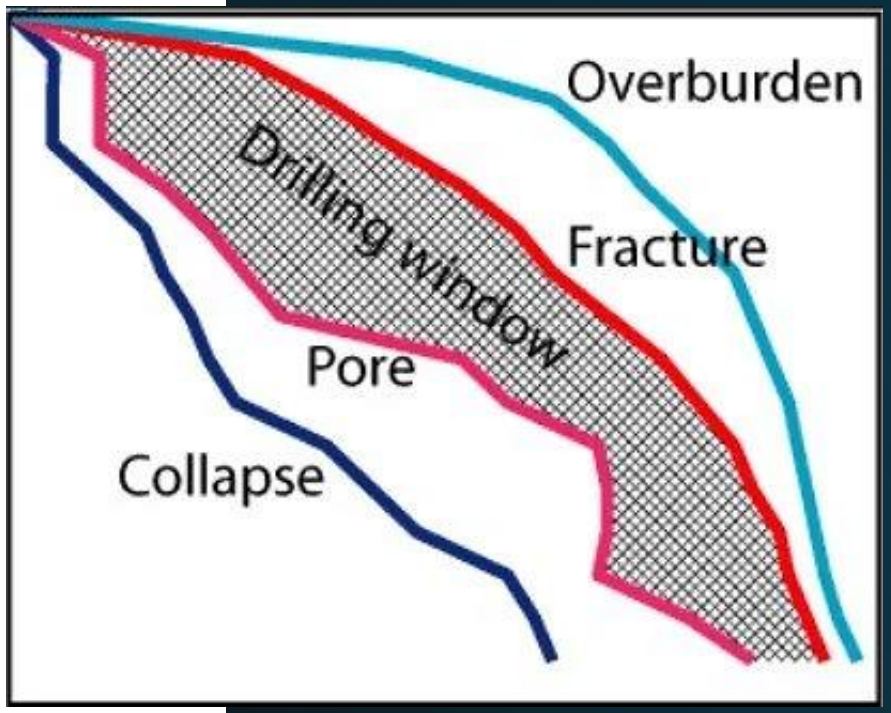
Ballooning

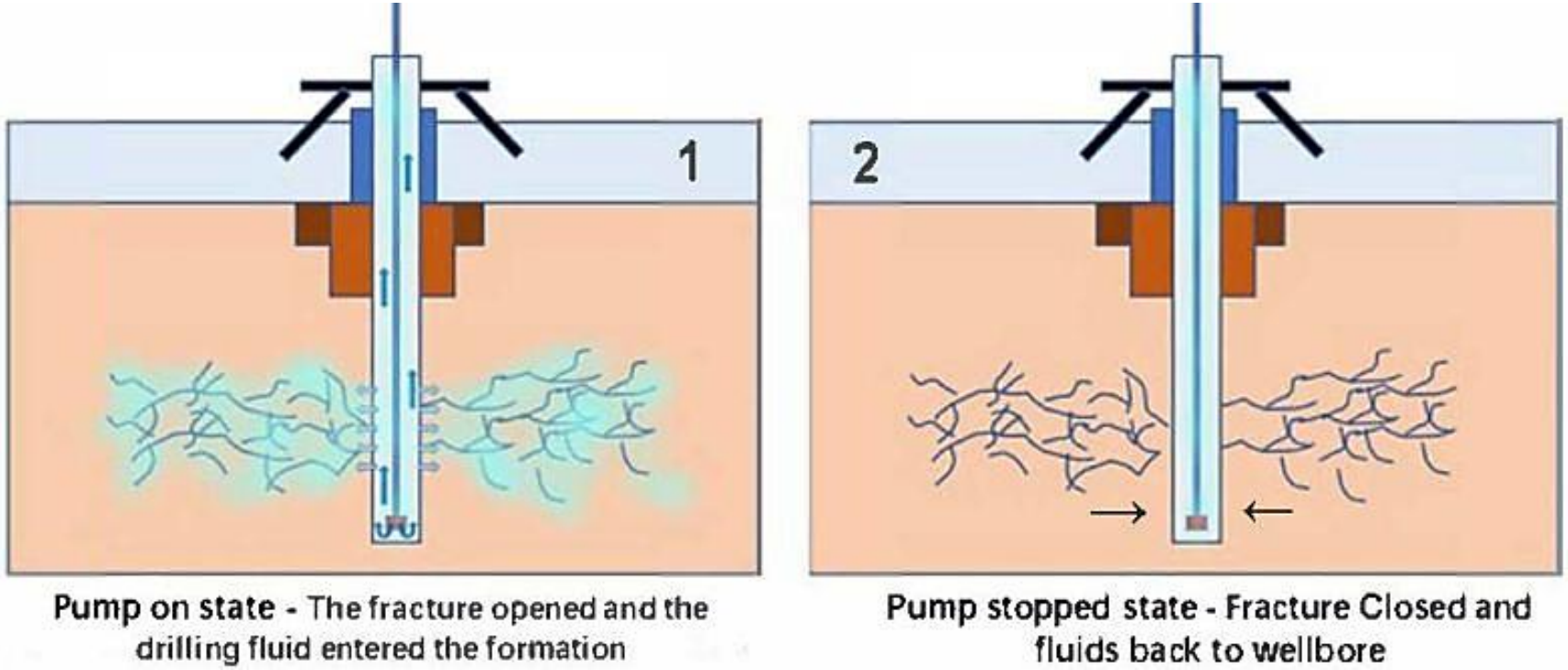
- The well appears to lose drilling fluid during circulation, but the fluid returns to the surface when circulation stops.

- It occurs in naturally fractured formations or deformable shale/clay zones, where:

    - During circulation, ECD (Equivalent Circulating Density) increases → pressure opens tiny fractures → mud "leaks" in.

    - When pumps stop, ECD drops → fractures close back → mud flows back into the wellbore





Pump on state - The fracture opened and the drilling fluid entered the formation

Pump stopped state - Fracture Closed and fluids back to wellbore

How to Detect

- Apparent mud losses while pumping.
- Returns increase when pumps are off.
- No drop in pit volume after extended shutdown.
- Confuses well control decisions as it can be mistaken for a kick or influx

Kick vs Ballooning

Feature	Ballooning (Wellbore Breathing)	Kick (Formation Influx)
Primary Cause	Mud flows into fractures during circulation and returns when pumps stop.	Formation fluids (gas, oil, water) flow into the well due to underbalance.
Timing of Returns	Occurs specifically **after pumps stop** (flowback).	Returns **continue or increase** even after pumps are stopped.
Pit Volume Behavior	Apparent gain during flowback, which then **stabilizes**.	Pit volume **continues to increase** unless the well is shut-in.
Flow Check Results	**No continuous flow** after the initial flowback period.	**Sustained, continuous flow** after shut-in.
Gas Detection	No increase in background gas levels.	**Elevated gas readings** detected at the surface.
Shut-in Pressures	**No buildup** observed in shut-in pressures.	**SIDPP and SICP increase** over time.
Pump Restart Effect	No additional gain; may even show a slight loss.	May show **continued or worsened** influx.
Long-term Behavior	Well returns to normal circulation patterns.	Condition **gets worse** if not shut in properly.

Well Control

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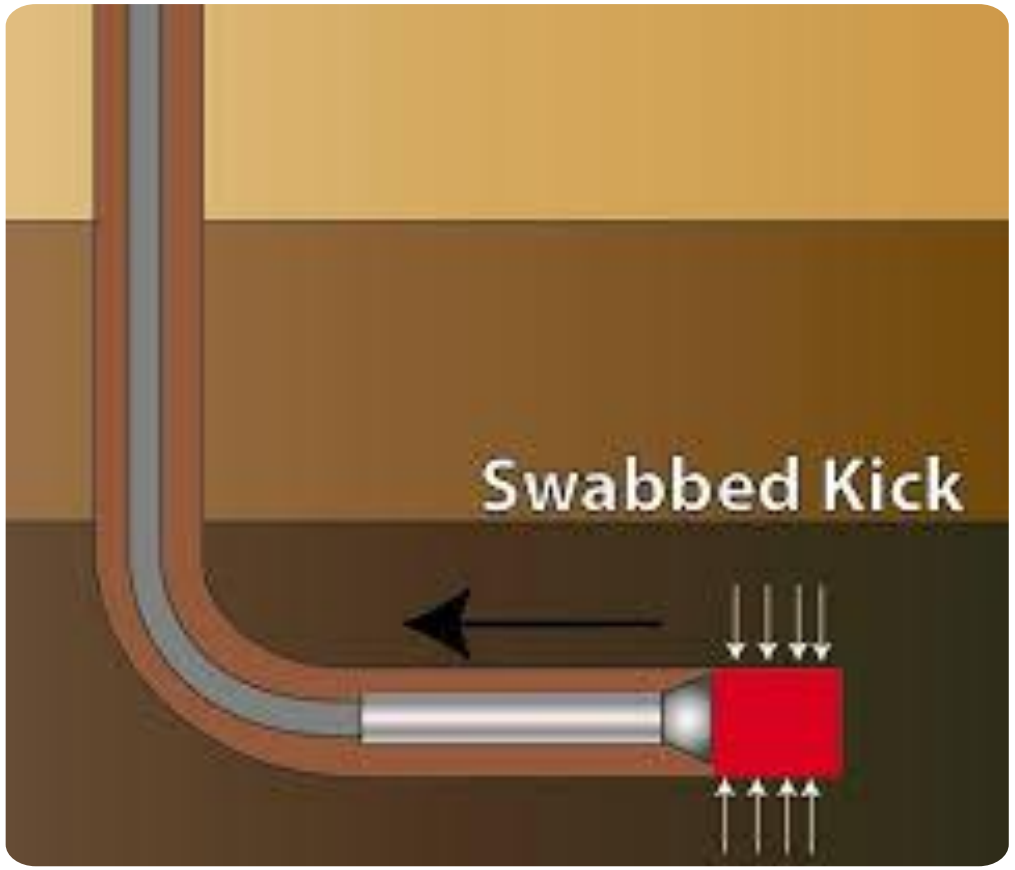
Well Control (Kick)

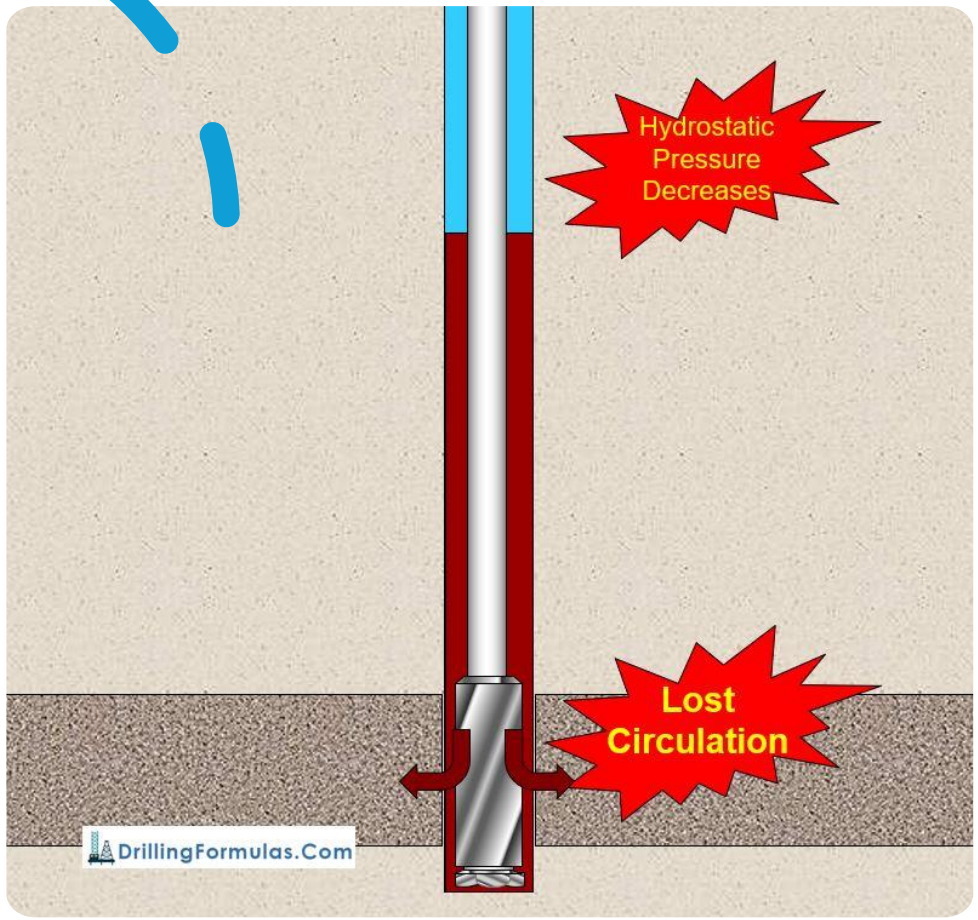


- **Drilling Kick:** Drilling into a formation with an unexpectedly high pore pressure that exceeds the hydrostatic pressure of the drilling fluid.

- **Swabbed Kick**: Accidently swapping on a well while pulling out of hole.

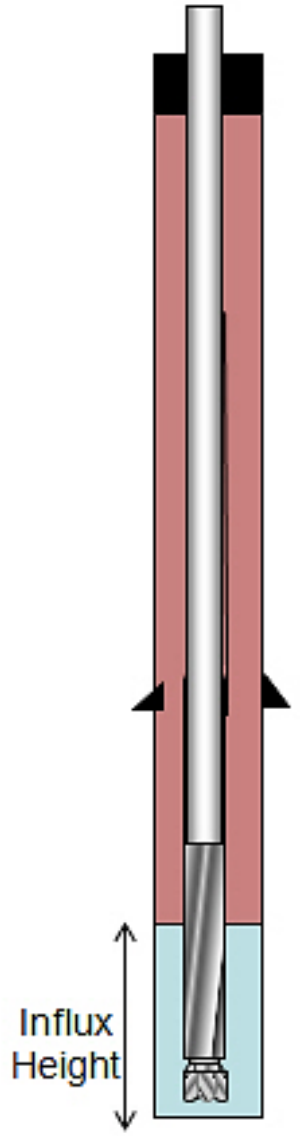
Causes of Kicks

- **Drilling Kick:**
  - Miscalculated mud weight.
  - Decrease in mud weight due to high background gases
  - Losses followed by failure to keep the well full.
  - Abnormal pressure zone.
- **Swabbed Kick**:
  - High POOH speed
  - Small clearance
  - Viscous drilling fluid



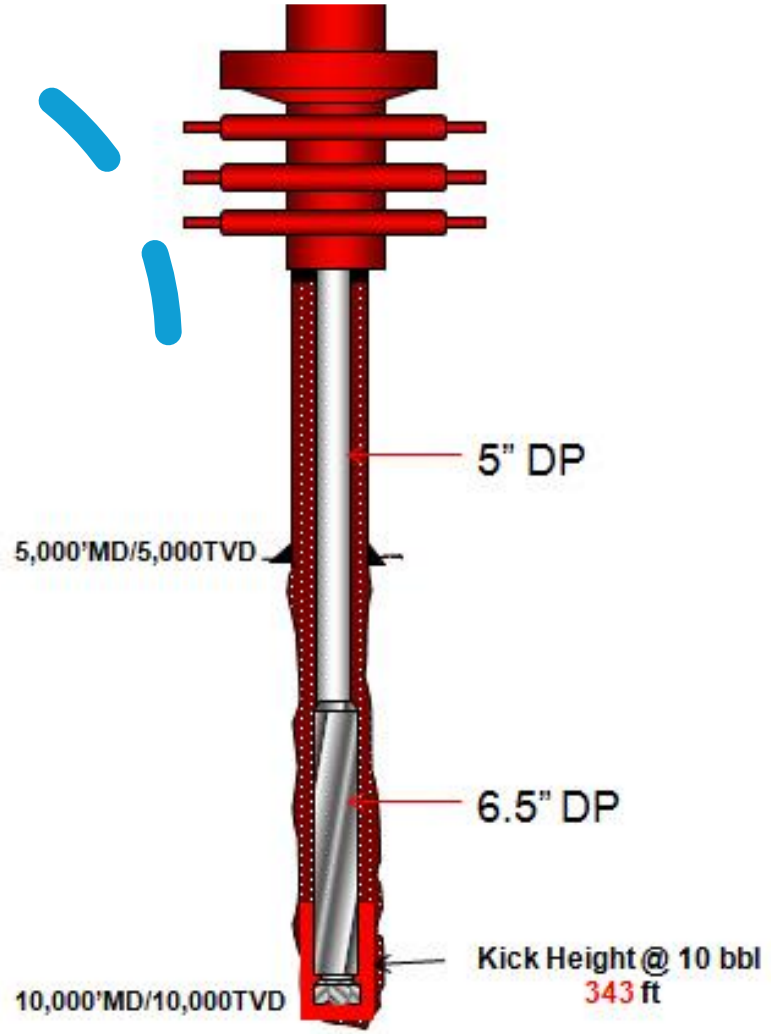
How to Detect

- Kick Warning Signs:
    - Fast drilling break
    - Decrease in pump pressure.
    - Large splintered cuttings on shaker.
    - Hole not taking the correct displacement volume during trips.
    - Increase in Background gases.
    - Presence of connection gases.
- Stop the pumps & flow check



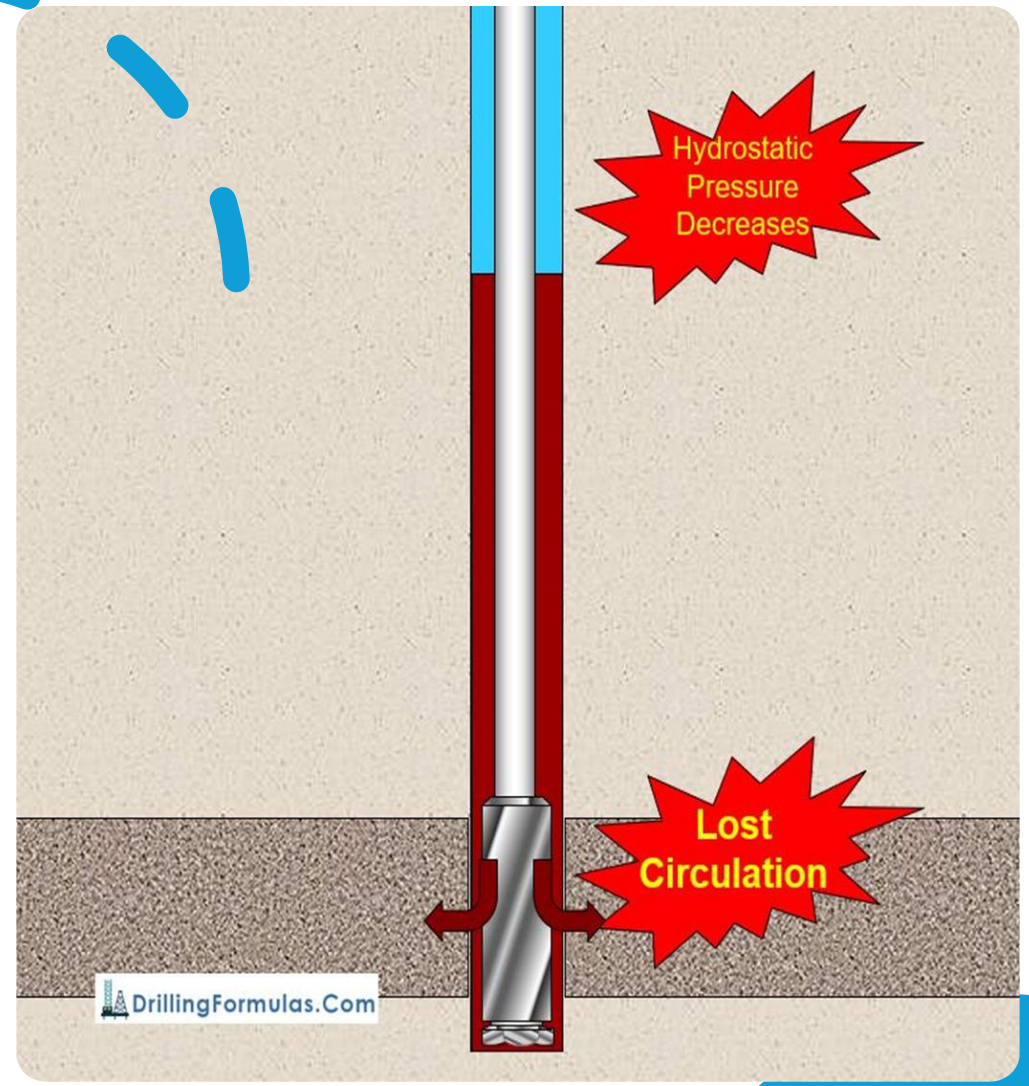
How to Detect

- Kick Warning Indicators:
    - Increase in Pit Volume
    - Increase in Return Flow Rate
    - Flow with Pumps Off
- Immediately shut-in the well.
- Prepare for killing the well.



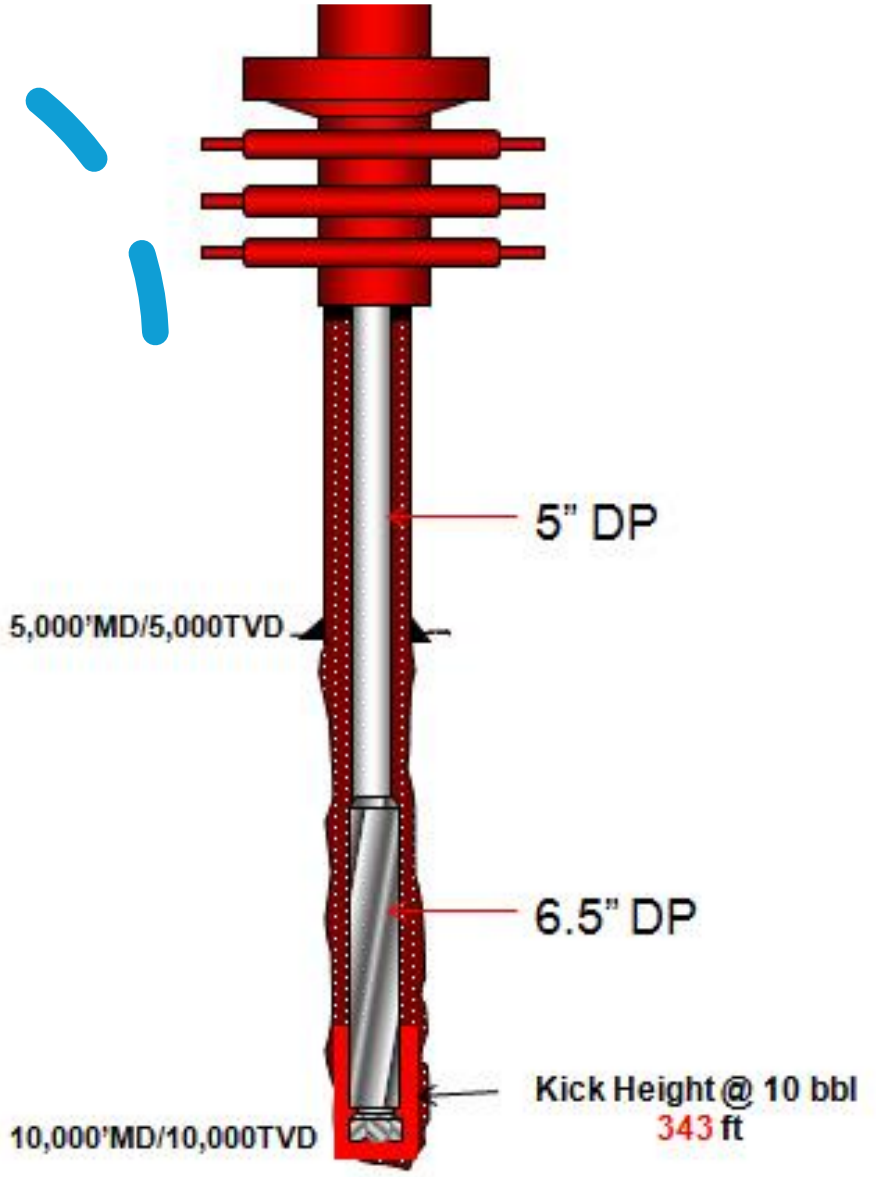
How to Prevent

- Always keep the well full.
- Close monitoring to mud weight.
- Accurate determination of PPFG.
- Use Swab & Surge Model.
- Avoid Problematic geological structures.



How to Troubleshoot

- Driller’s Method: Two Circulations
- Wait & Weight Method: Two Circulations
- Volumetric and lubricate & bleed: No Circulation
- Bullheading: Workover



Thank You

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