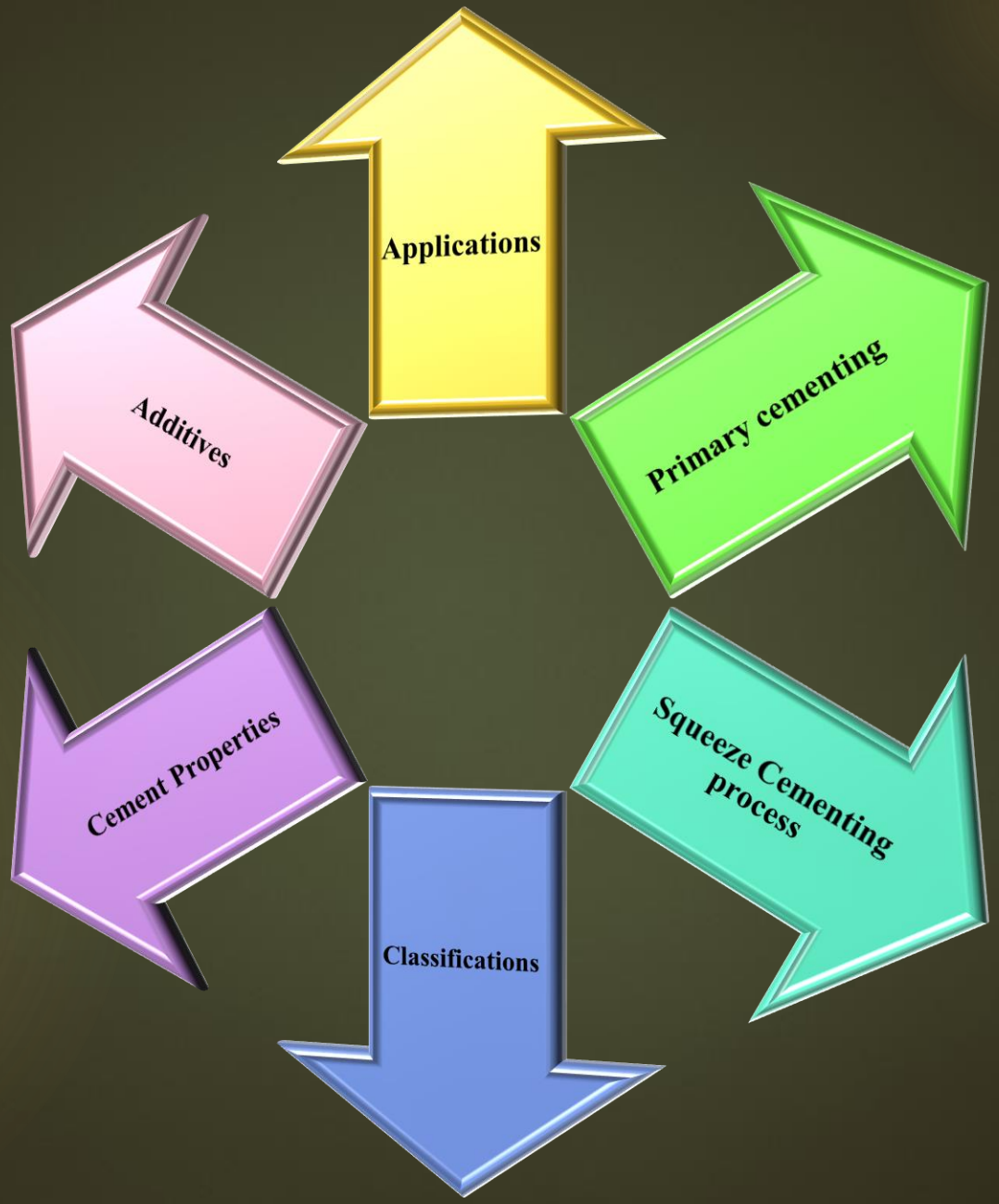
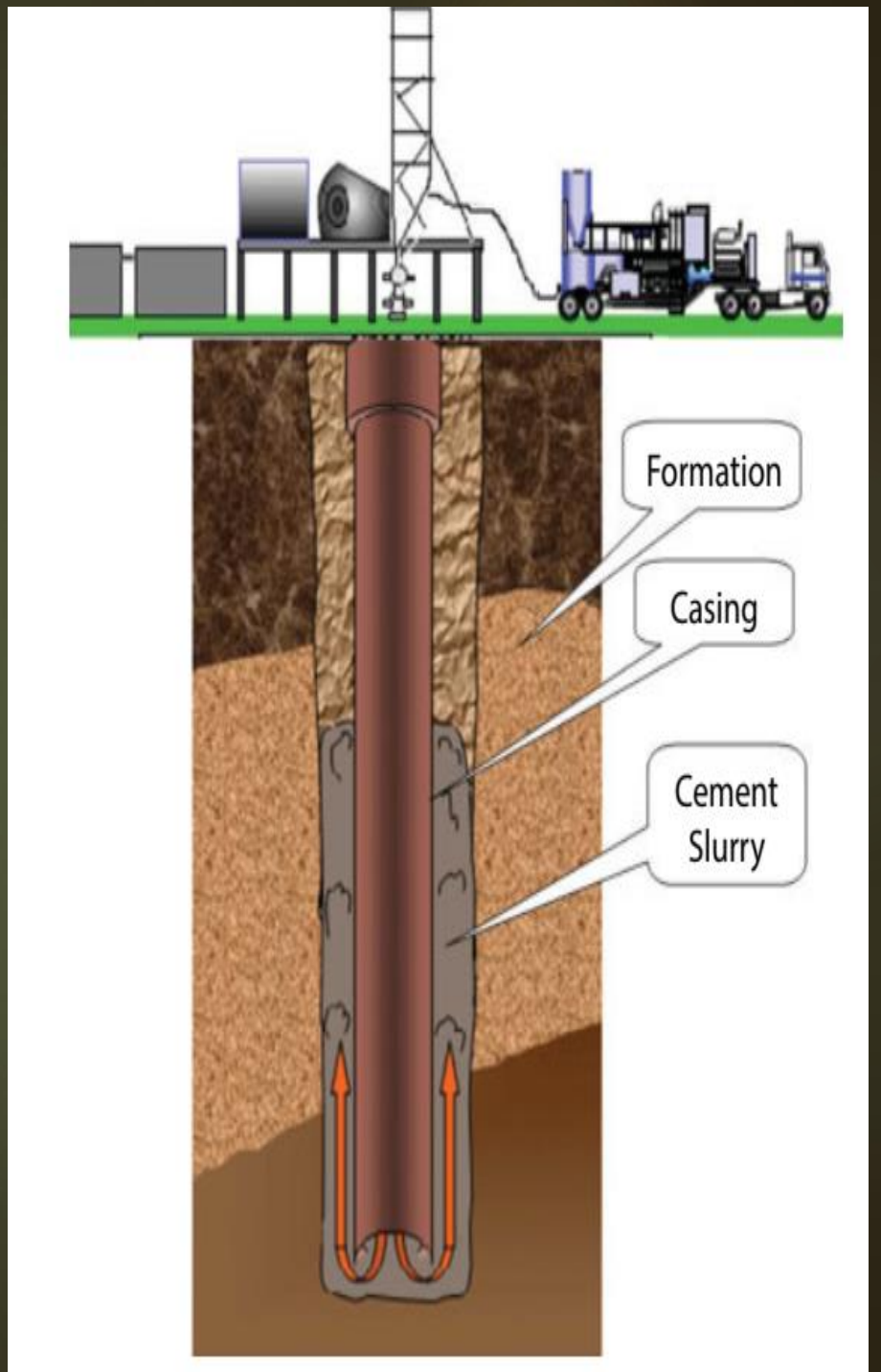
Oil Well Cementing

DR. RAED HAMEED ALLAWI

Outline

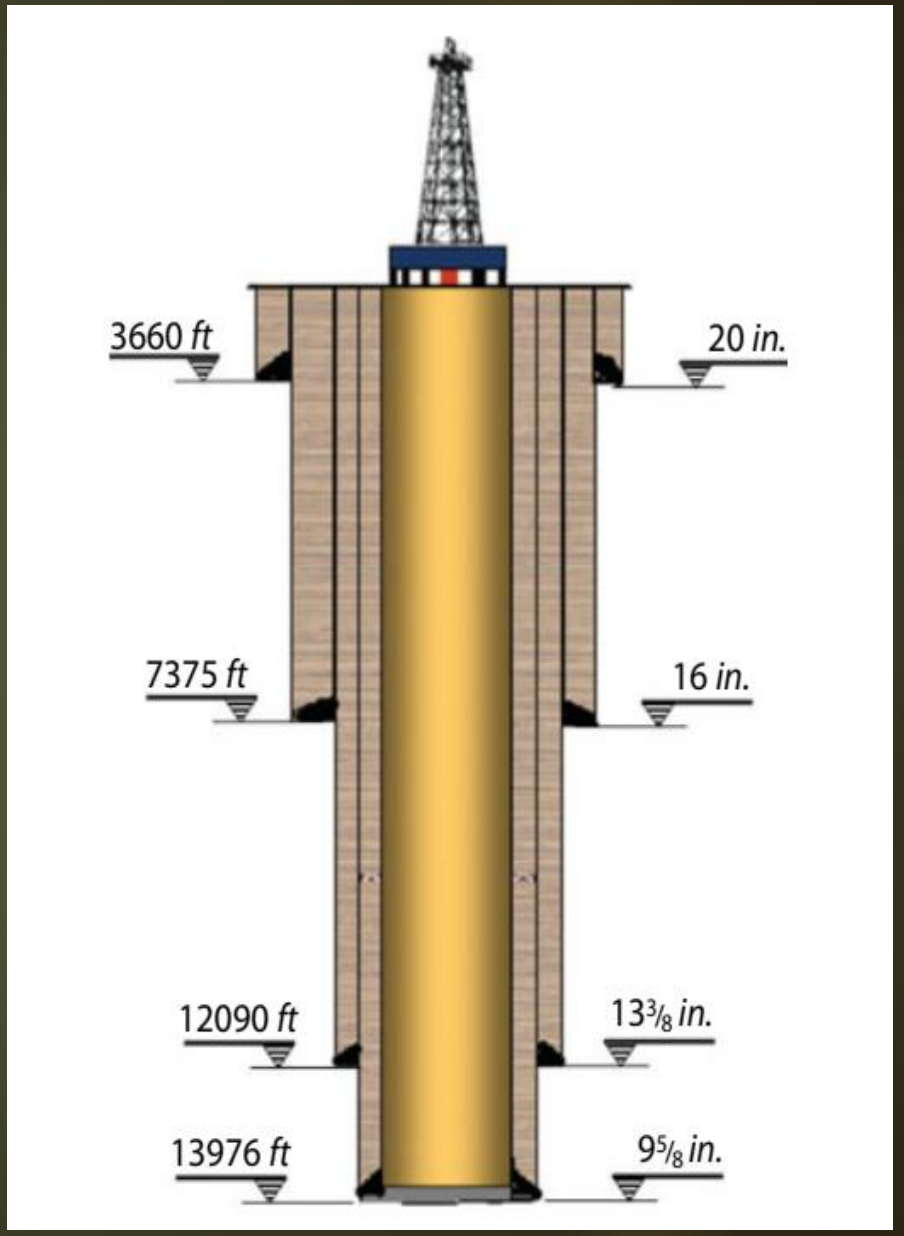

Applications
Primary cementing
Squeeze Cementing process
Classifications
Cement Properties
Additives

The cement slurry flows to the bottom of the wellbore inside the casing, and then flows up in the space between the casing and the wellbore to the surface or the target depth



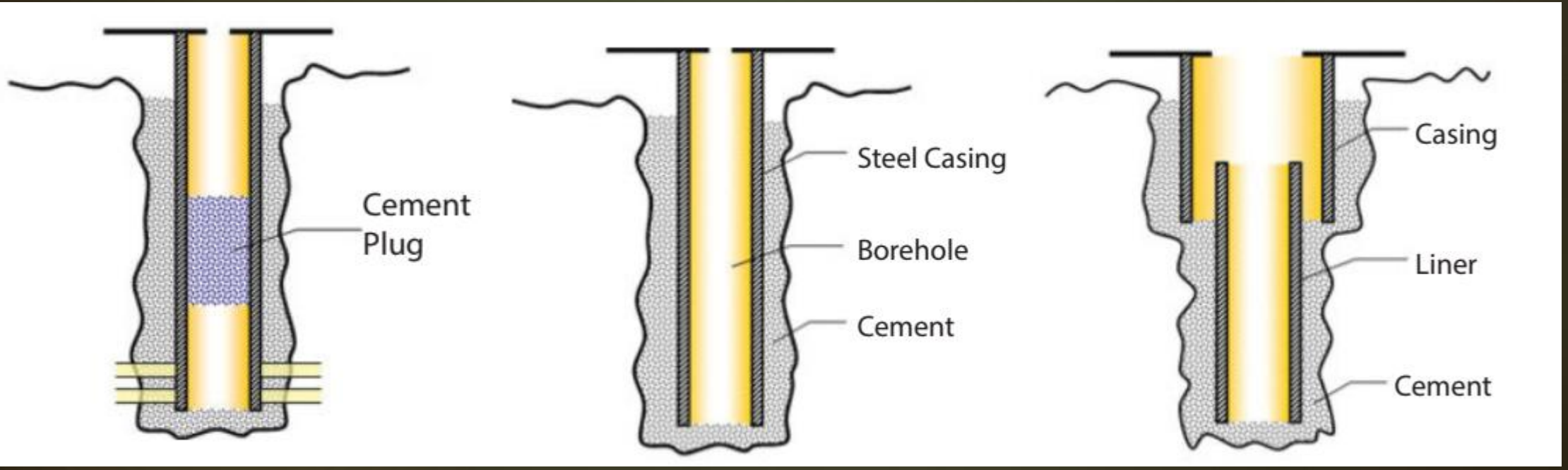
Applications of Oil Well Cements

- To support the walls of the wellbore to prevent formation collapse.
- To provide zonal isolation between formations in order to prevent movement of gas or fluids between different geological formations.
- To protect oil producing zones from salt water flow.
- To protect well casing from collapse under pressure.
- To protecting well casings from corrosion.
- To reduce the risk of groundwater contamination by oil, gas or saltwater.

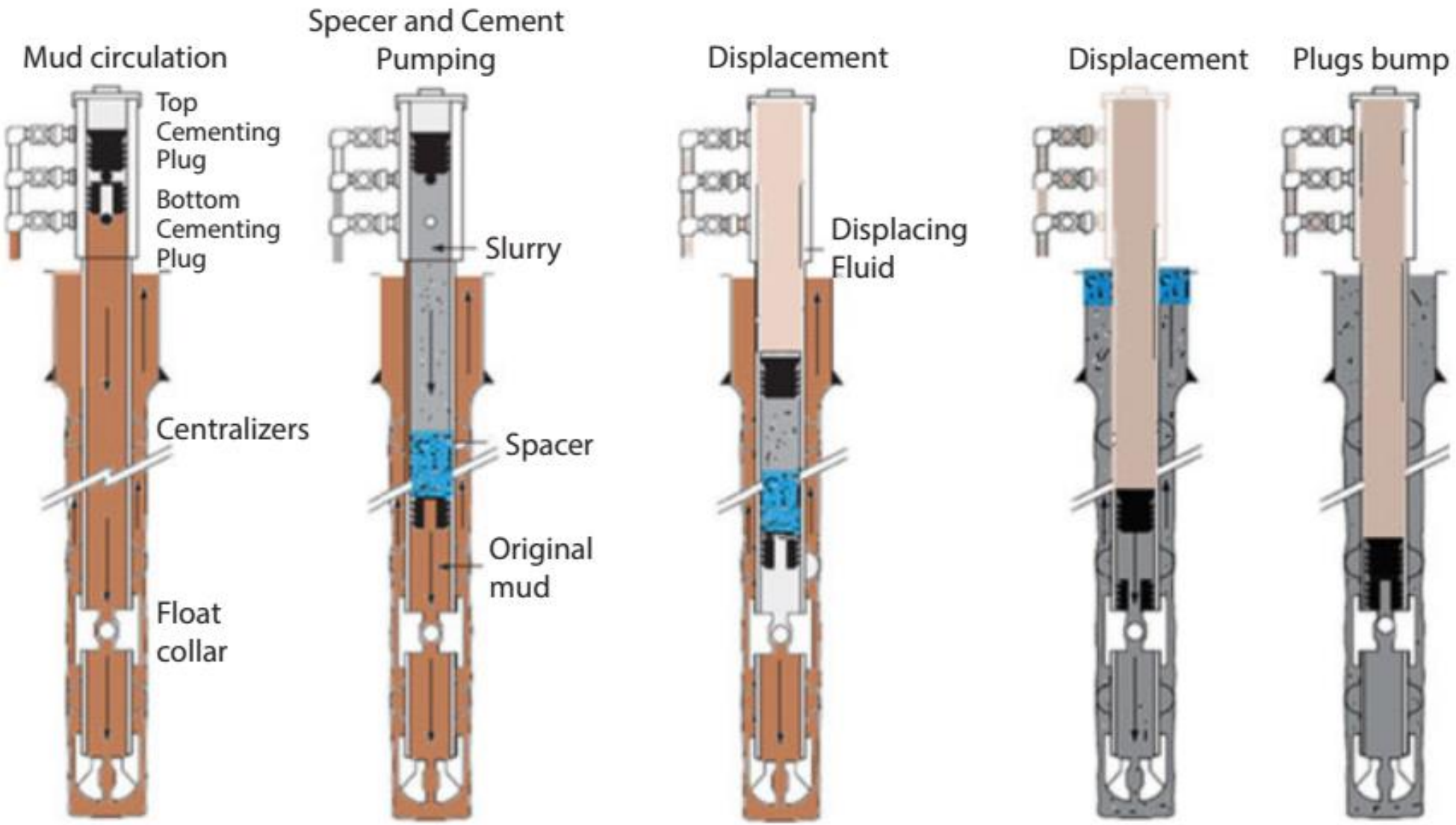


Cement Applications

- **Primary Cementing** : Primary cementing is applied in wells after casing is lowered to the setting depths to provide the various functions stated earlier



Primary cementing process.



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Primary Cementing operation

1. Circulation of Mud for well conditioning
2. Releasing bottom wiper plug
3. Pumping of spacer
4. Pumping of cement slurry
5. Releasing top wiper plug
6. Displacing with displacement fluid (generally mud) until the top plug lands on the float collar
7. Pressure testing of the casing

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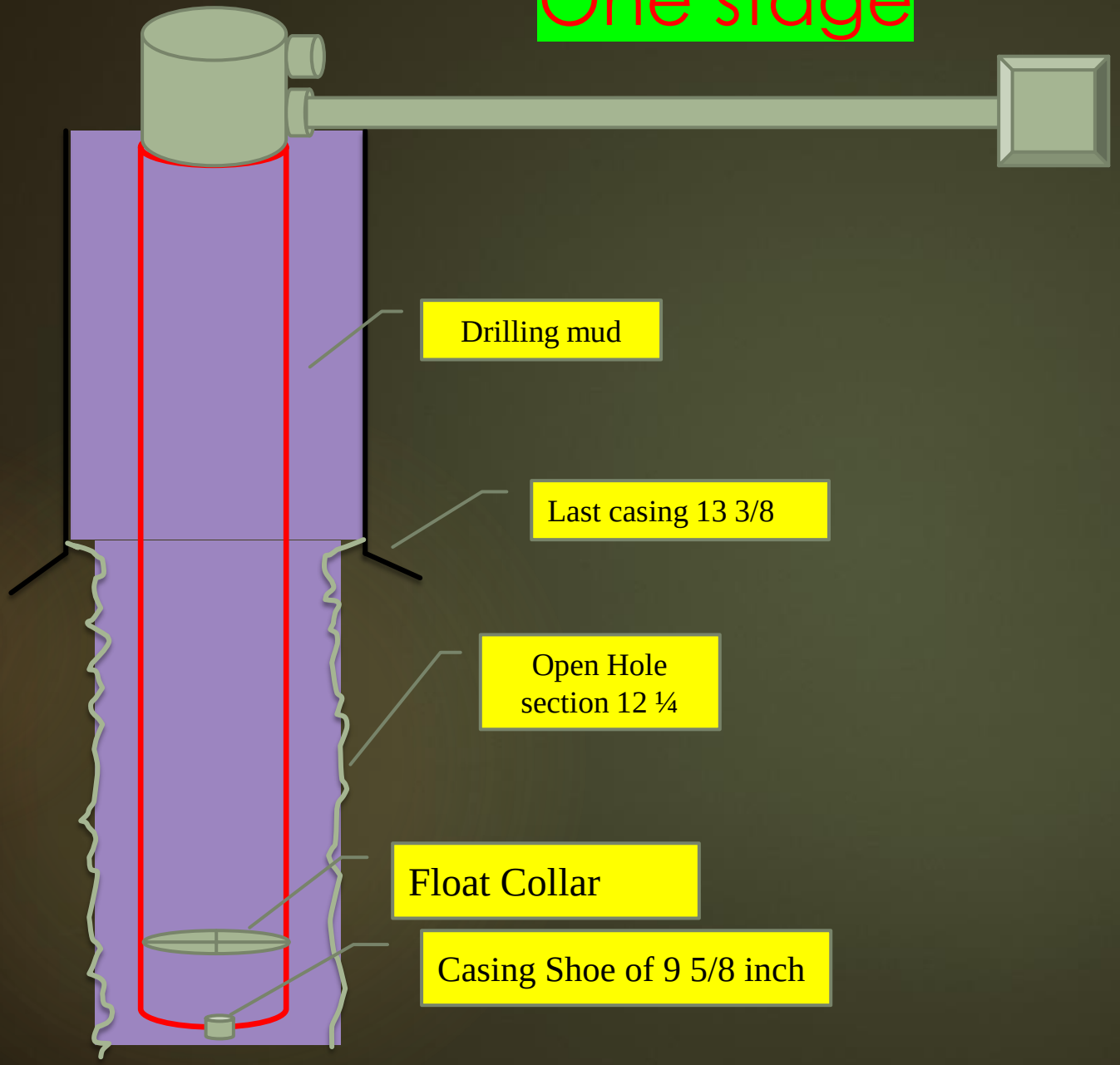
One stage



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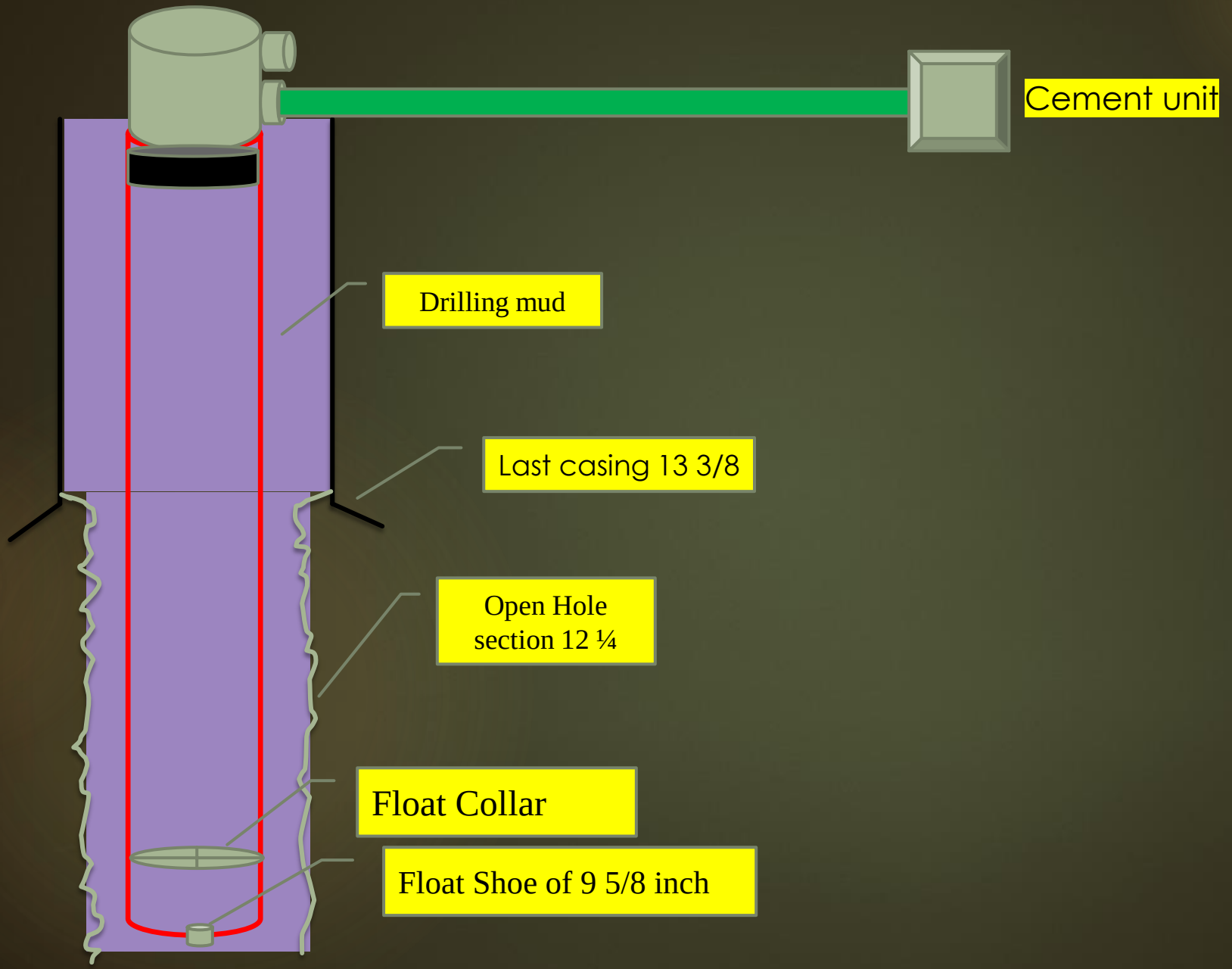

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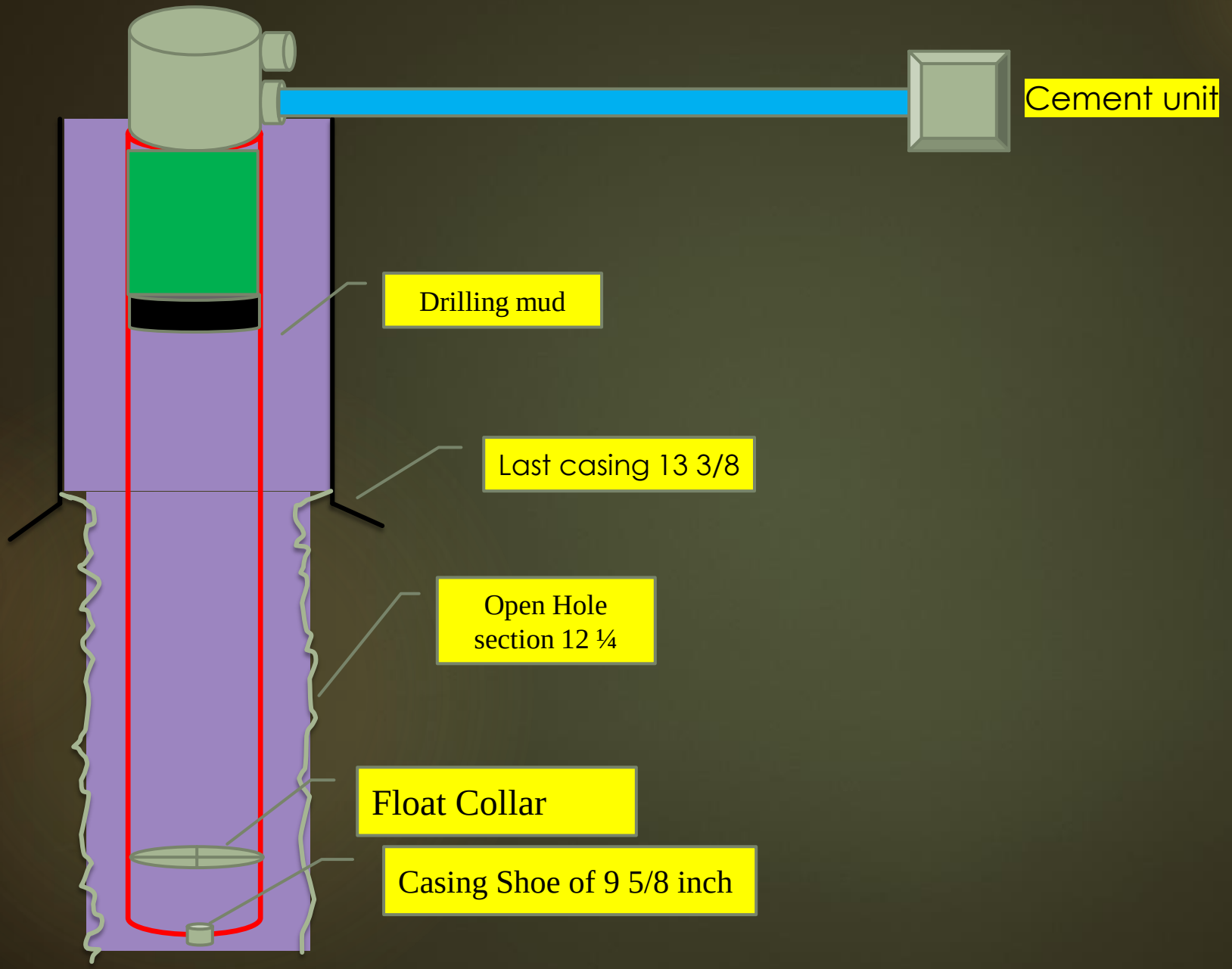

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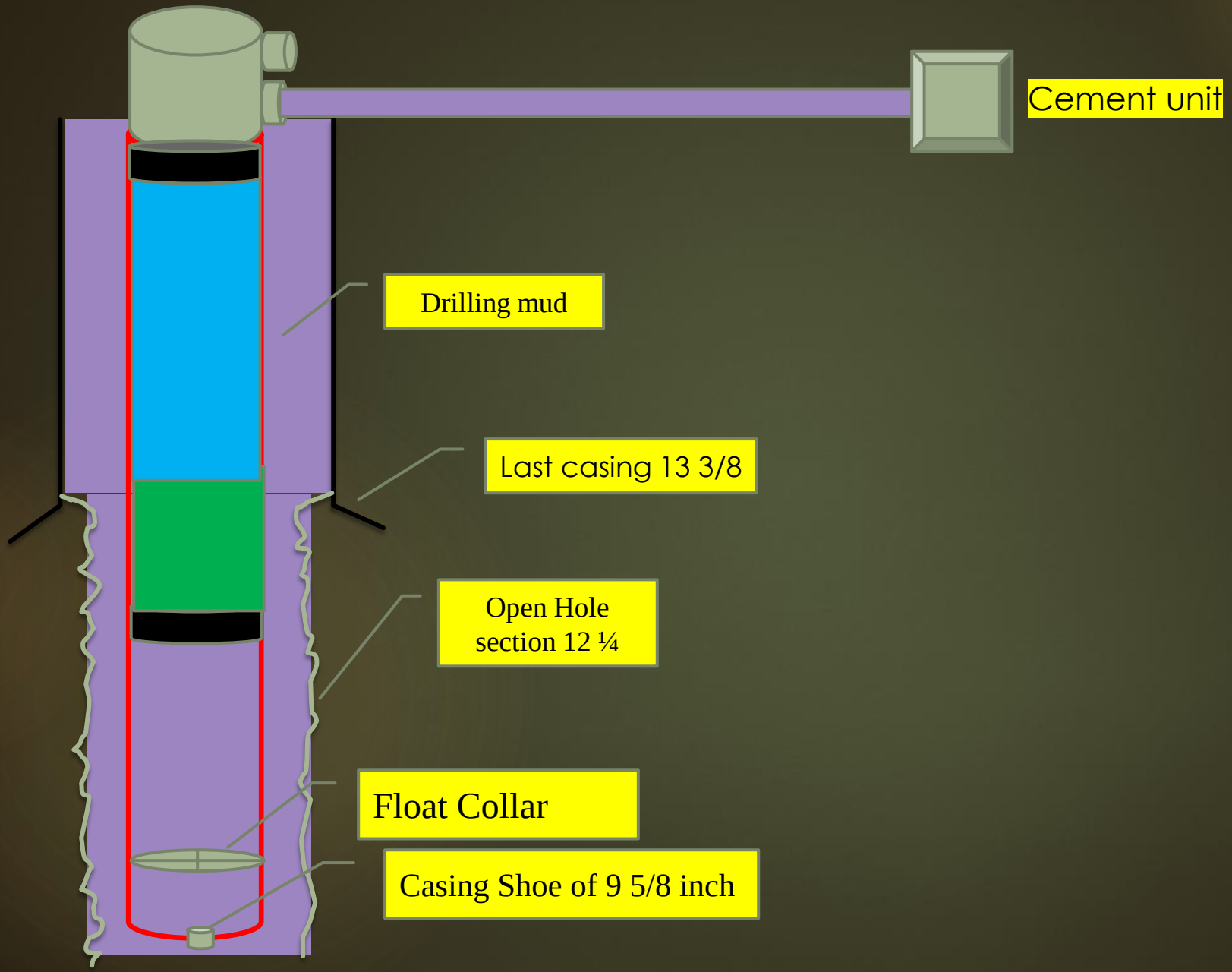

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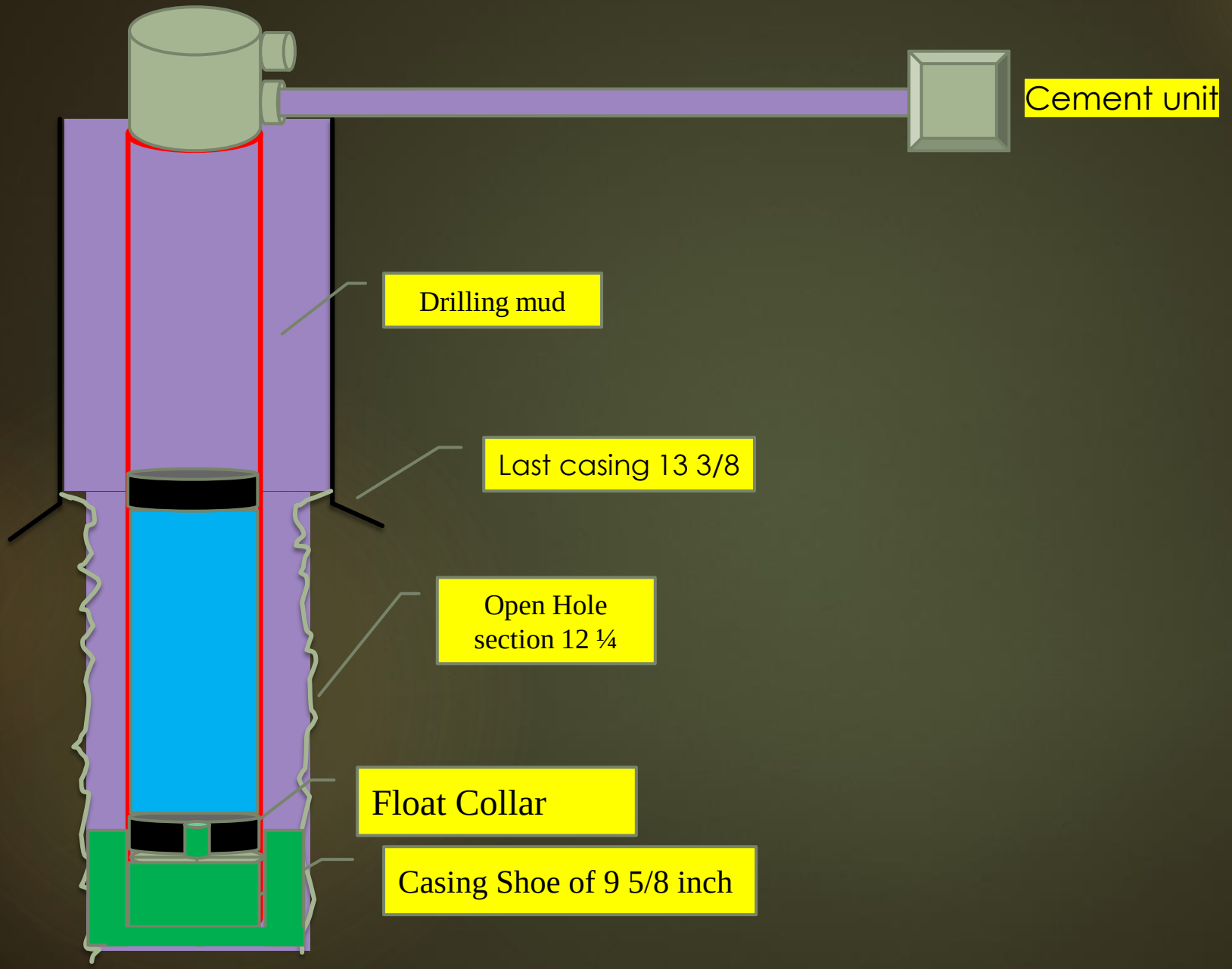

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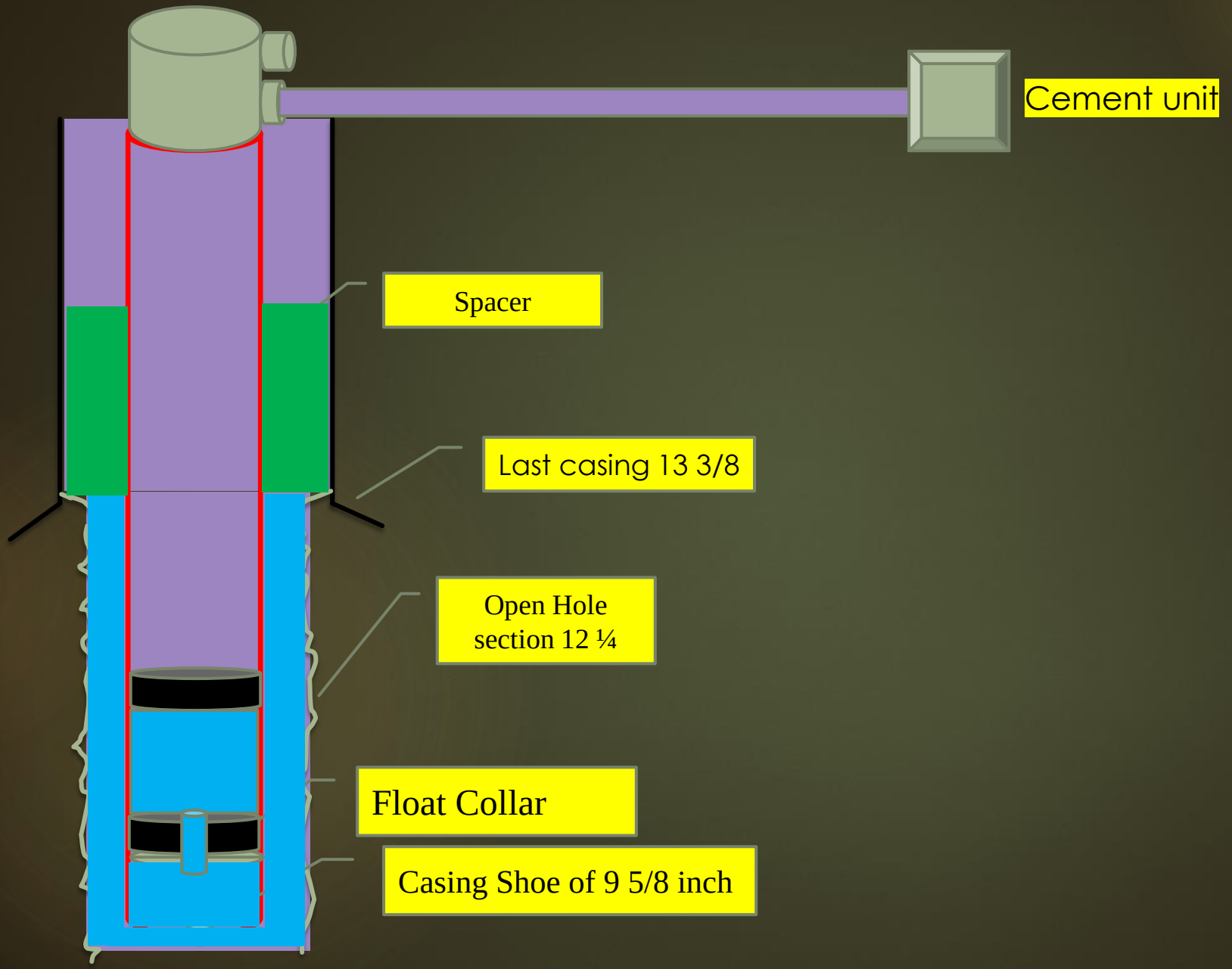

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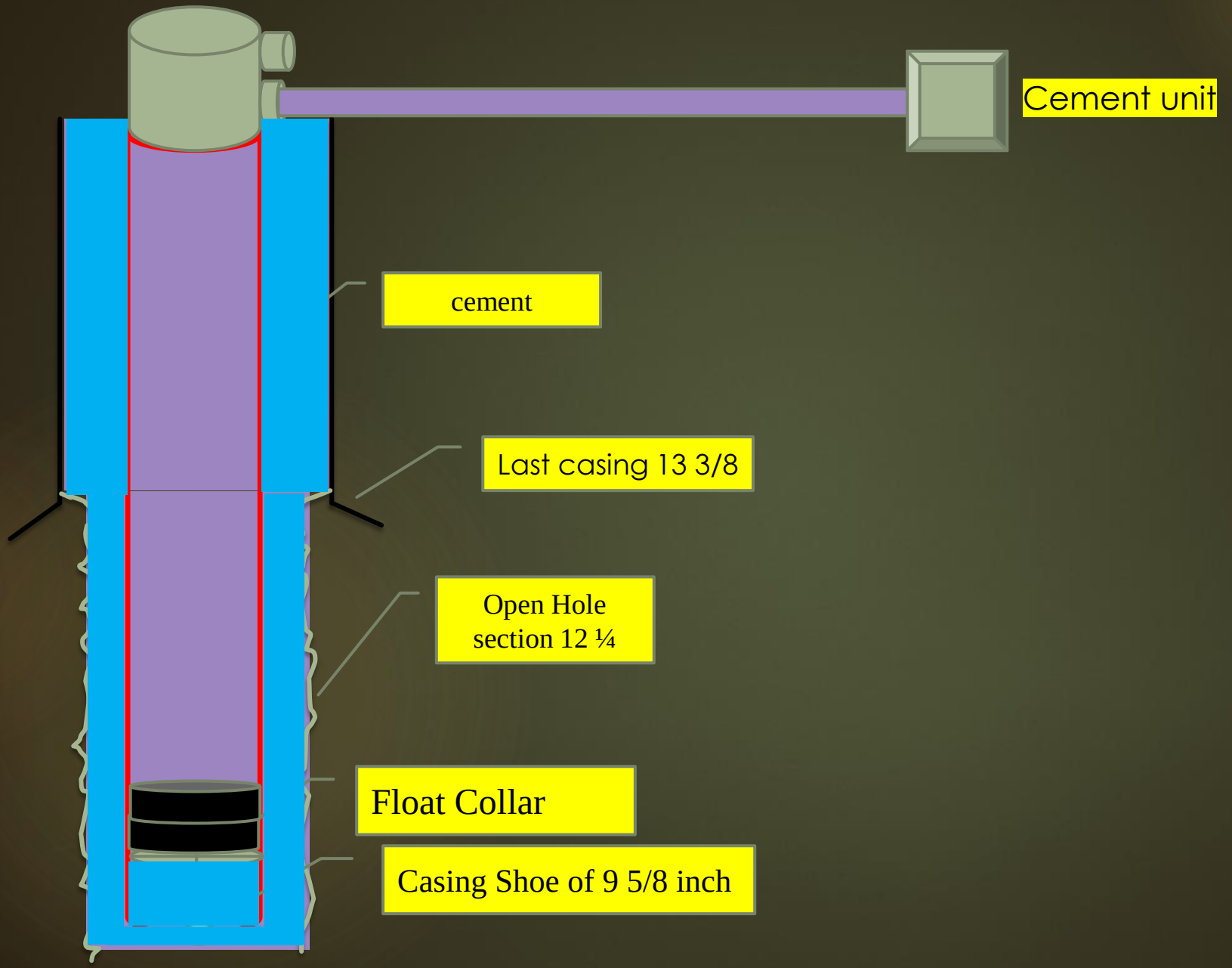

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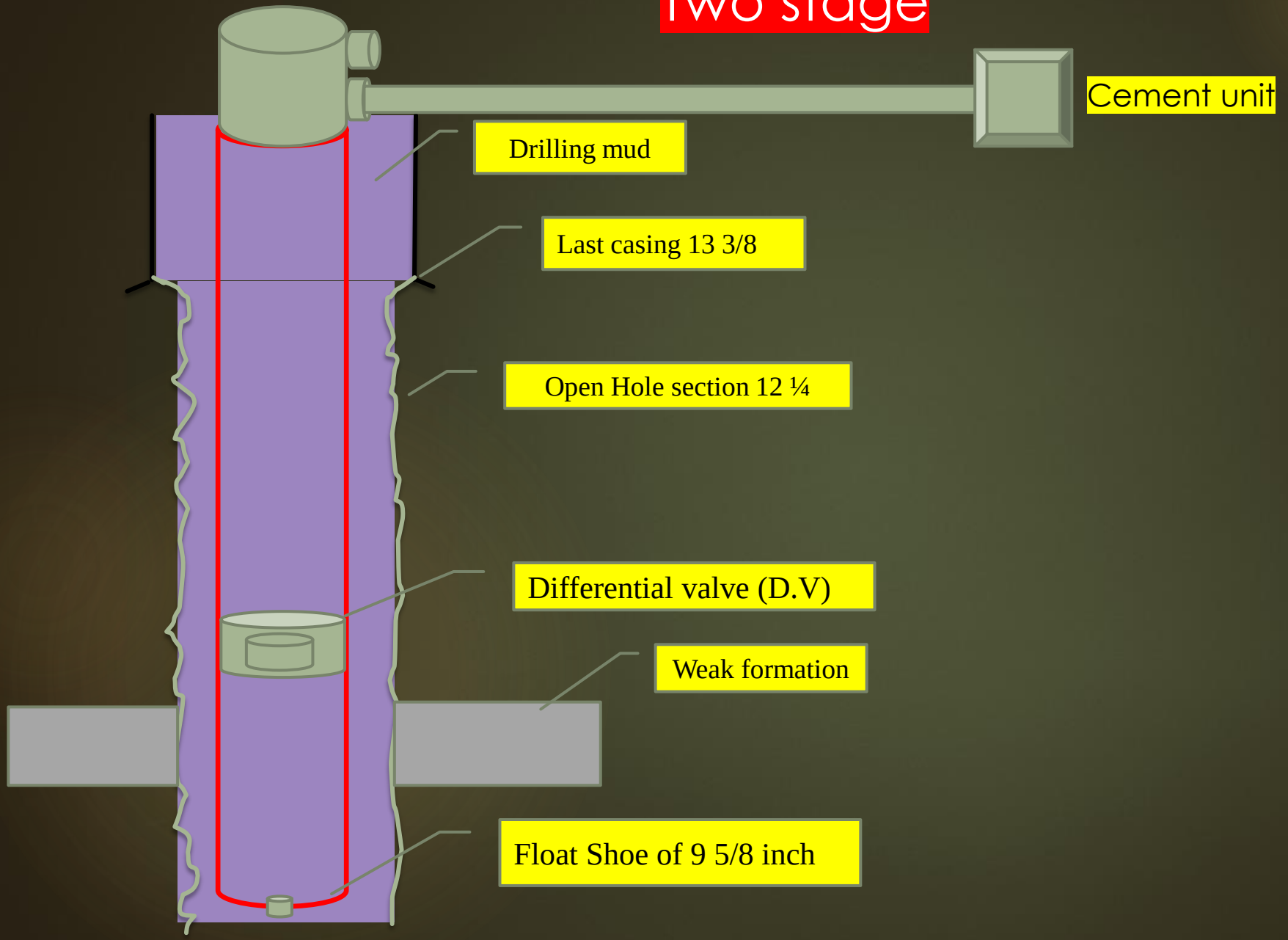
Two stage



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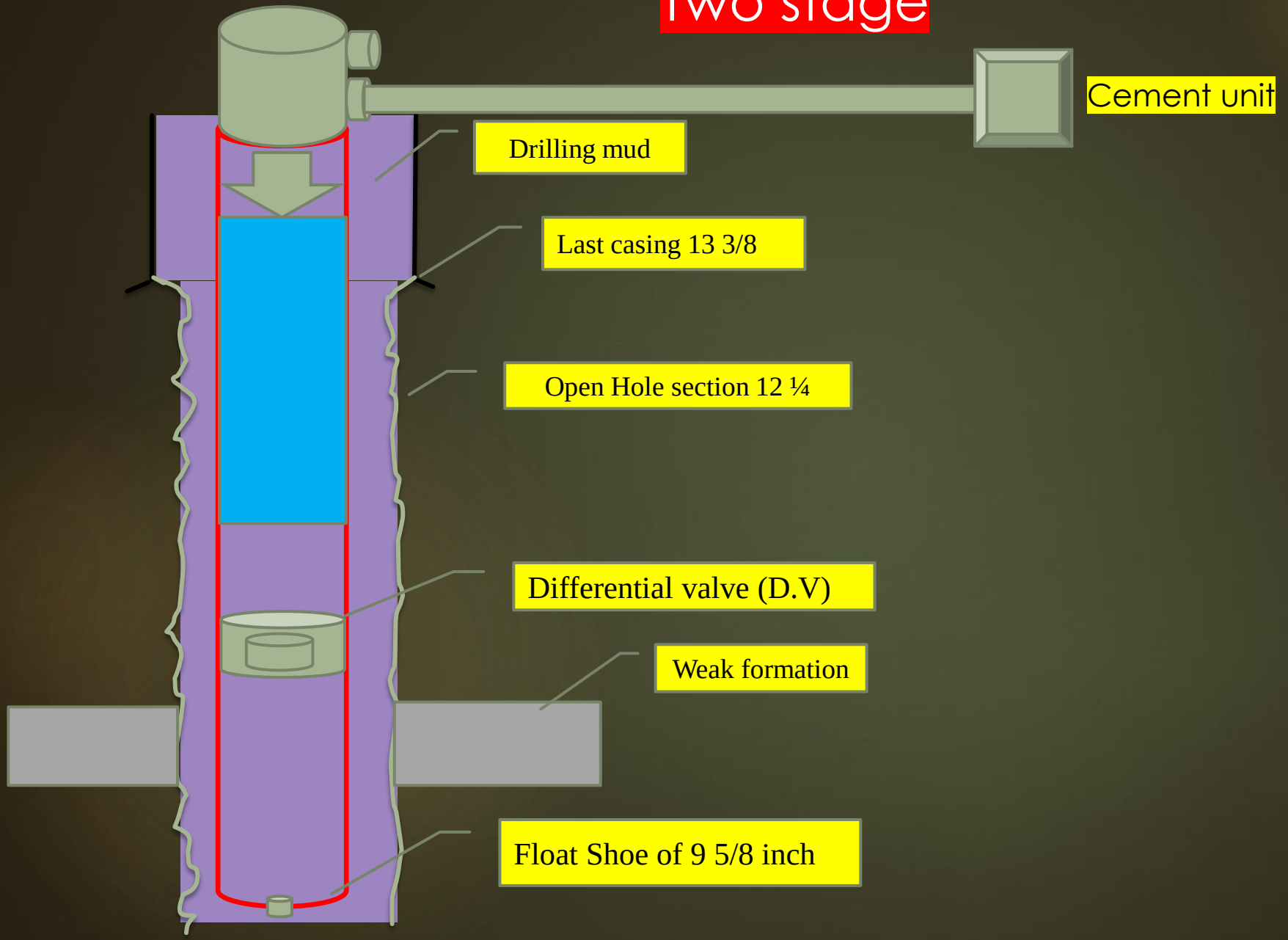

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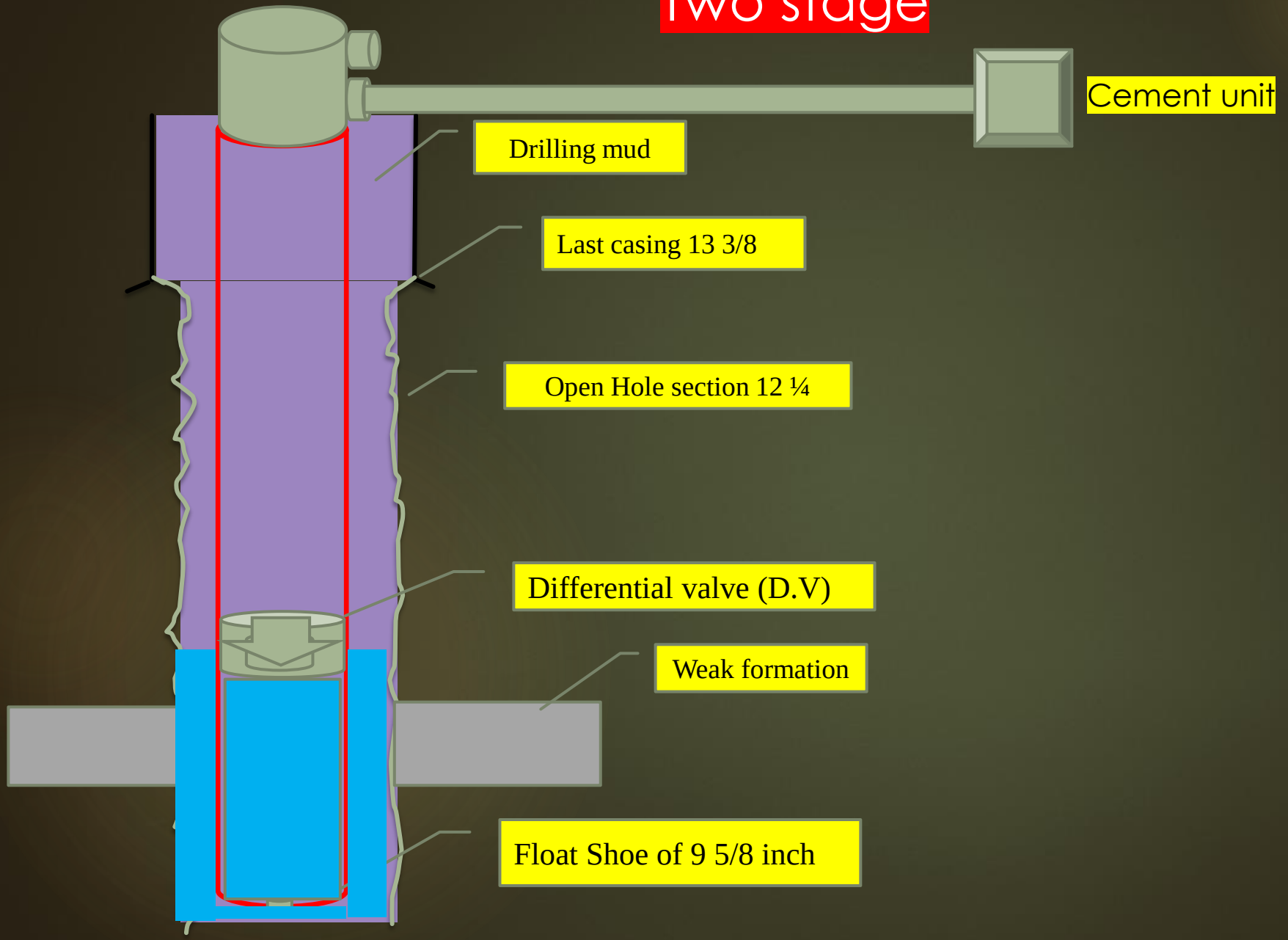

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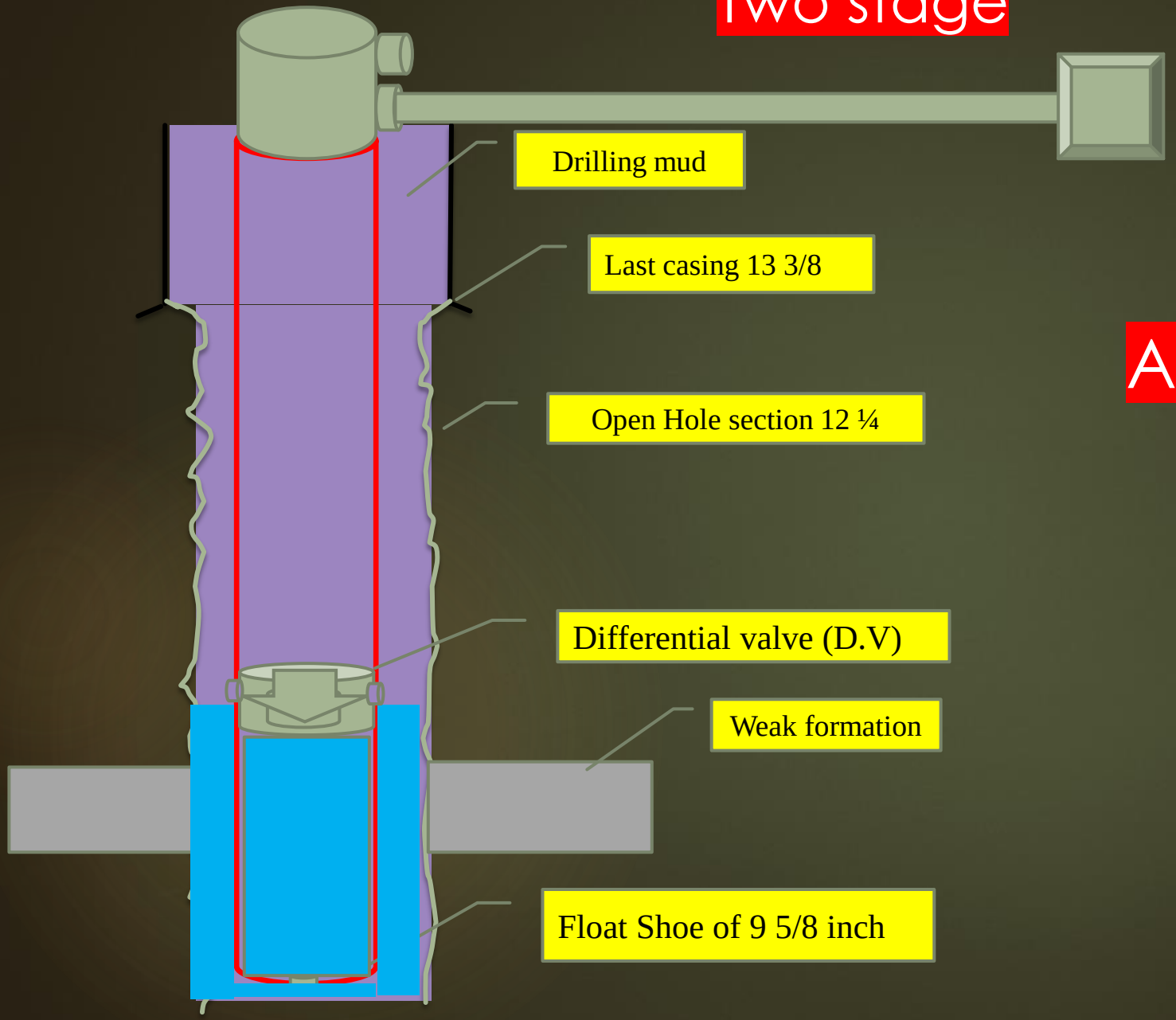

After 24 hours

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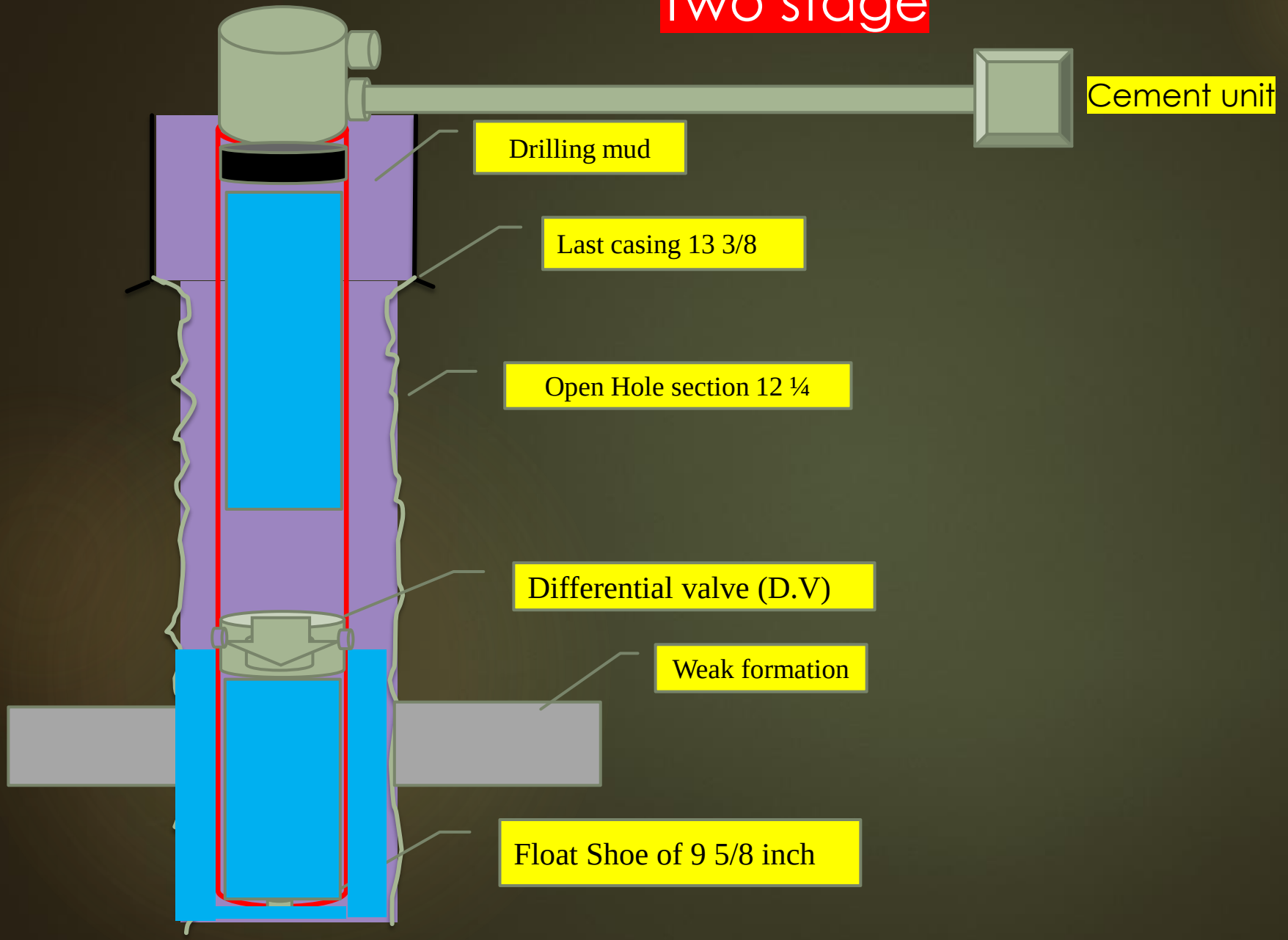
Two stage



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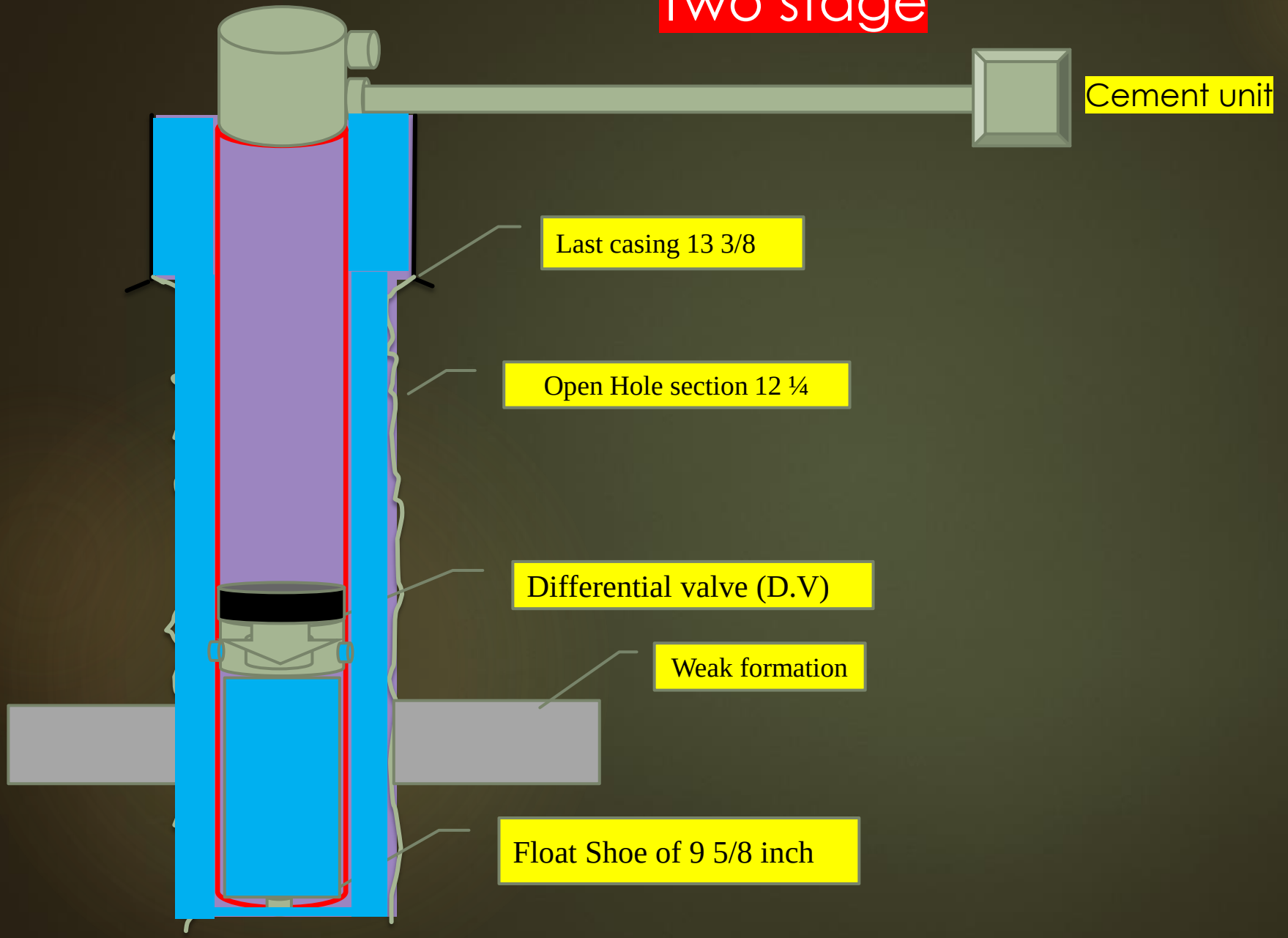

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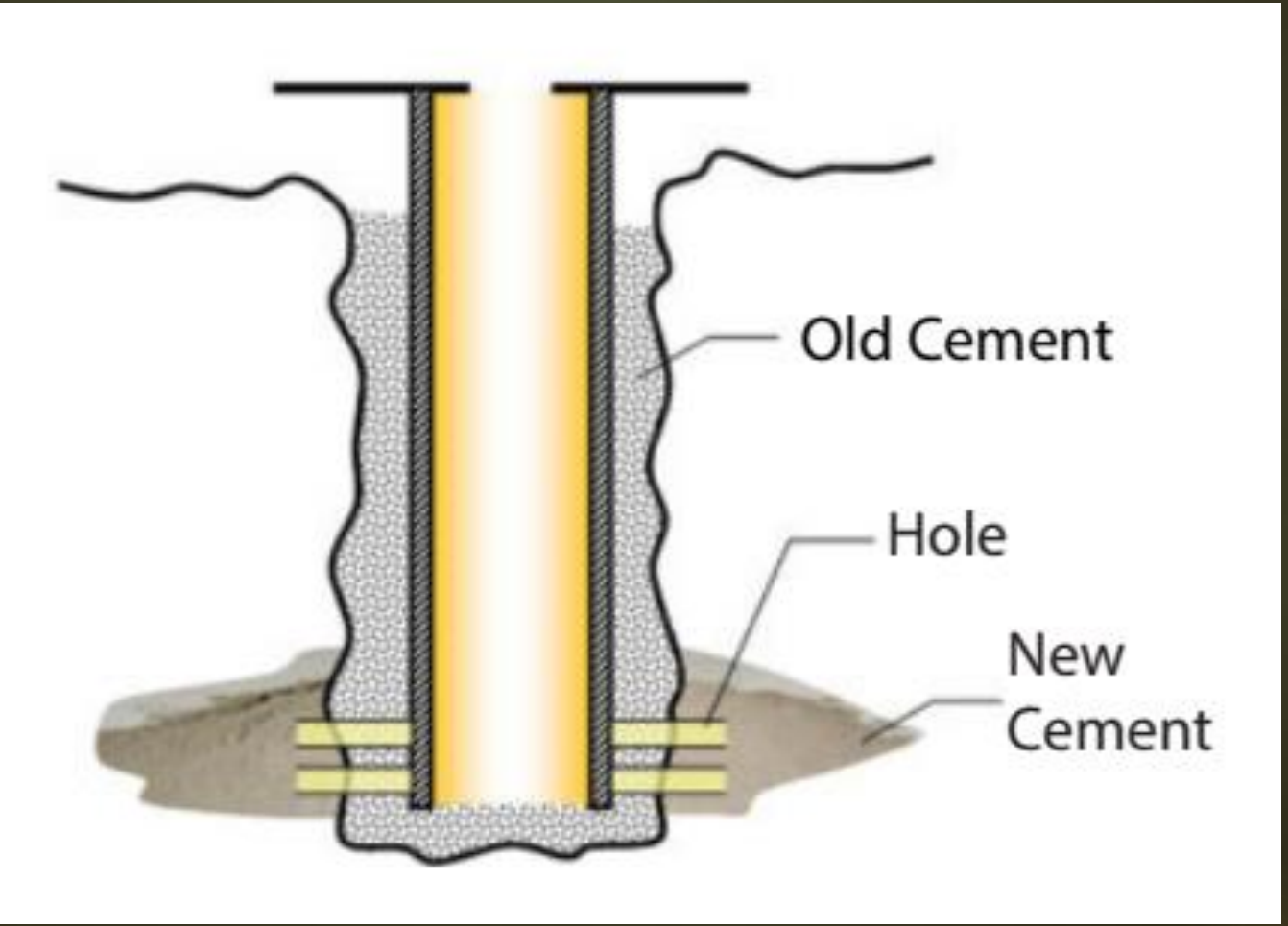
Squeeze Cementing: Squeeze cementing is the process of **injecting cement** into a confined zone behind the casing such as casing leaks and flow channels in formations



The applications of squeeze cementing include:

- Casing leaks: can develop due to corrosion caused by water or hydrogen sulfide gas or other kinds of fluids.
- Weak cementing zone behind casing: sometimes void spaces or channels exist in the annulus between casing and wellbore due to improper primary cement placement.
- Water shut off: cement slurry are also forced into lower casing perforations to seal off or at least control water production into a producing well.

- Gas shut off: in a high gas oil ratio well, sealing the upper casing perforation can reduce the volume of gas production into a producing well.

- Selective zonal isolation: depleted reservoirs, water aquifer, or abnormal pressure zones can be isolated by squeeze cementing.

Classifications of Oil Well Cements

Cement Class	A	B	C	D	E	F	G	H
w/c, % mass fraction of cement	46	46	56	38	38	38	44	38
Range of depth, m	0 to 1830	0 to 1830	0 to 1830	1830 to 3050	3050 to 4270	3051 to 4880	0 to 2440	0 to 2440
Availability	O* grade compatible with ASTM C 150, Type I Portland Cement	MSR** and HSR*** grades, Comparable with ASTM C 150, Type II	O*, MSR** and HSR*** grades, Comparable with ASTM C 150, Type III	MSR** and HSR*** grades	MSR** and HSR*** grades	MSR** and HSR*** grades	MSR** and HSR*** grades	MSR** and HSR*** grades
	Cost	Lower Cost	Lower Cost	More costly than ordinary portland cement	More costly than ordinary portland cement	More costly than ordinary portland cement	—	—

Cement Properties

- ✓ Density
- ✓ Fluid Loss
- ✓ Thickening Time
- ✓ Viscosity and Yield Point
- ✓ Permeability
- ✓ Compressive Strength
- ✓ Soundness
- ✓ Fineness

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Density

- If cement density is high, the pressure generated by the cement column will be high and might be higher than the fracture pressure of weak formations and if so it could result in fracturing the formations or cause lost circulation.

- On the other hand if the cement density is low, the pressure in the over pressured formations could be higher than the cement column pressure and lead to influx from the formation to the latter into blowout

$$P_{slurry}\left(\frac{lbs}{gal}\right)=\frac{lb_{cement}+lb_{water}+lb_{additives}}{gal_{cement}+gal_{water}+gal_{additives}}$$

Fluid Loss

- It occurs when the water in the cement slurry leaves it and invades the permeable formation due to the pressure differential between them

- When large volumes of liquid are lost it will degrade the cement properties leading to a poor cement sheath

Thickening Time

- Thickening time is the time duration in which cement slurry remains pumpable

- The thickening time of cement slurry is a function of several parameters which includes downhole pressure and temperature

$$T_m = \frac{\text{Volume of dry cement}}{\text{Mixing rate}}$$

$$T_d = \frac{\text{Amount of fluid required to displace plug}}{\text{Displacement rate}}$$

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Viscosity and Yield Point

Pumping high viscosity cement through the casing and the annulus at high rate generates high frictional loss that can result in formation fractures.

$$\mu_p = \theta_{600} - \theta_{300}$$

$$\tau_y = \theta_{300} - \mu_p$$

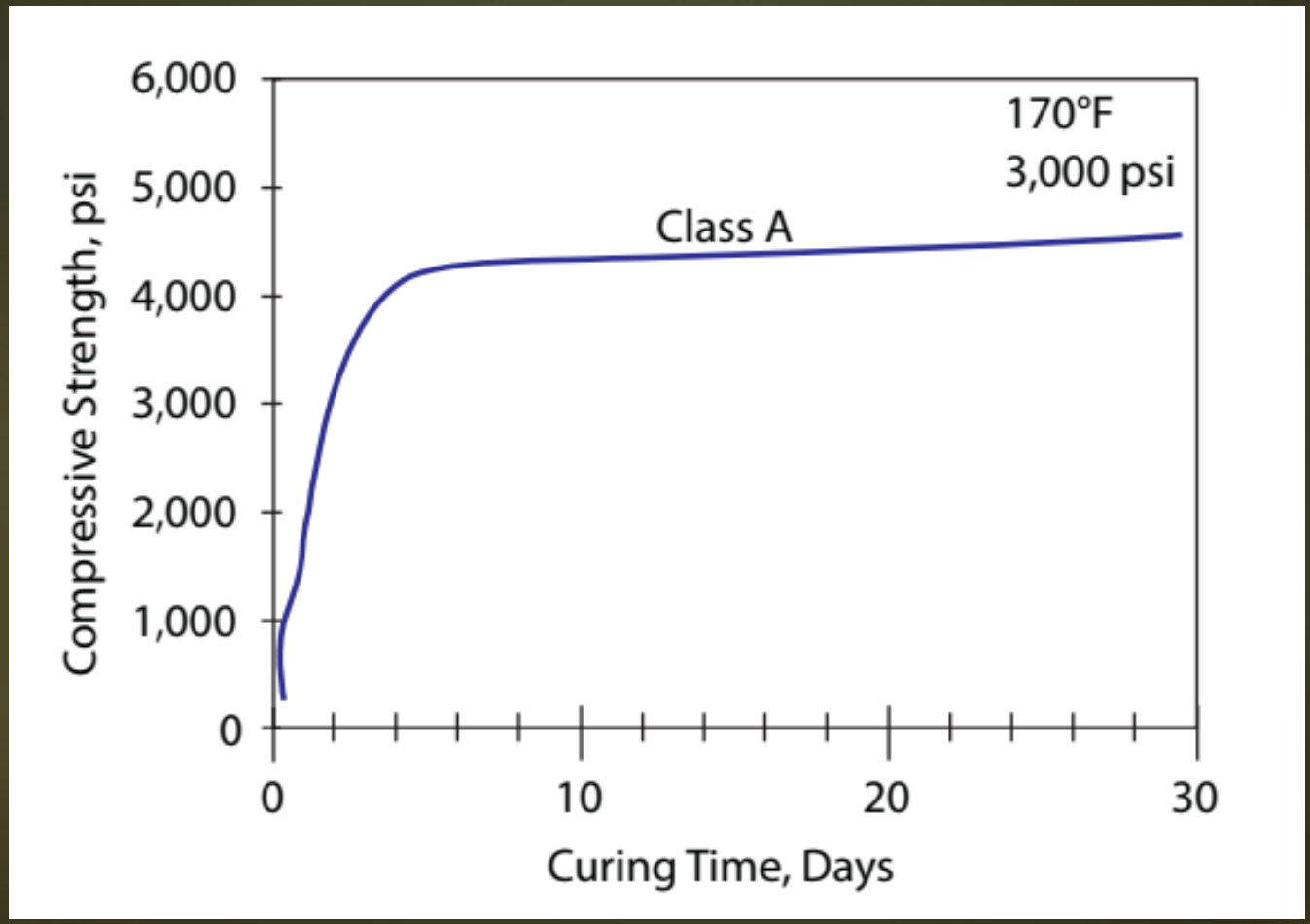
Permeability

- Main goal is a good seal (no permeability)

- where:
  Q = Flow rate, lit/s
  k = Permeability, md
  A = Cross Sectional Area, cm2
  OP = Outlet Pressure, atm
  IP = Inlet Pressure, atm
  μ = Viscosity, cp
  L = Length, cm

$$k = (2000 \times OP \times Q \times \mu \times L) / (A \times (IP_2 - OP_2))$$

Compressive Strength



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Two processes by which cement can be squeezed

- **High pressure squeeze -** This technique requires the formation to be fractured and then allows the cement slurry to be pumped into the fractured zone.

- **Low pressure squeeze** – During this technique the fracture gradient of the formation is not exceeded. Cement slurry is placed against the formation, and when pressure is applied the fluid content (filtrate) of the cement is squeezed into the rock, while the solid cement material (filter cake) builds up on the face of the formation.

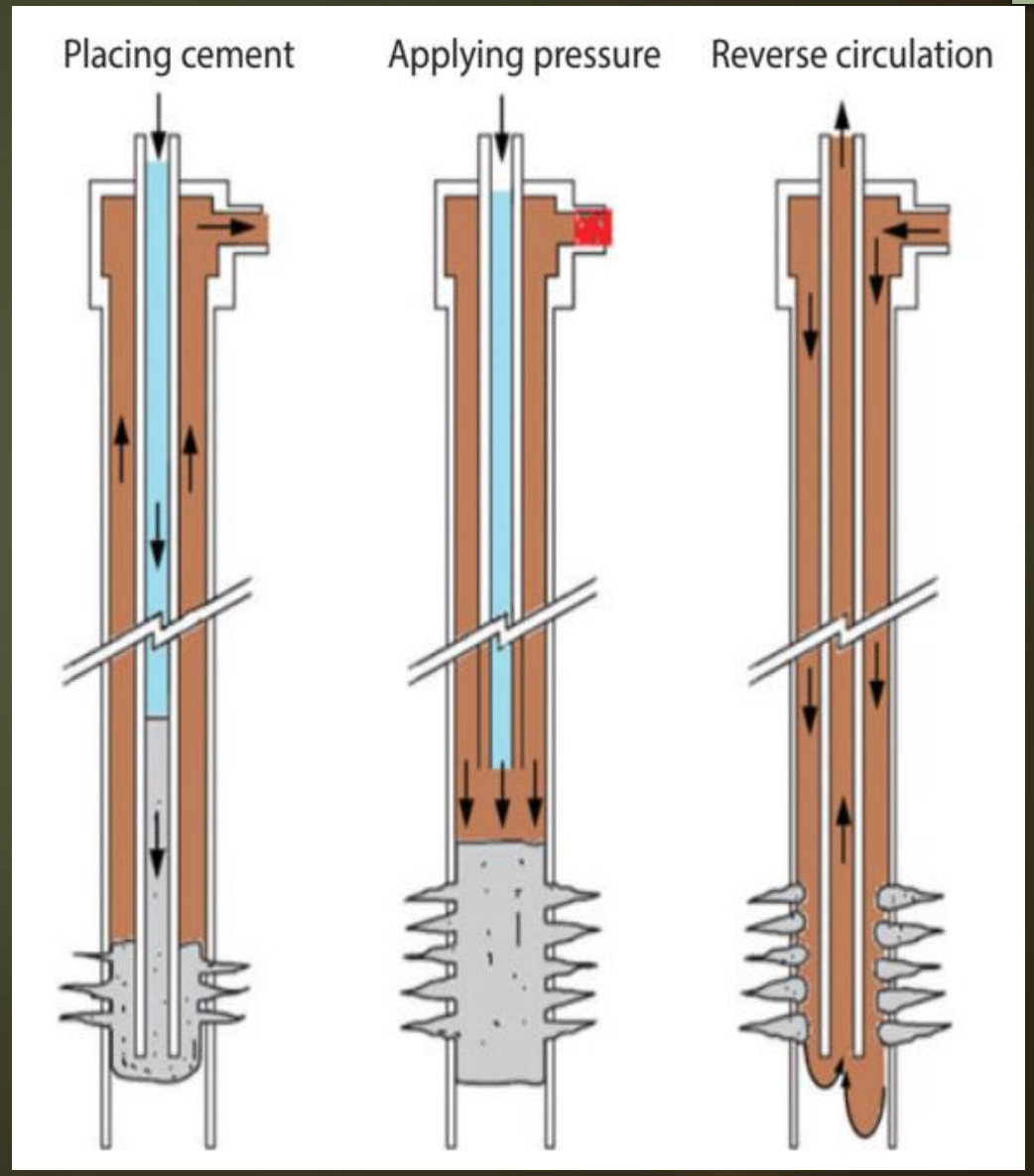
Equipment used in Squeeze Cementing

Bradenhead Squeeze: This technique involves pumping cement through drill pipe without the use of a packer

- The BOPs and the annulus are closed in and displacing fluid is pumped down, forcing the cement into the perforations, since it cannot move up the annulus.

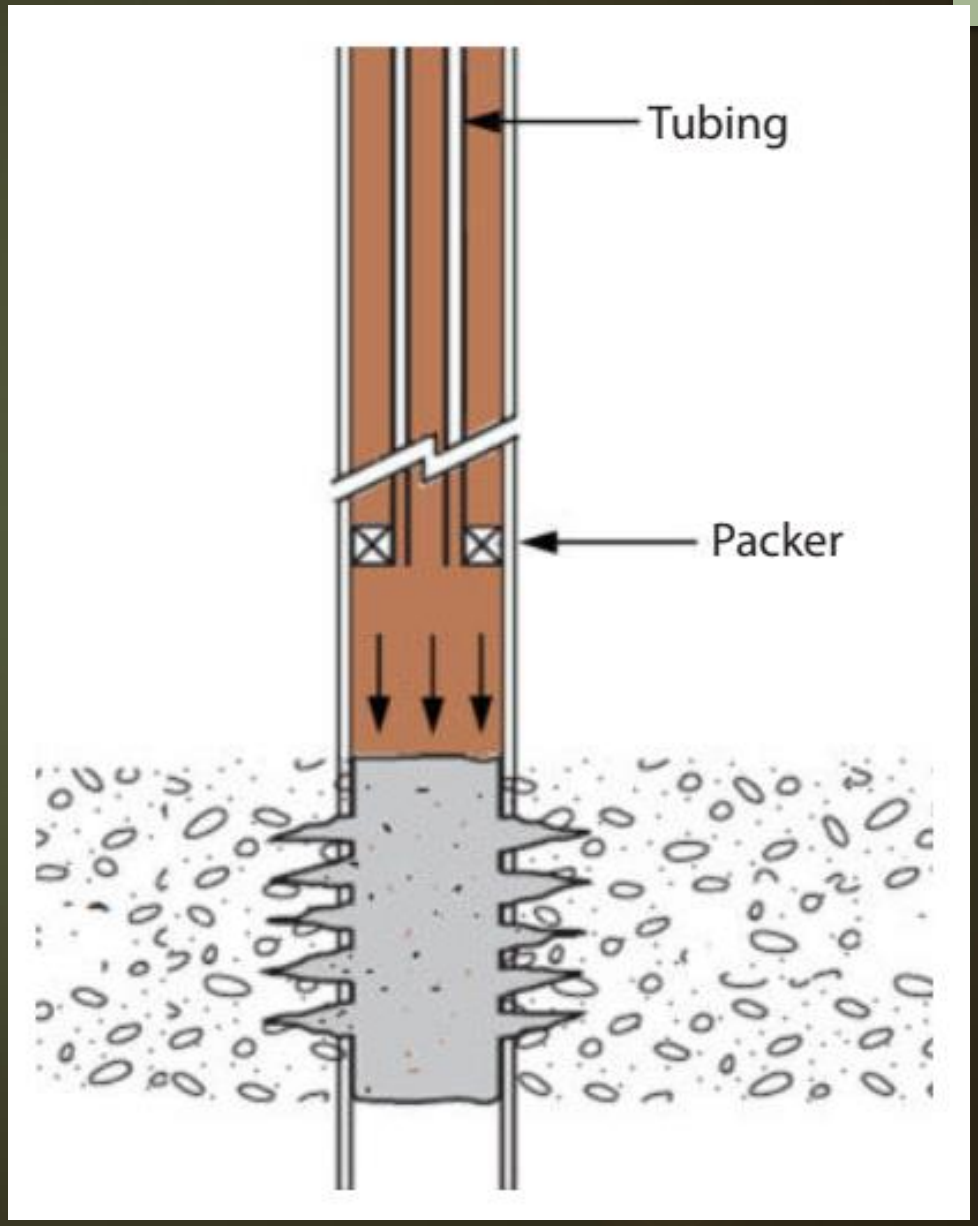
- This is the simplest method of placing and squeezing cement, but it has problems of placing cement at target zone and can pressurized the casing.

- it is recommended only for low pressure squeeze cementing operation



Squeeze using a Packer

The use of a packer makes it possible to place the cement more accurately, and apply higher squeeze pressures.



Plug Cementing

- Abandonment of depleted zones
- Shut off lost circulation zones
- Providing a kick off point for directional drilling
- Isolating a zone for formation testing
- Abandoning an entire well.

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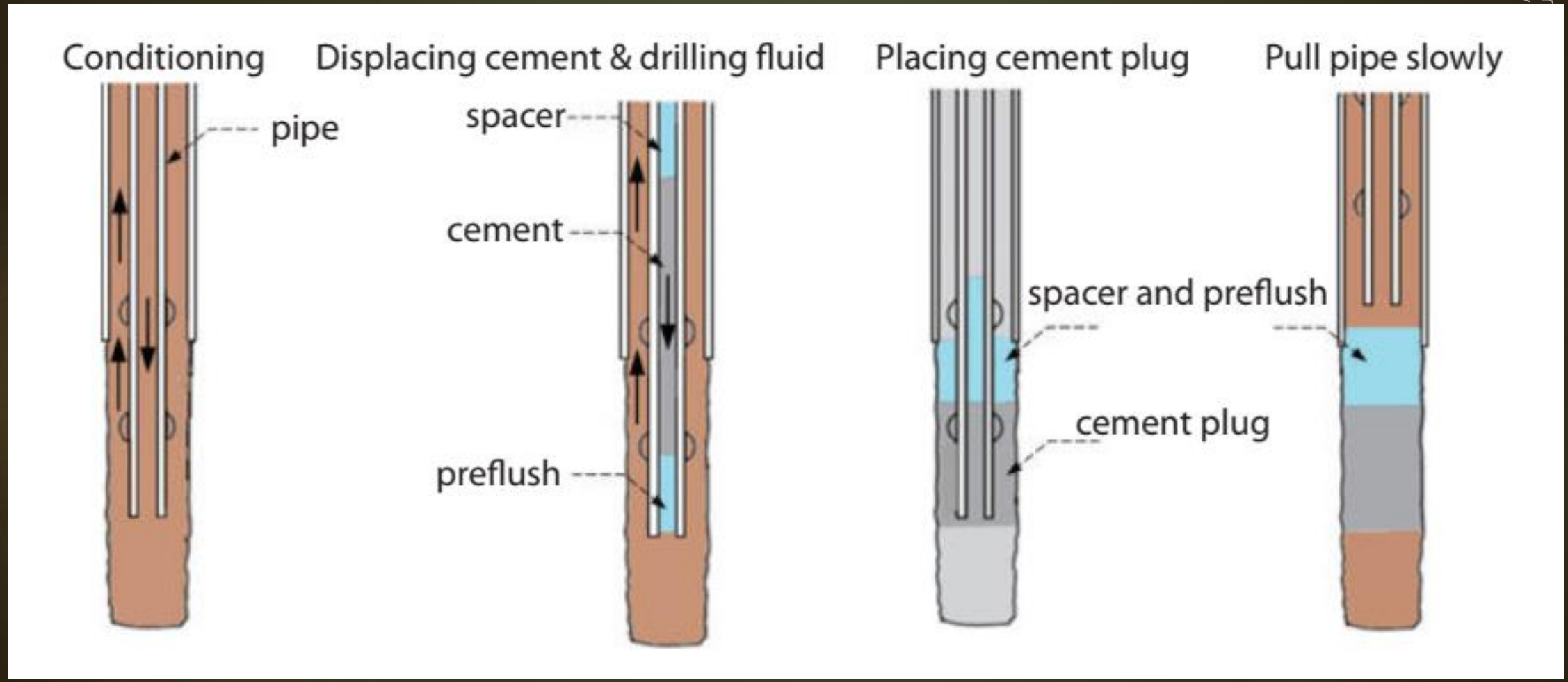
There are two commonly used techniques for placing a cement plug:

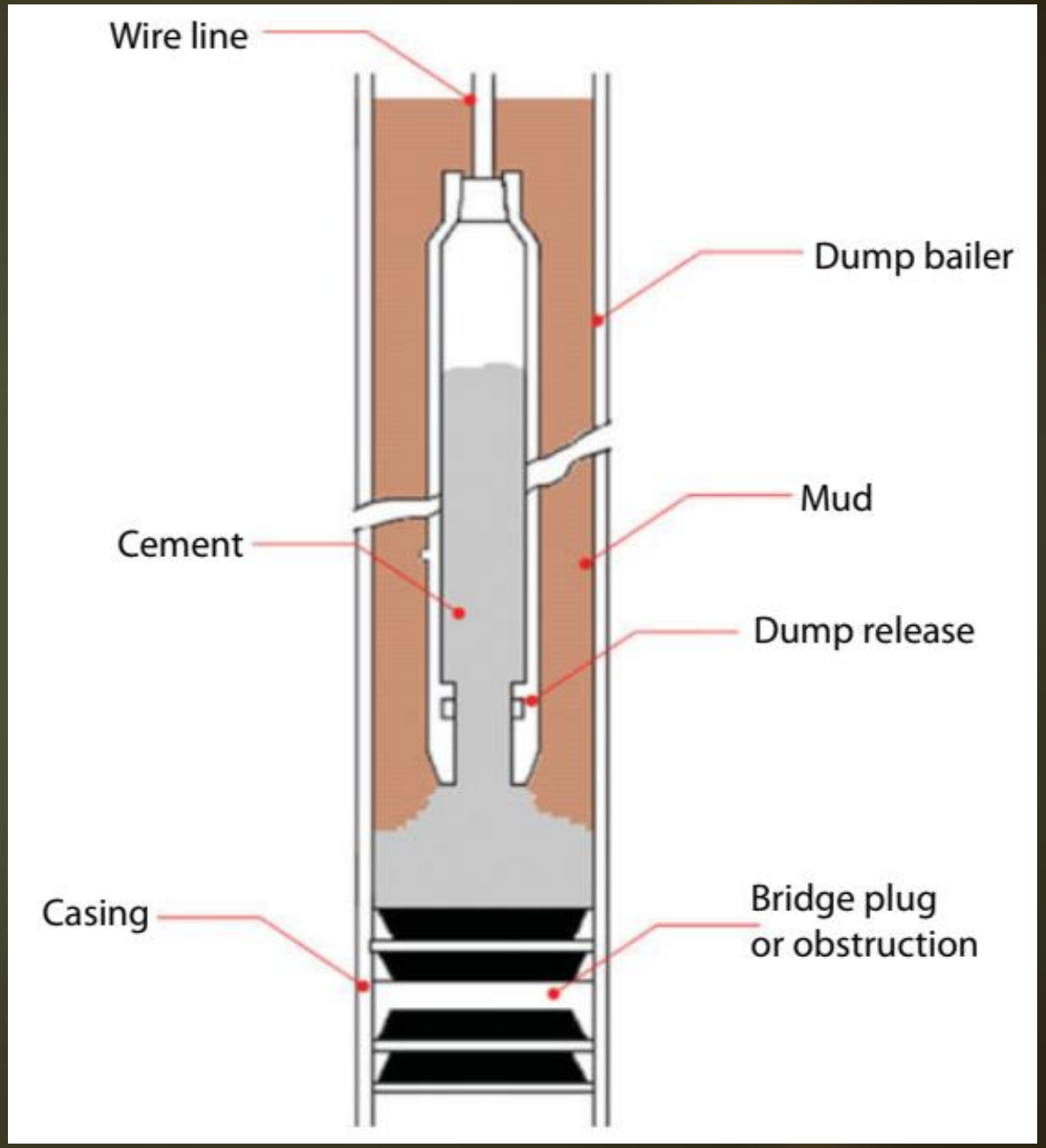
1. Balanced plug: This method is designed to achieve an equal level of cement in the drillpipe and annulus

2. **Dump bailer:** A dump bailer is an electrically operated device which is run on wireline.

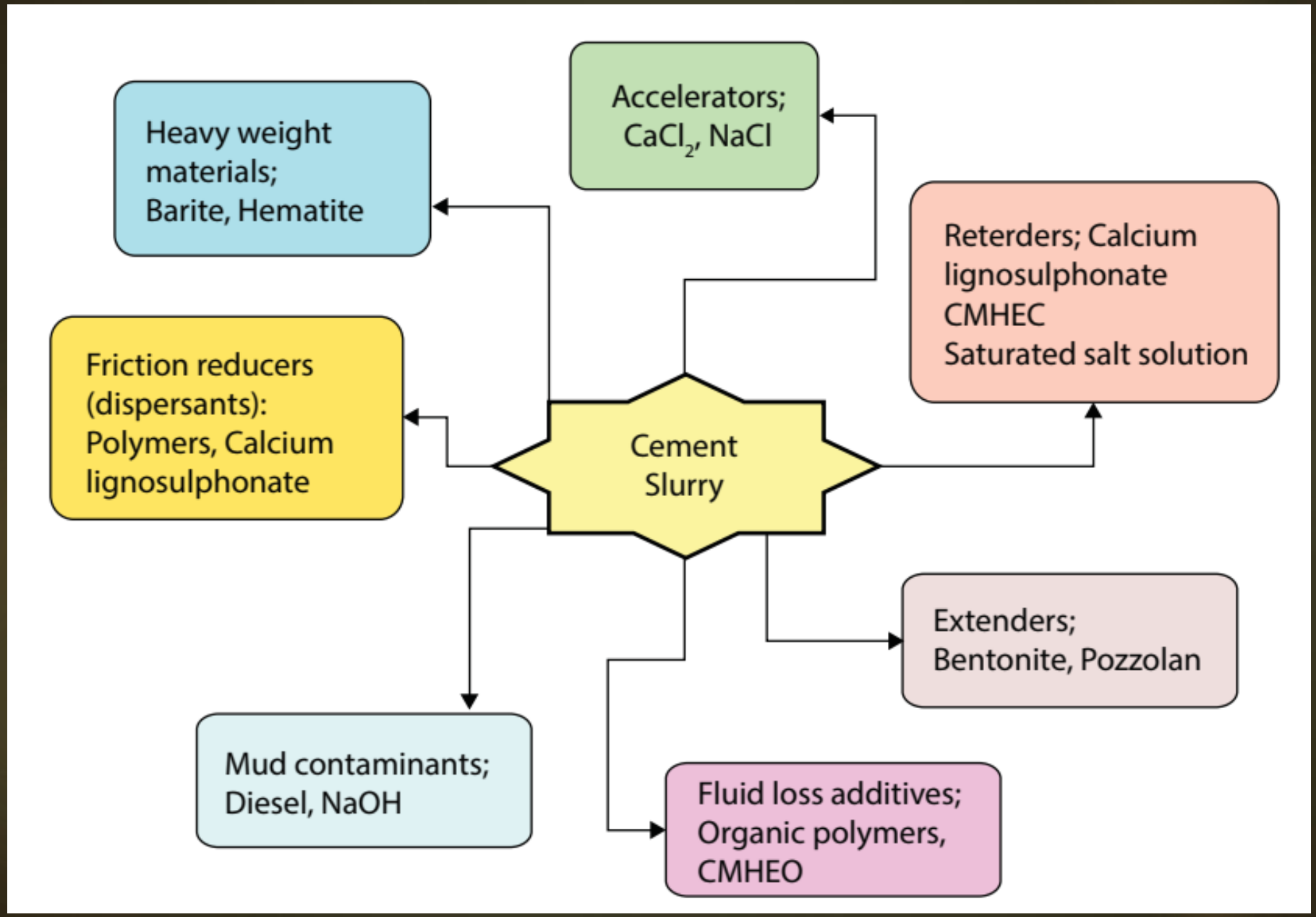
Balanced plug



Dump bailer


Wire line
Dump bailer
Mud
Cement
Dump release
Casing
Bridge plug
or obstruction

Oil Well Cement Additives



Questions?

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