Drilling

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Life of a well

- 1. Drilling a well (chips/cuttings, sidewall cores, cores)
- 2. Testing a well

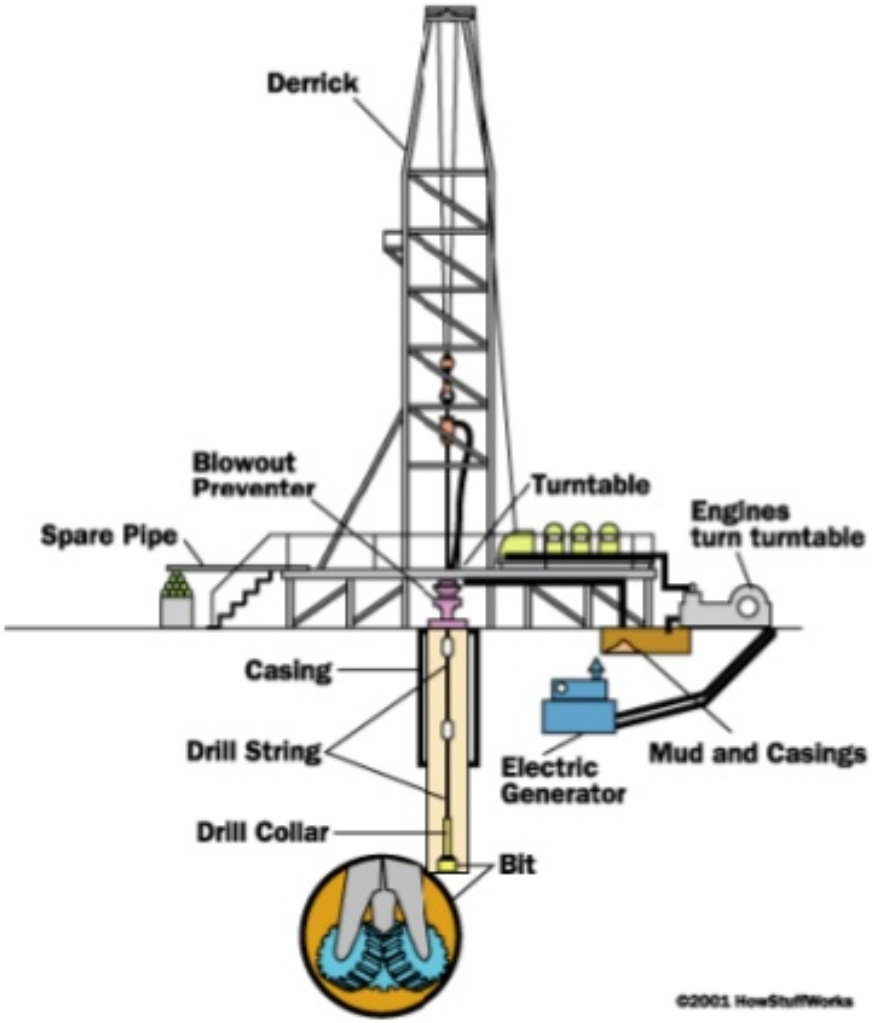
  - logging (info: lithology, HC content, porosity)

  - well tests (info: permeability, HC content)
- 3. a. Completing a well (if it is productive)
- 3. b. Plug and abandon (if it is dry)

Well drilling

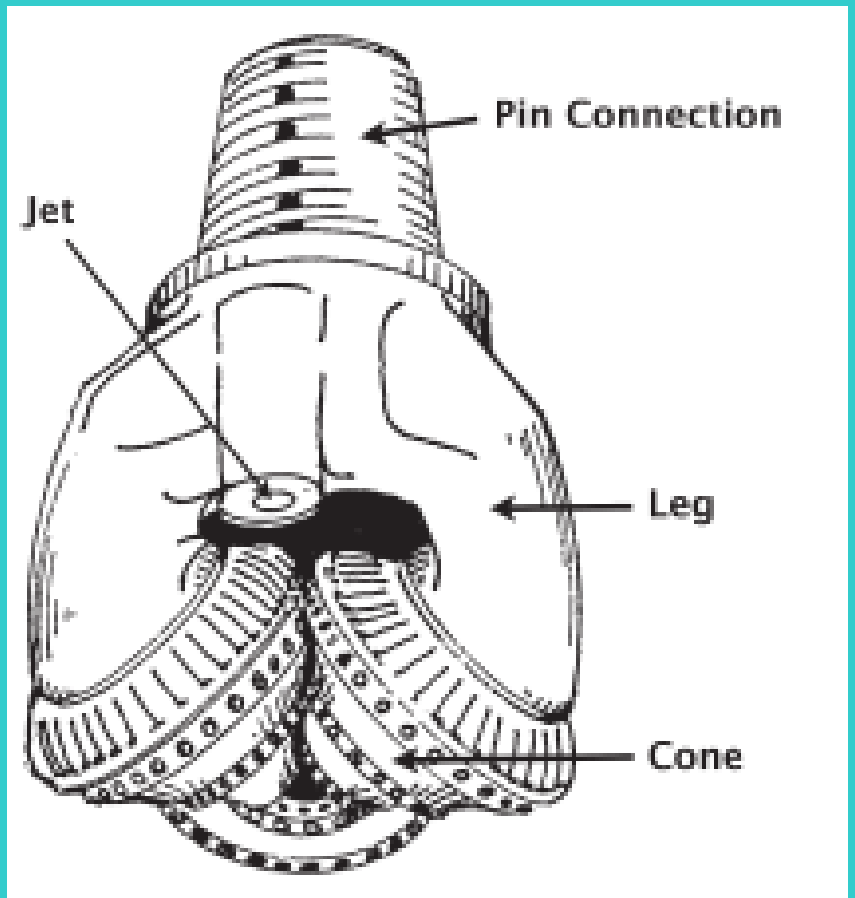
The drilling rig consist of four main parts:

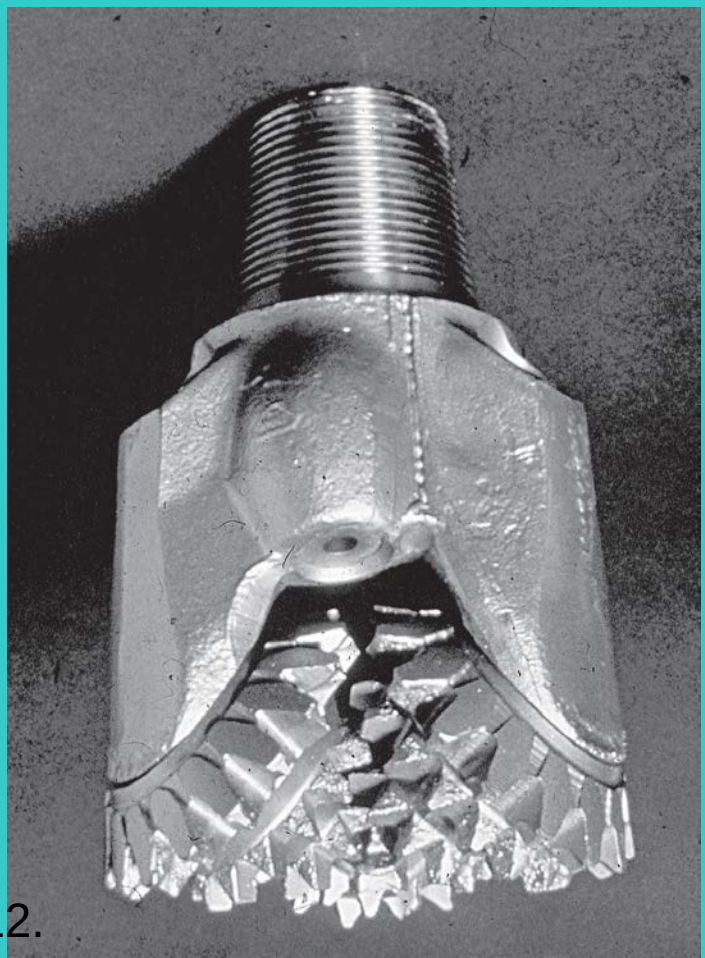
- **Derrick** - tall steel structure equipped with gear for raising and lowering the drill equipment.
- **Drill column or stem** – consist of main section of steel pipes to lower end of which the drilling bit is attached.
- **Rotating mechanism** – at the upper end of drill column.
- **Mud circulation system** – drilling fluid.



Rotary cone bit

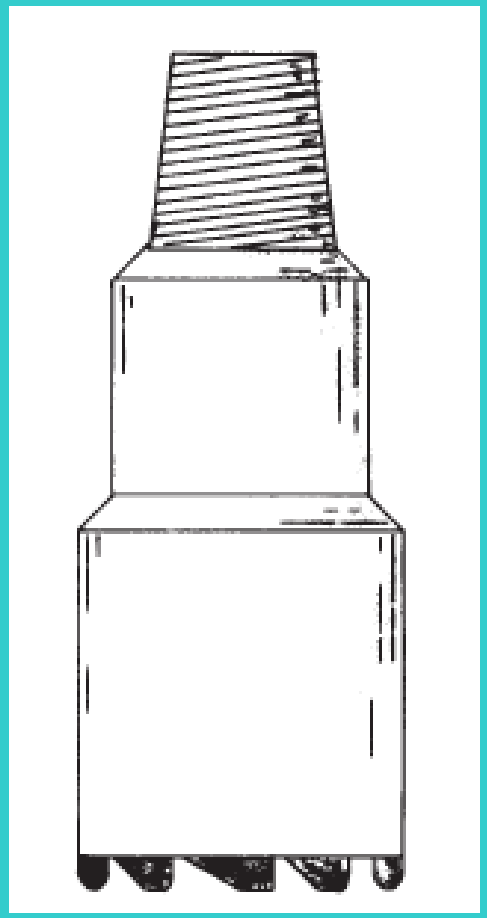
- *Rotary cone bit* with three rotating cones, called a ***tricone bit***.
- The body of the tricone bit is made of three legs. Each leg has a jet and channel for drilling mud to flow though it. During drillings the cones rotate. Teeth on the cones are designed to crush the rock on the bottom of the well. The rock chips that are formed are called *well cuttings* or *chips*.





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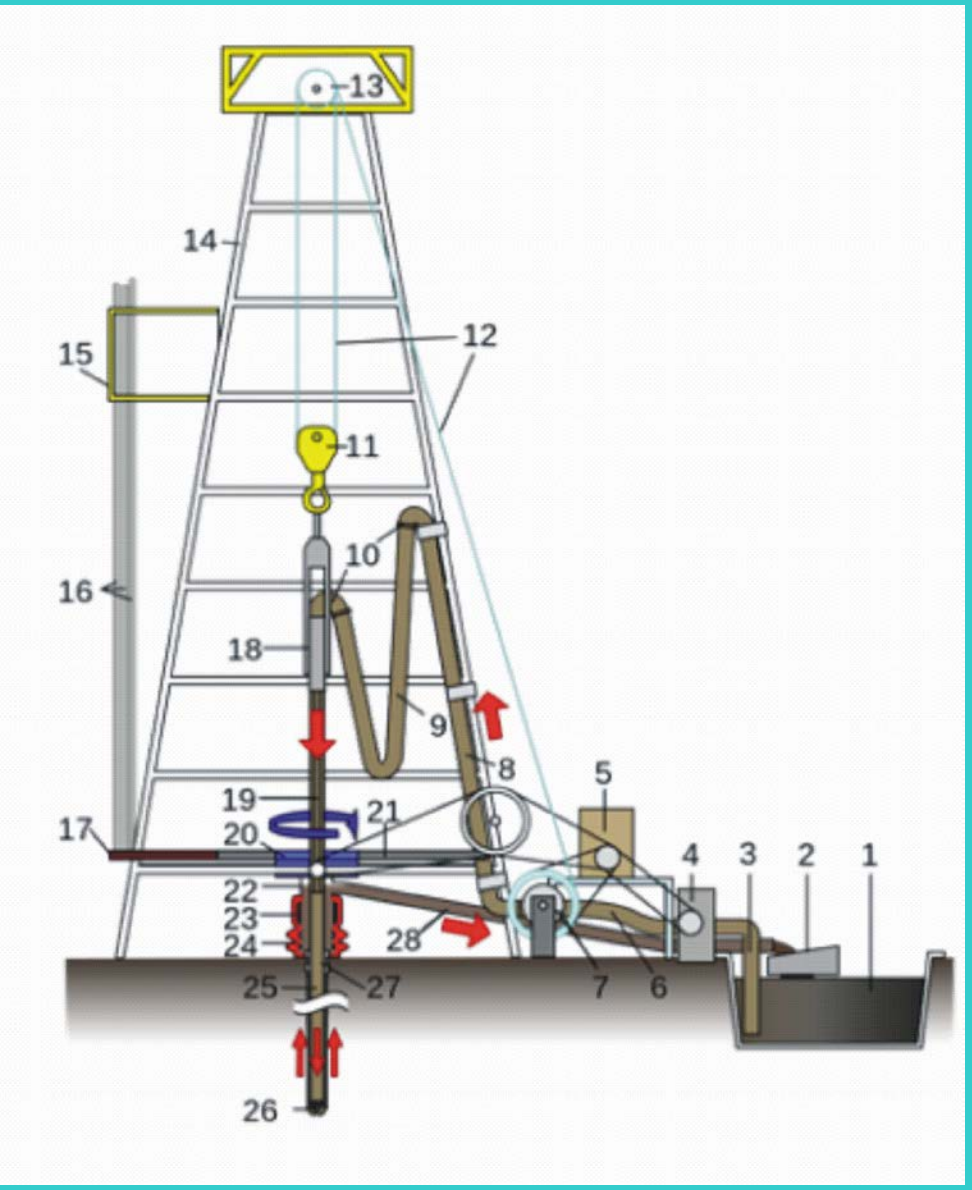
Polycrystalline diamond compact (PDC)



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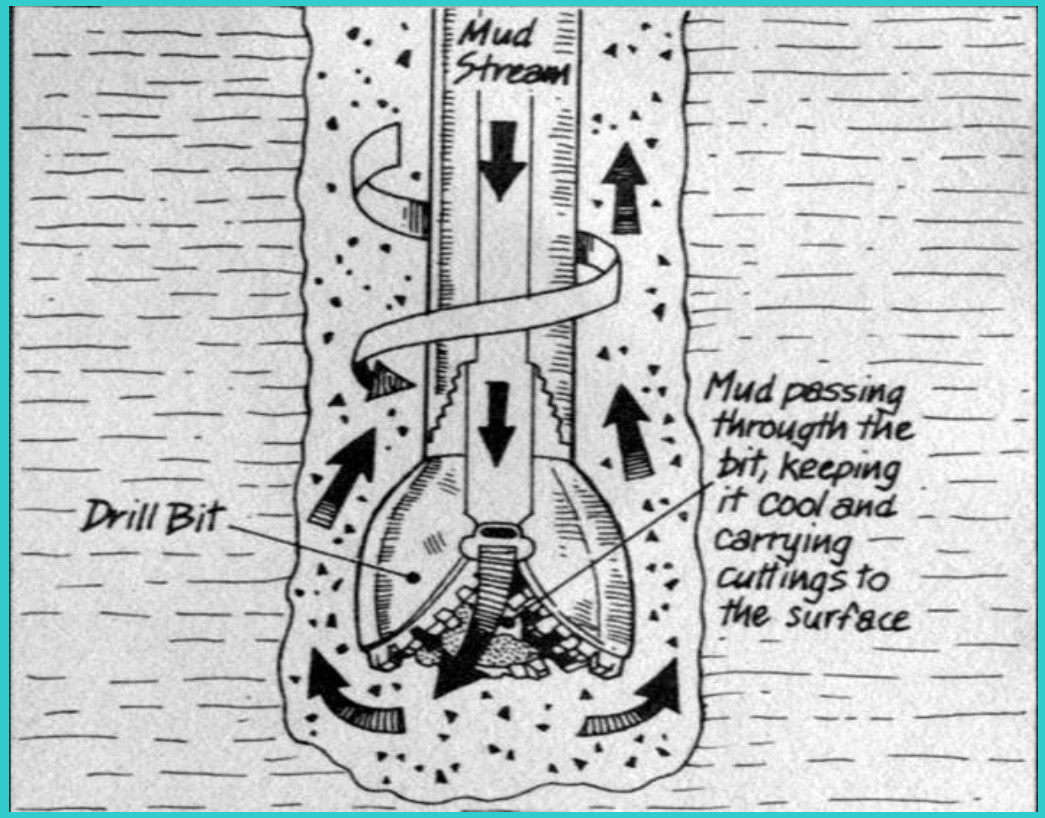
- A solid metal diamond bit with no moving parts. The cutters are faced with blanks of synthetic industrial diamonds that have been cemented on. This bit is designed to continuously shear away the rocks to produce cuttings.
- These are the most expensive bits.
- Avantage: a PDC bit, can often be used for several hundred hours and drill more meter in a well than other types of bits.
- **Disadvantage: cuttings made by PDC can't be used for geological observations!**

Mud system



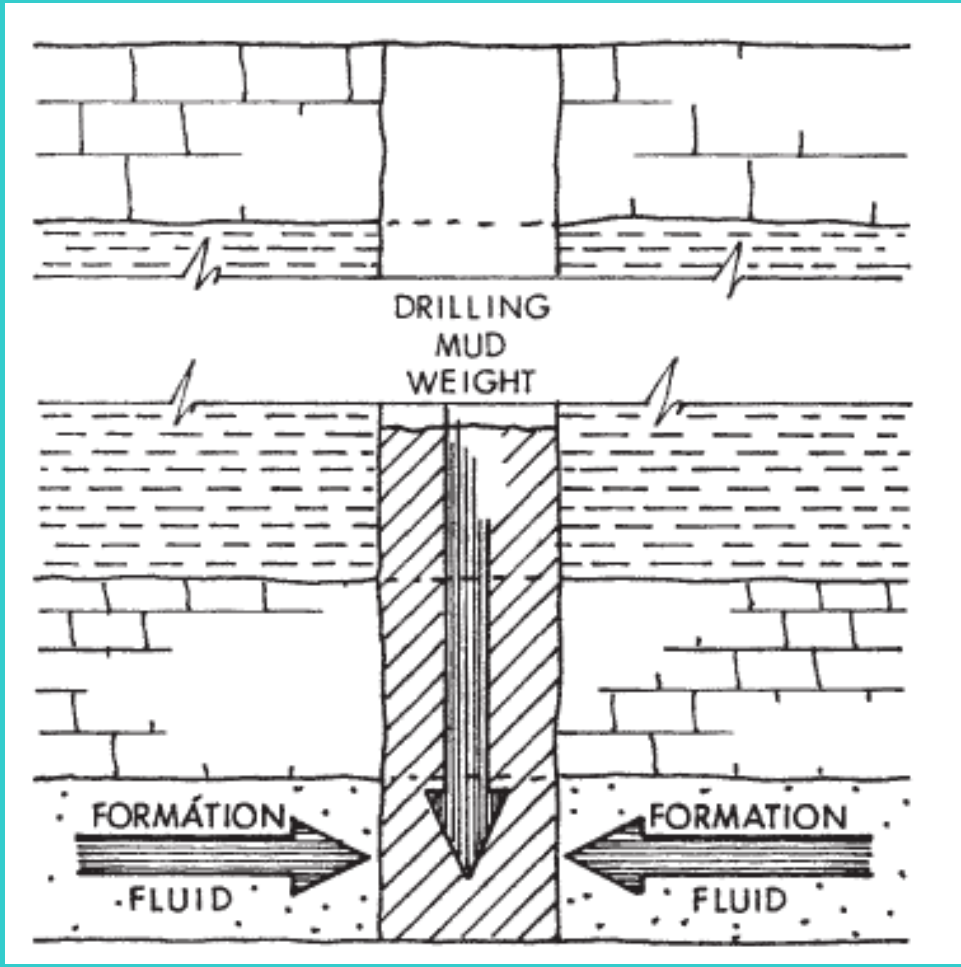
- - Mud is pumped into the top of the kelly
- - down until the bit
- - back up to the surface via the space between the pipe and the wall of the well
- through sieves into the tank
- - from the tank it will be recycled

Function of the mud



- Remove cuttings from the well
- Control formation pressure
- Seal permeable formation
- Maintain wellbore stability
- Cool, lubricate and support the bit and drilling assembly

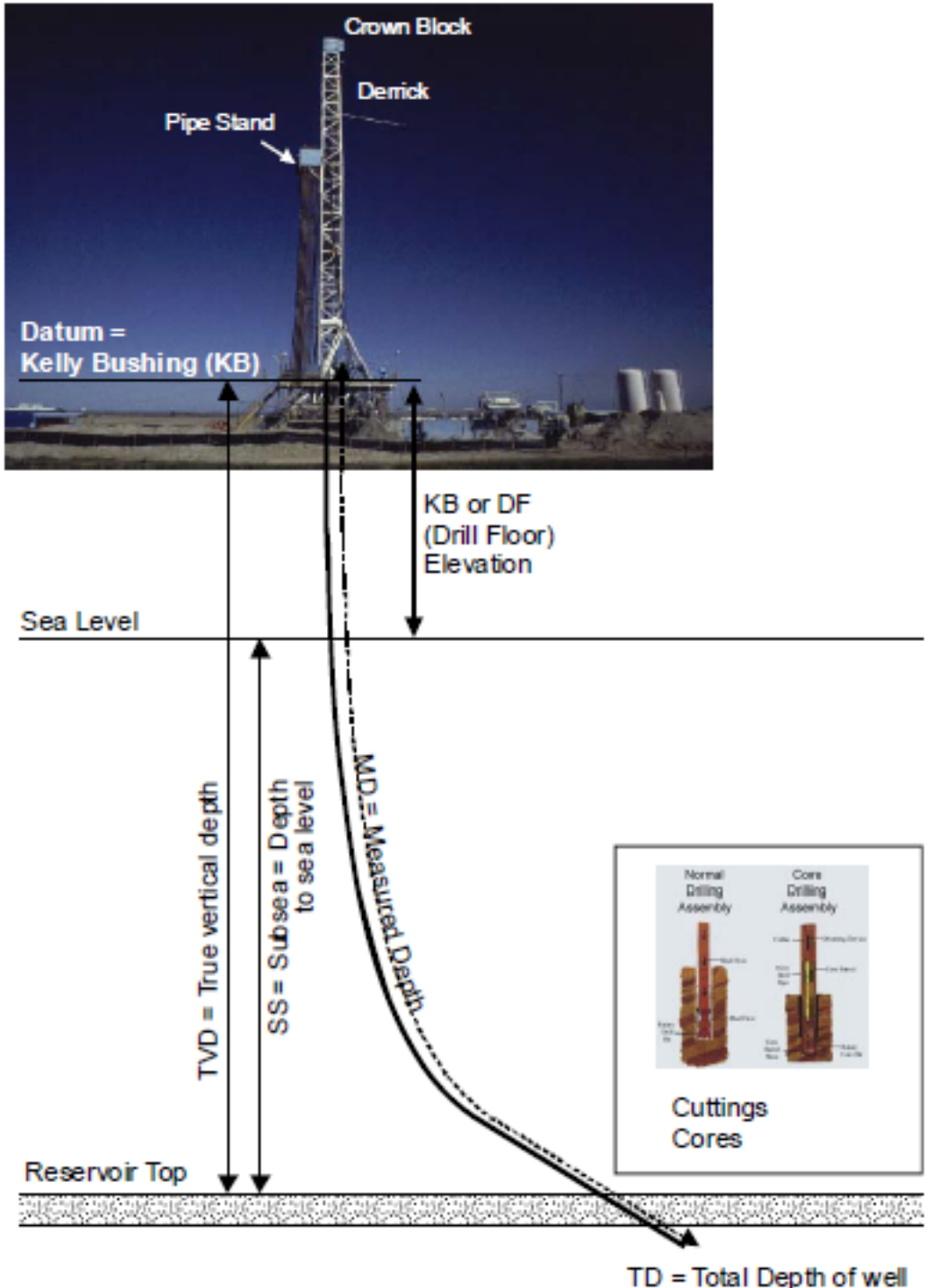
Drilling mud controls pressures in the well and prevents blowouts



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- Pressure on fluids in the pores of the rock tries to force the fluids to flow through the rock and into the well.
- Pressure exerted by the weight of the drilling mud tries to force the drilling mud into the surrounding rocks.
- If the pressure on the fluid in the subsurface rock is greater than the pressure of the drilling mud (*underbalance*), water, gas, or oil will flow out of the rock into the well. In extreme cases, it can cause a blowout where fluids flow uncontrolled and violently onto the surface.

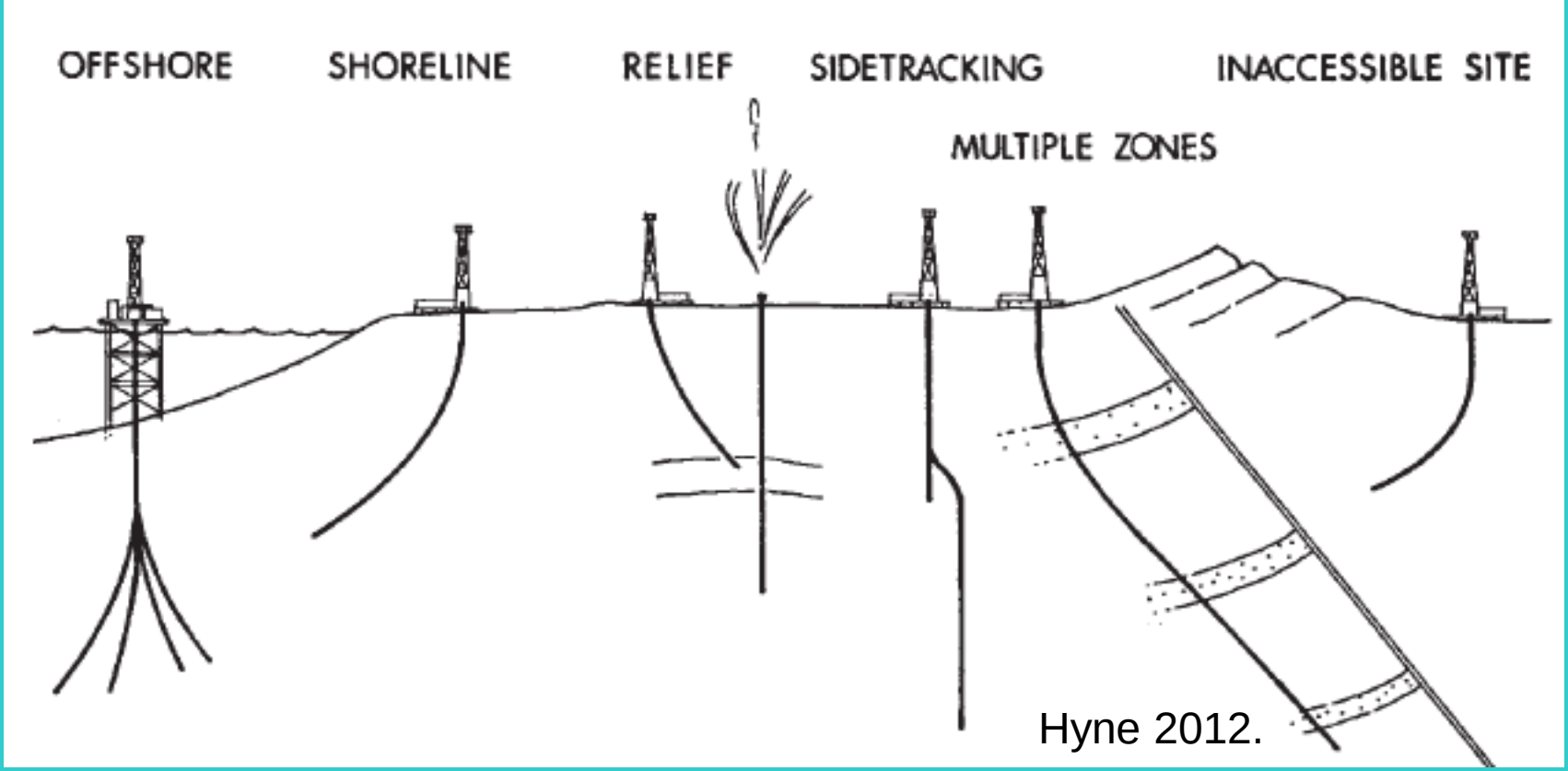
Boreholes


Crown Block
Derrick
Pipe Stand
Datum =
Kelly Bushing (KB)
KB or DF
(Drill Floor)
Elevation
Sea Level
TVD = True vertical depth
SS = Subsea = Depth
to sea level
MD = Measured Depth
Normal
Drilling
Assembly
Core
Drilling
Assembly
Cuttings
Cores
Reservoir Top
TD = Total Depth of well

Abgelenkte Bohrungen



Deviated well uses



Offshore production platforms are very expensive:

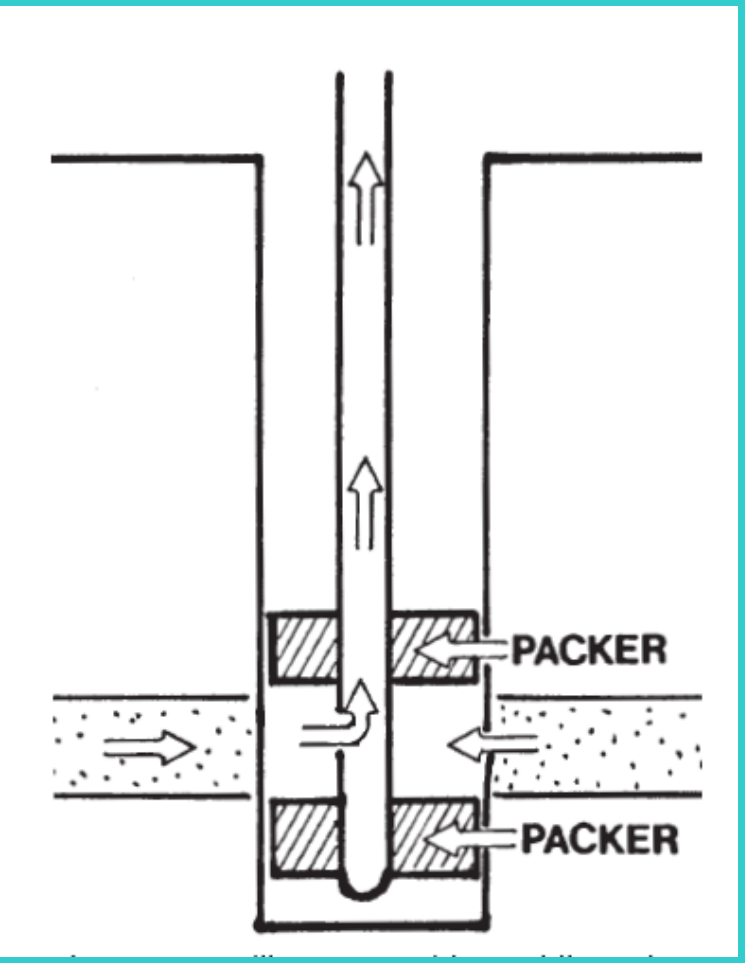
1. using one large production platform with numerous deviated wells that radiate out to the sides.
2. An oilfield in very shallow waters can be more economically developed by deviation drilling from the beach.

Relief well: if a well is on fire (*wild well)* it can be brought under control by *relief well.* It drills into the abnormal high-pressure zone that causes the blowout, and the pressure is reduced by producing the gas. After the pressure has been reduced, heavy drilling mud (*kill mud*) is then pumped from the relief well through subsurface rocks and into the wild well to control it.

Completing a well

- Completing it means that heavy steel casing will be run into the hole, and cement will be pumped between the outside of the casing and the inside of the drilled hole (called *annulus*).
- Completing a well usually costs more money than drilling a well.
- Because of this, a well must be tested after it has been drilled. Will this well produce enough gas or oil to make it worthwhile to complete?
- After testing have to make decision either complete the well, or plug it.

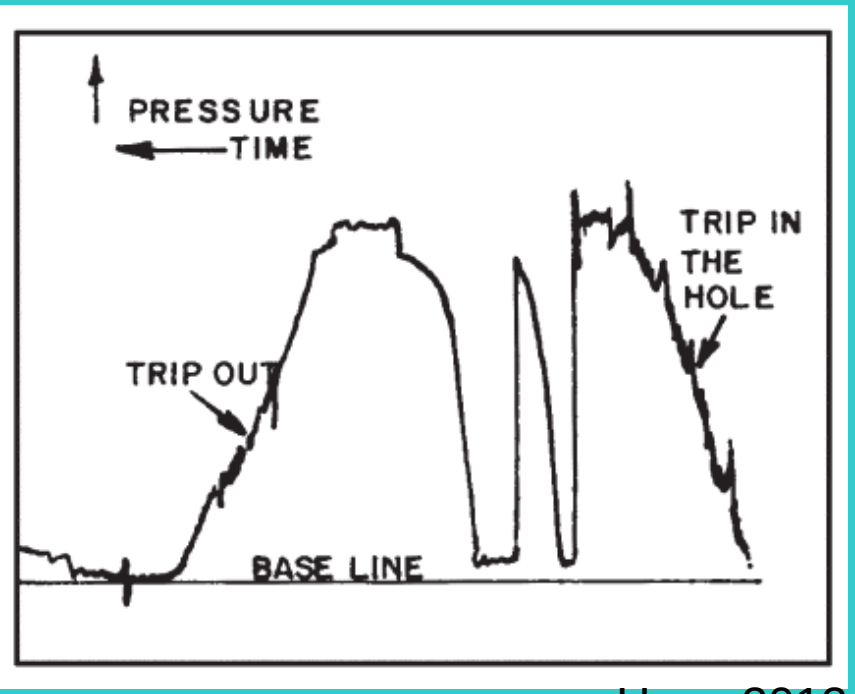
Drillstem test



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- If the logs indicate a potential reservoir, a drillstem test can be run.
- It is run in a well that is filled with drilling mud. The drillstem has one or two packers, perforated pipe, pressure gauges, and a valve assembly.
- ***Packers*** are cylinders made of a rubber-like material that can be compressed to expand against the well walls to seal that portion of the well and prevent any vertical flow of fluid in that section of the well.
- Once seated the packer(s) water, gas, or oil can flow out of the formation into the well. The formation fluids flow up the drillstem.
- If **gas** is present, it will flow up the drillstem and onto the surface where it is measured and *flared* (burned).
- **Oil** sometimes has enough pressure to flow to the surface during a drillstem.
- Normally, however, the oil fills the drillstem only to a certain height that is measured.

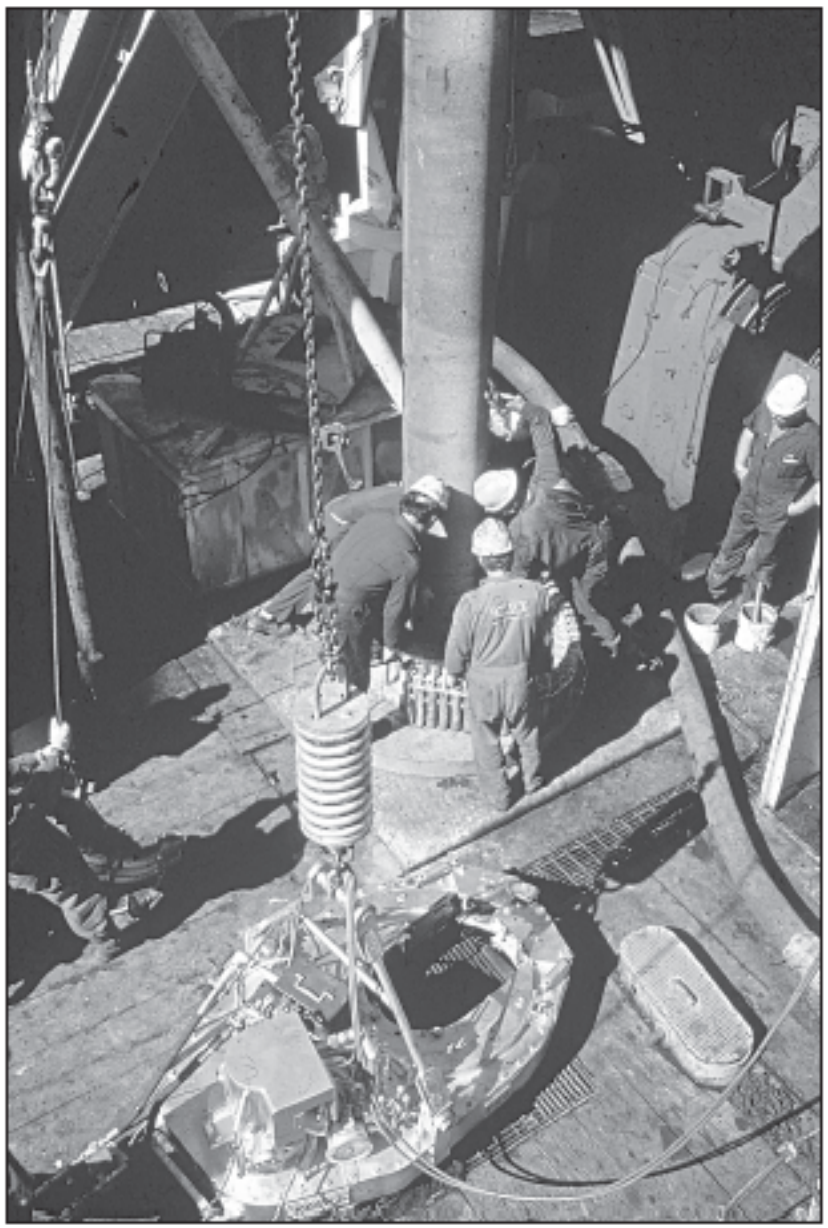
Pressure buildup curve



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- During the drillstem test, pressure on the fluid flowing into the drillstem is continuously measured. The valve on the drillstem is opened and closed several times, and fluid pressure buildup and drop-off are recorded on a chart of pressure versus time called a *pressure buildup curve.*
- Engineers use the pressure records to **calculate formation permeability, reservoir fluid pressure, and the extent of any formation damage**.
- The test can take 20 minutes to three days.
- Drillstem tests are usually run only on exploratory wells because of the rig time expense.

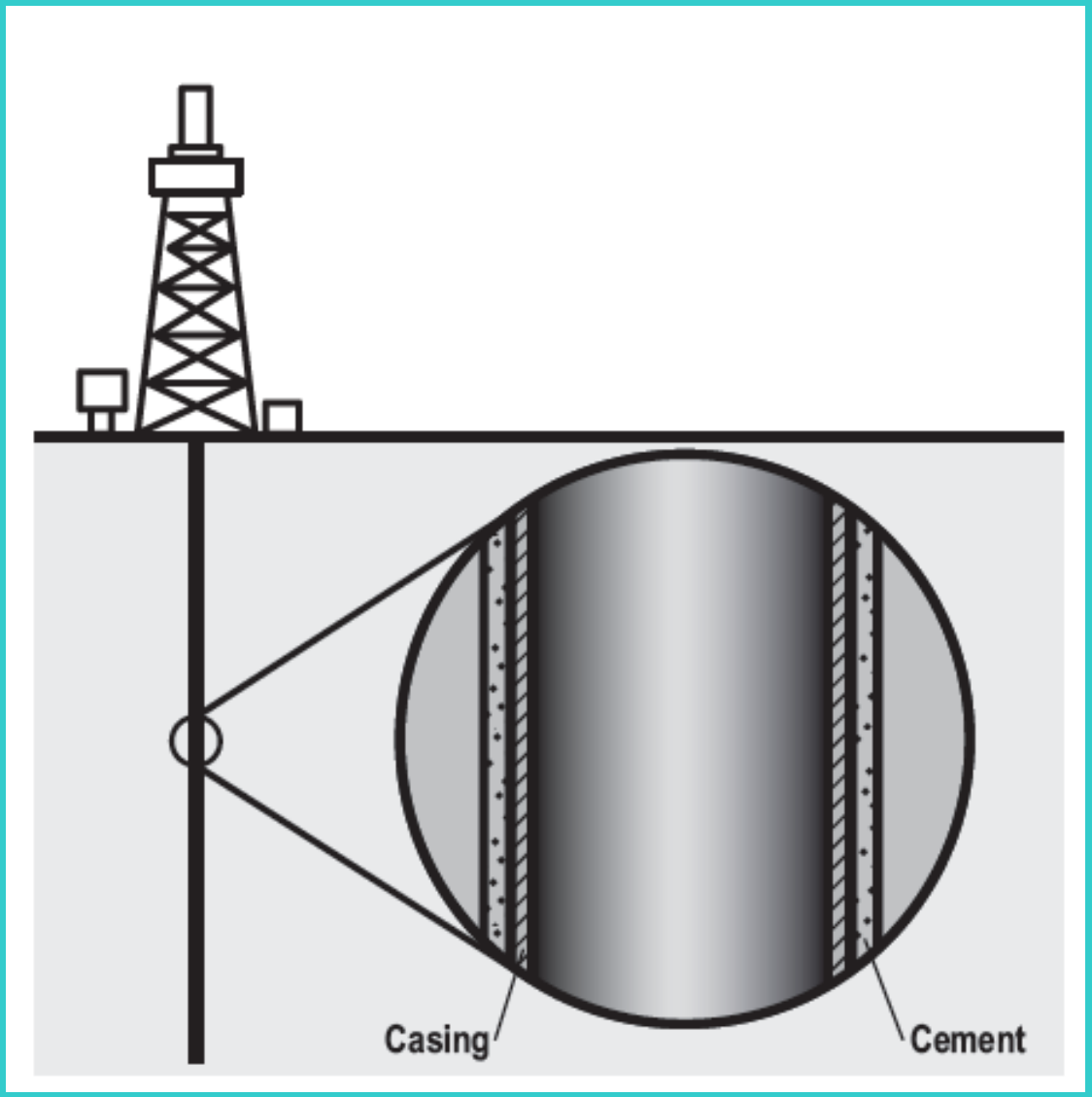
Casing the well



- If the well contains economic amount of oil or gas, well is cased (*set pipe*) to complete the well.
- *Casing* is relatively thin-walled steel pipe. The casing string is run into the well and cemented to the sides of the well in a *cement job*.
- **Casing:**

- stabilizes the well and prevents the sides from caving into the well.
- It protects freshwater reservoirs from the oil, gas, and saltwater brought up the well during production.
- Casing also prevents the production from being diluted by waters from other formations in the well.

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Casing cemented into a well
Hyne 2012

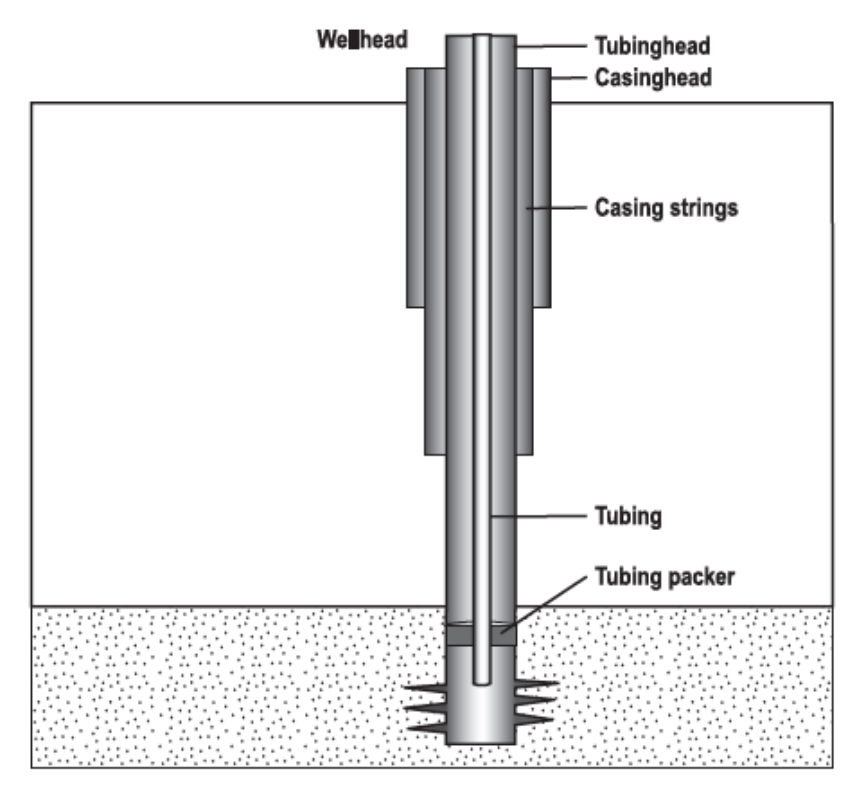
Tubing



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- Small-diameter pipe called *tubing* is run into the well to just above the bottom to conduct the produced fluids (oil and gas) to the surface.

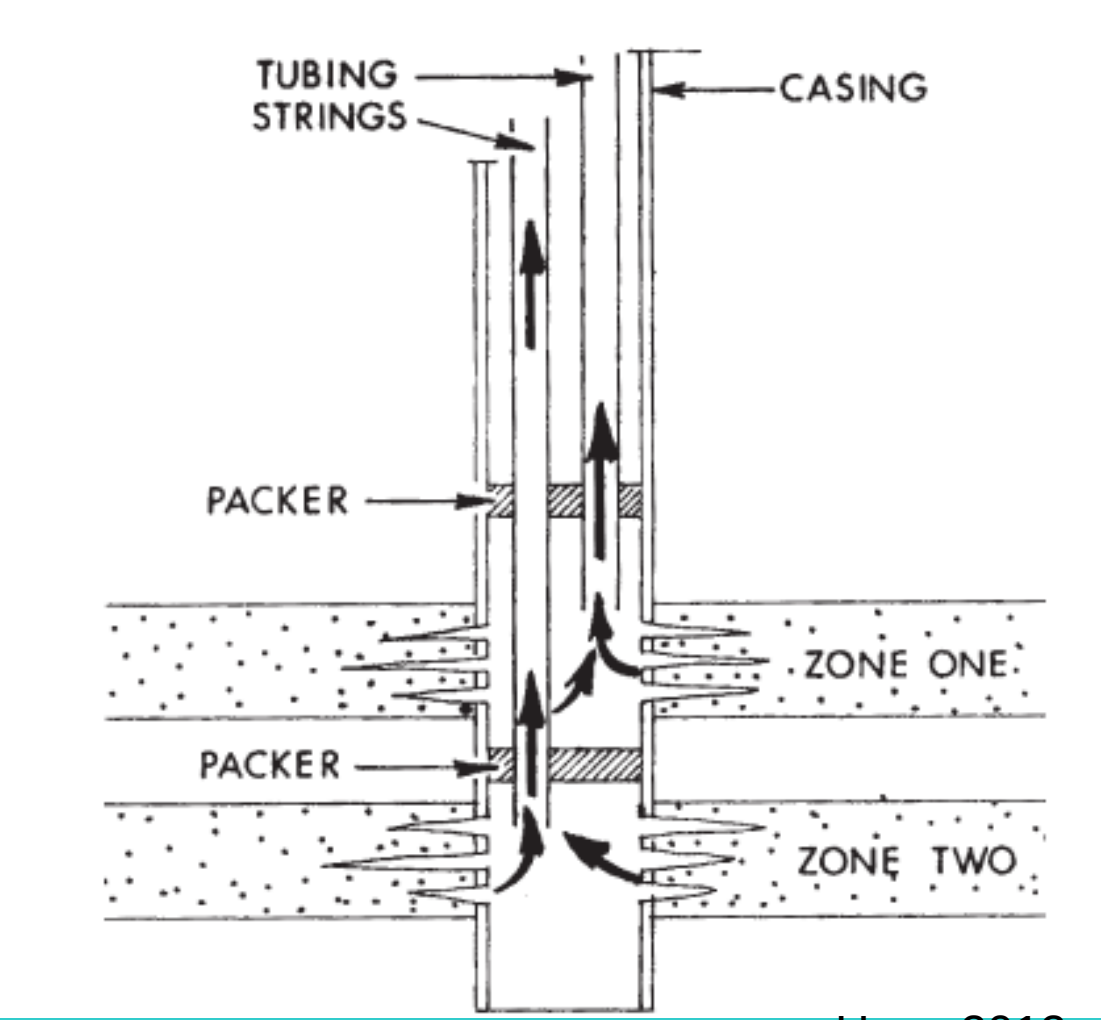
Tubing



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- A *tubing* or *completion packer* is used near the bottom of the tubing string. It keeps the tubing string central in the well and prevents the produced fluids from flowing up the outside of the tubing string.
- **Tubing** protects the casing from corrosion by the produced fluids.
- Because the casing has been cemented in the well, it is very difficult to repair the casing. The tubing string, however, is suspended in the well and can be pulled from the well to repair or replace it during a workover.

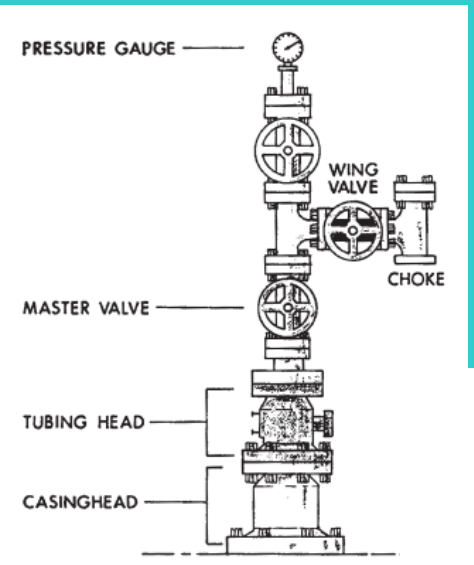
The bottom of a dual completion well

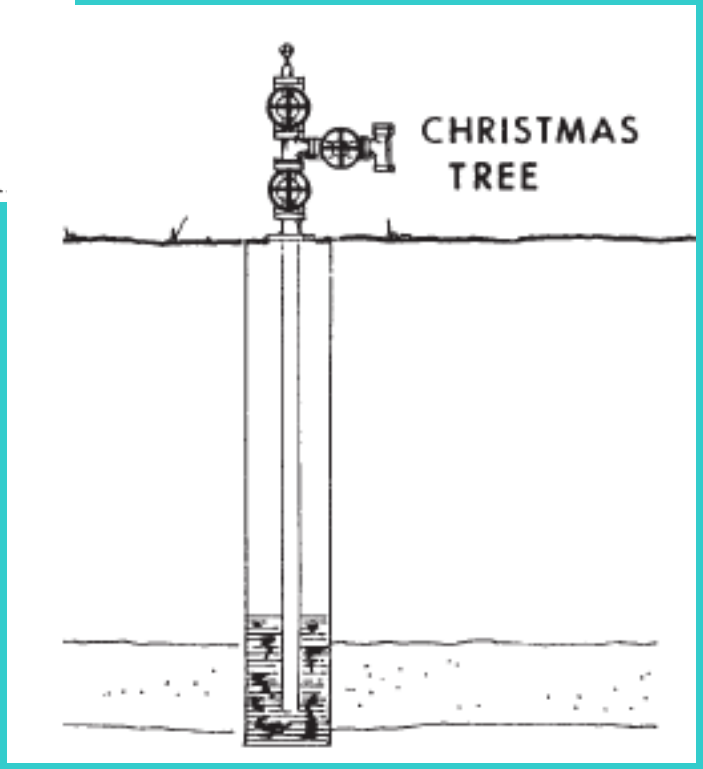


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If there are two producing zones, two packers and two tubing strings are used in a *dual completion*

Christmas or production tree





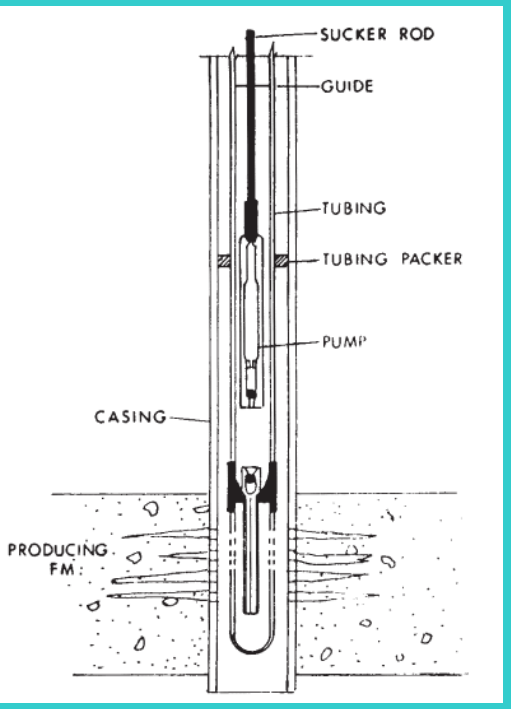
Hyne 2012.

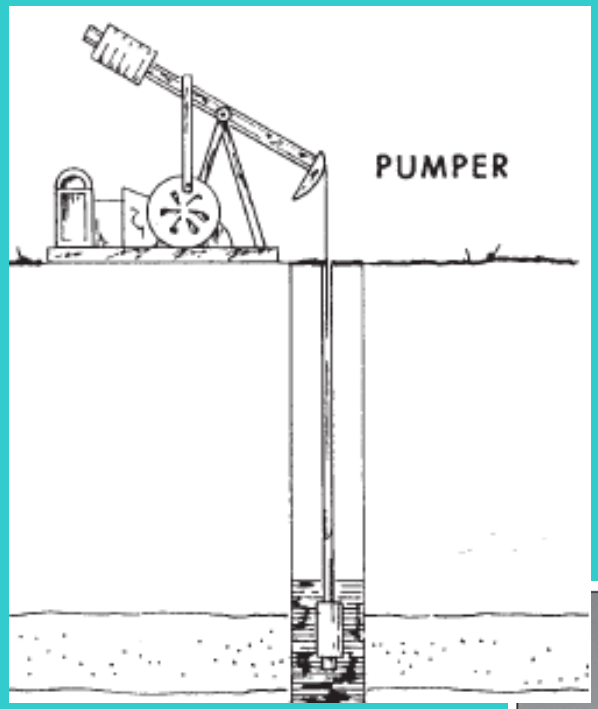
- Gas wells flow to the surface by themselves. There are some oil wells (4% in the United States) in which the oil has enough pressure to flow up the tubing string to the surface. For gas wells and flowing oil wells, a structure of pipes, fittings, valves, and gauges are welded to the wellhead to control the flow it is called c**hristmas tree**

- In most oil wells (95% in the United States), the oil does not have enough pressure to flow all the way up the tubing to the surface. The produced oil will fill the well only to a certain level and has to be lifted to the surface by *artificial lift*.
- Even with a flowing oil well, as more fluids are produced from the subsurface reservoir, the pressure on the remaining oil can decrease until it no longer flows to the surface. When this happens, the Christmas tree has to be removed and a surface pumper installed in a process called *putting the well on pump*.

Sucker-rod Pump

- The sucker-rod Pump lifts the oil from the reservoir through the well to the surface,



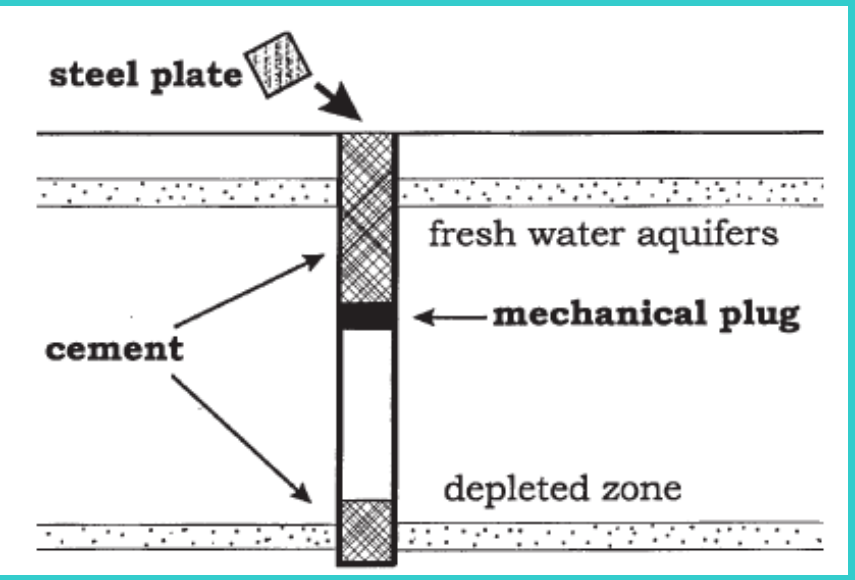


A sucker-rod pump on the bottom of a well. Hyne 2012.



Hyne 2012.

Plug and Abandon (P&A)



A plugged and abandoned well (P & A)
Hyne 2012.

- Both **dry holes** (doesn't contains economic amount of oil or gas) and **depleted** producing wells, either onshore or offshore, must be properly *plugged and abandoned* (*P & A*).
- First, if possible, casing is cut and pulled for salvage.
- All depleted producing formations are sealed by placing cement plugs at those levels
- Near-surface freshwater reservoirs are also protected by cement.
- The casing is cut 2 m below the surface, and a steel plate is welded to the top of the casing.
- The surface hole is then filled with dirt, and a marker is installed.

- Offshore wells are plugged and abandoned just like land wells.