

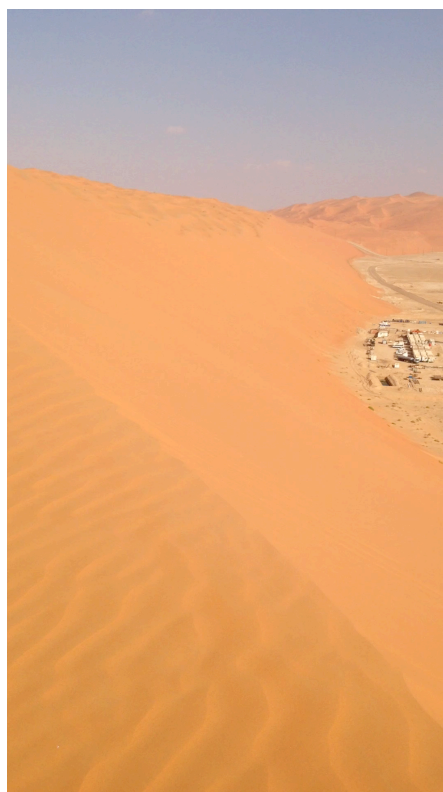
BOREHOLE GEOLOGY – FORMATION EVALUATION

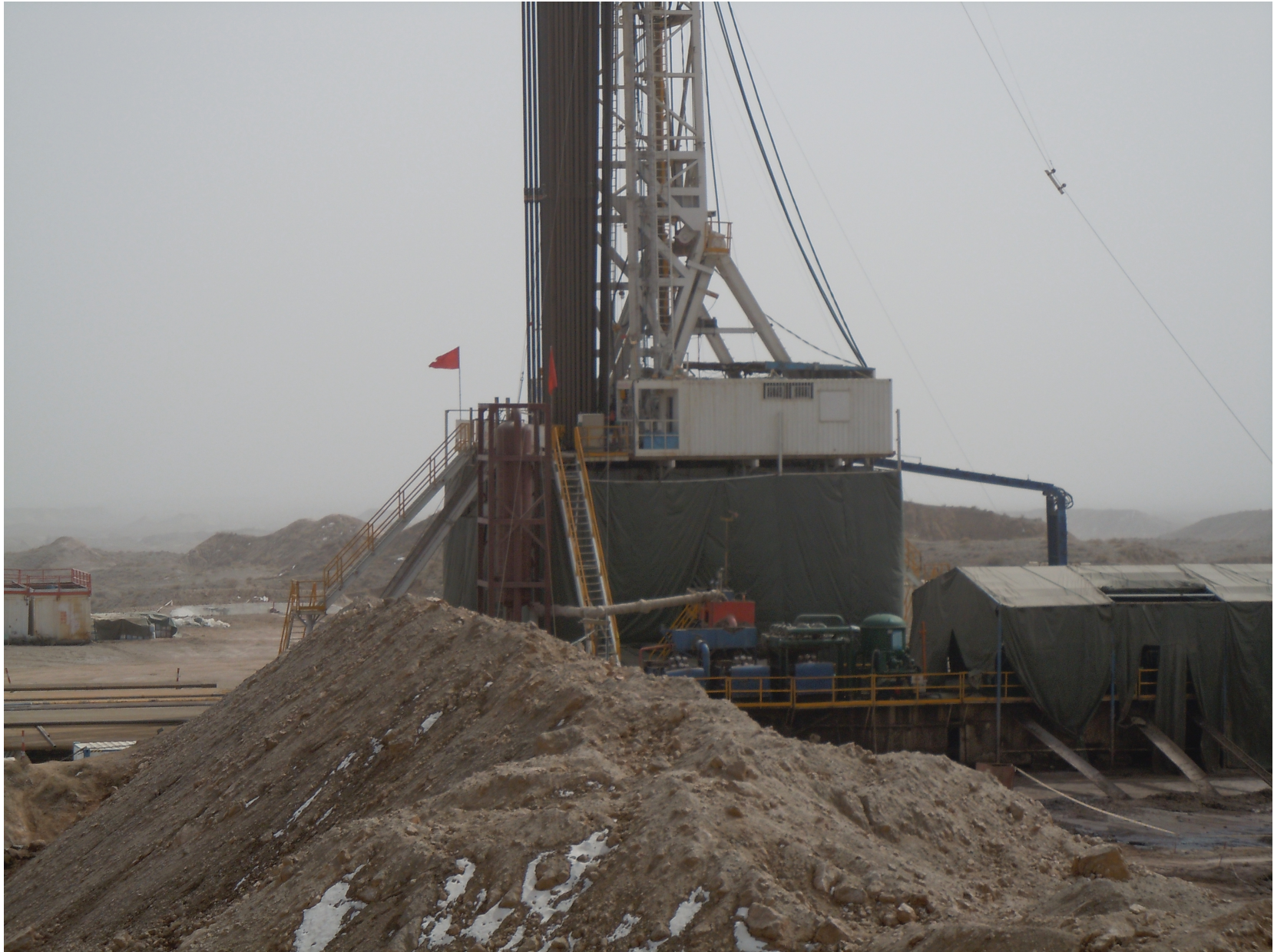
TYPES OF OIL RIG

- LAND RIG











JACK-UPS









SEMI SUBS



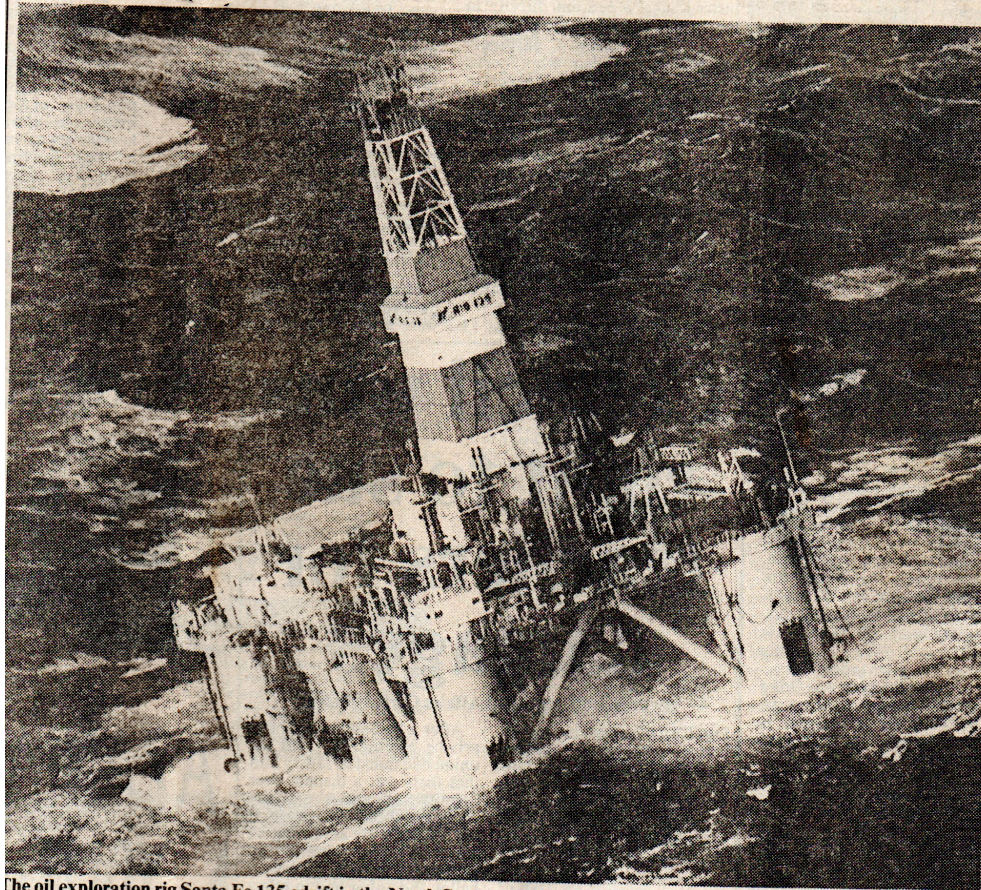


TIMES

TUESDAY MARCH 1 1988

Printed in Scotland

Oil rig adrift in gale-lashed North Sea



The oil exploration rig Santa Fe 135 adrift in the North Sea yesterday after breaking free in Arctic gales. 83 rescued, page 2

Production Platforms



Drill Ships



FORMATION EVALUATION

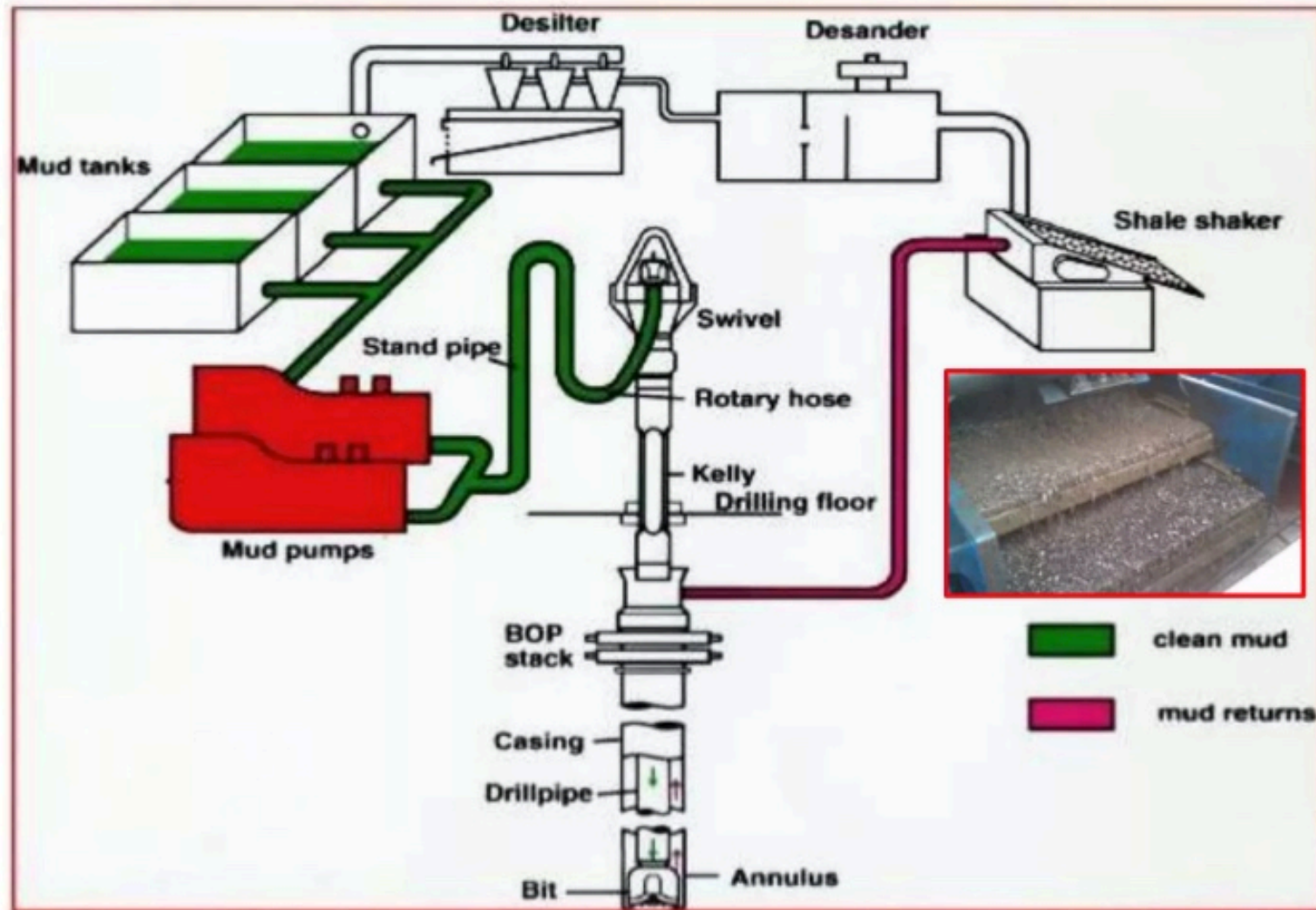
- Seismic Surveying can suggest presence of potential hydrocarbon traps/ fields or even in some circumstances the likelihood of the presence of Hydrocarbons. (Bright Spot anomalies)
- Oil Rigs can drill wells through those structures, but without some way of telling what the formations you are drilling through are, and if there is any Hydrocarbons present, you are in effect drilling blind.
- This is where Formation Evaluation comes in.

TYPES OF FORMATION EVALUATION

- MUDLOGGING (Realtime)
- CORING (Usually only performed when in potential reservoir)
- WIRELINE ELECTRIC (Petrophysical Logs -After section or well Drilled)
- LOGGING WHILE DRILLING (Petrophysical Logs – Realtime usually by Mud Pulse Telemetry).

- The simplest and most direct tool is [well cuttings](#) examination. Early Last Century oilmen ground the cuttings between their teeth and tasted to see if crude oil was present.
- Today, a wellsite geologist or mudlogger uses a low powered stereoscopic [microscope](#) to determine the [lithology](#) of the formation being drilled and to estimate porosity and possible oil staining.
- The Cuttings ground up by the bit are brought to the surface by pumping mud down the drill pipe and up the hole. Any gas in the formation is also pumped up and analysed by a chromatograph. The time taken to pump up the cuttings and gas is called the LAG TIME and is crucial in determining at what depth the formation came from.

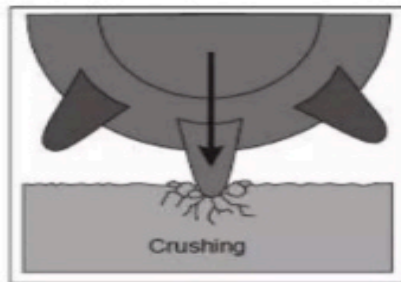
Mud Circulation System



Circulating System

- <https://www.youtube.com/watch?v=8RB-KDTbmwU>

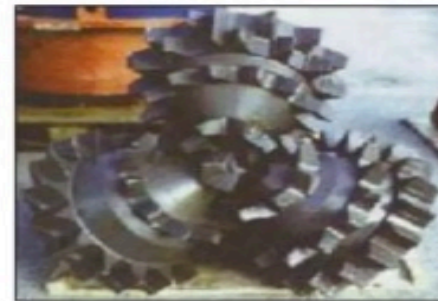
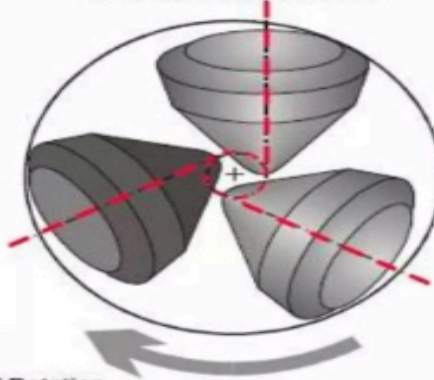
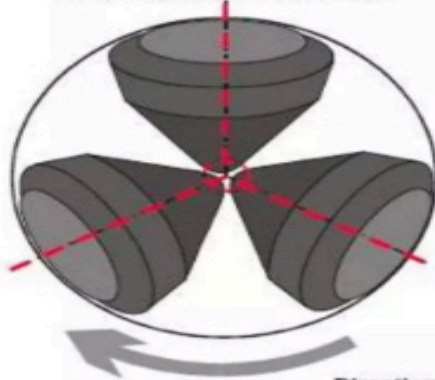
How Bits Drill?



Roller cone bit with no offset

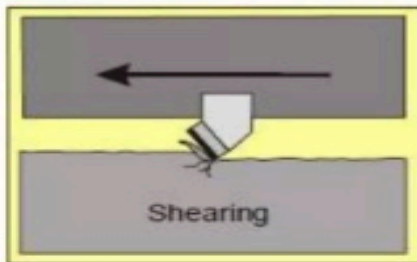


Roller cone bit with offset

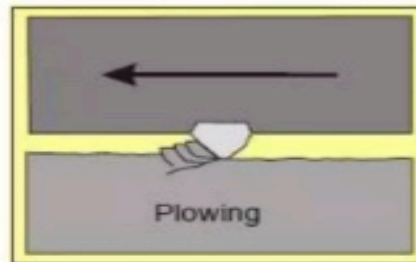


How Bits Drill?

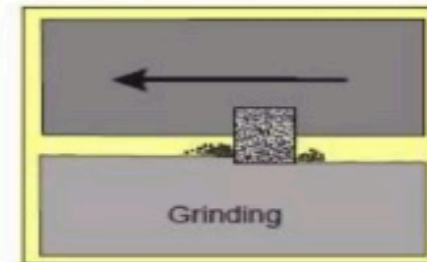
Cutting Size



PDC bit



Natural diamond bit

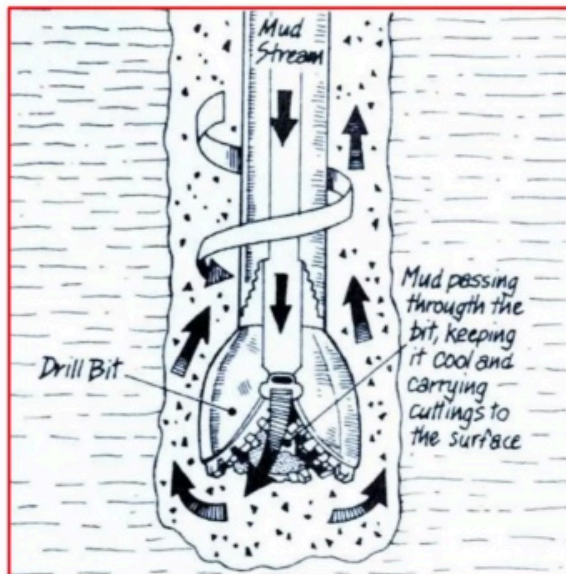


Diamond-impregnated bit



Well cuttings

- *Cuttings* are the small pieces of rock that are chipped away by the bit while a well is being drilled.
- Well cuttings are sampled at regular interval usually **2 m** (wildcat wells) and **5 m** (production wells).
- Interval is short at reservoir is strike called ditch sample.



Shale Shakers

- <https://www.youtube.com/watch?v=D4WOmplcQ3I>

Cuttings



Sample Drying



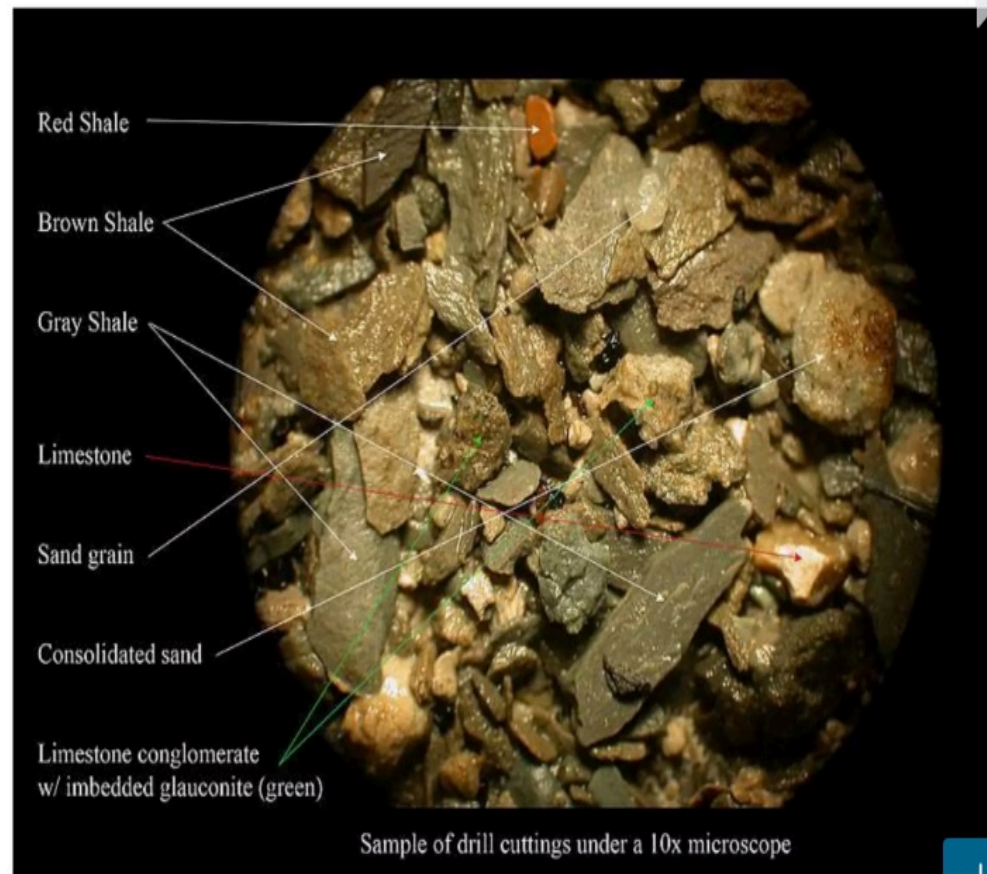


FIGURE 8. Drilling cuttings. (a) Normal PDC cuttings of shales; (b) blocky cuttings from a formation with preexisting fractures.

MUDLOGGING



Advantage of Cutting Analysis

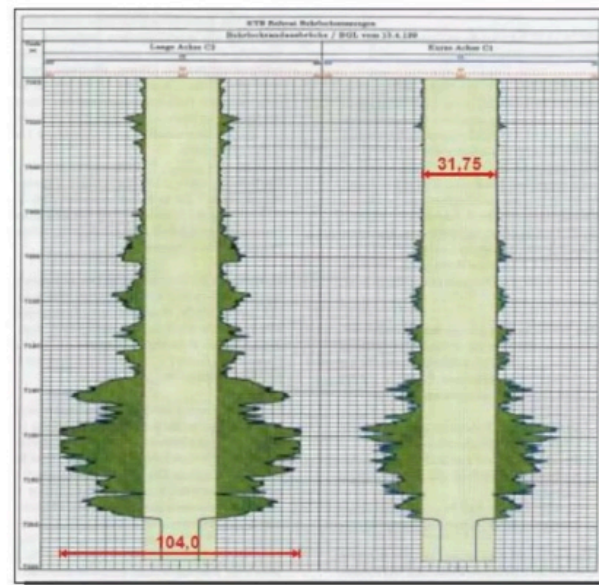
- Cheap and quick study
- First or only opportunity to look at the rock
- Immediate interpretation of Sed. Sequence
- Only small quantity of material required.
- Selection of fragments to be analyzed.
- Individual analysis of each fragments.
- Averaging of rock types over a certain interval
- Detailed information on rock composition, texture, fossil, ...

What is the Lag-Time?

„Lag-Time“ is the definite time interval, which is always required for pumping the samples from a particular depth to the surface where they become accessible.

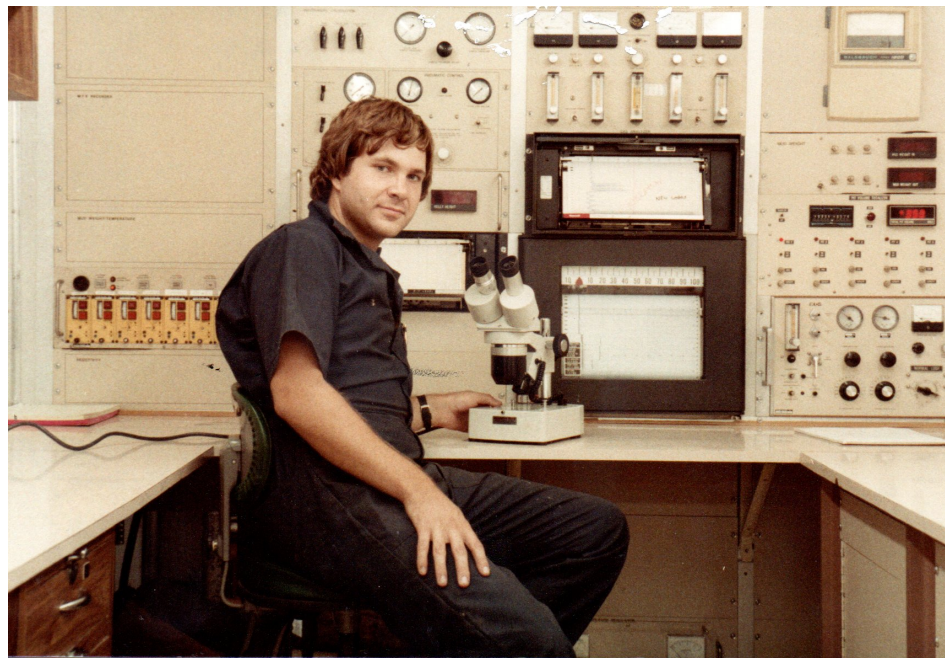
The lag-time applies to all downhole information, the formation cuttings and the fluids (gas, oil and water) which they contain.

Borehole Break-Outs



Various materials (such as whole oats, rice, barley or lentils) may be used as tracers and picked up on the shaker screen for approximating the lag.











Cutting petrography



Cuttings Sample Description	
1. Rock name	
2. Color	
3. Hardness, fissility	
4. Elements or grains	
Clastics	Carbonates
a. grain size	a. "grain" nature
b. roundness	b. "grain" size
c. sphericity	
d. sorting	
5. Cement and matrix	
Clastics	Carbonates
a. abundance	a. abundance
b. nature	b. crystallinity
6. Accessories, fossils	
7. Visual porosity estimation	
8. Hydrocarbon indications	
a. visual (stains and bleeding)	
b. direct fluorescence (extent, intensity and color)	
c. cut fluorescence (rate, intensity and color)	





Normal cutting

Caving and Sloughing

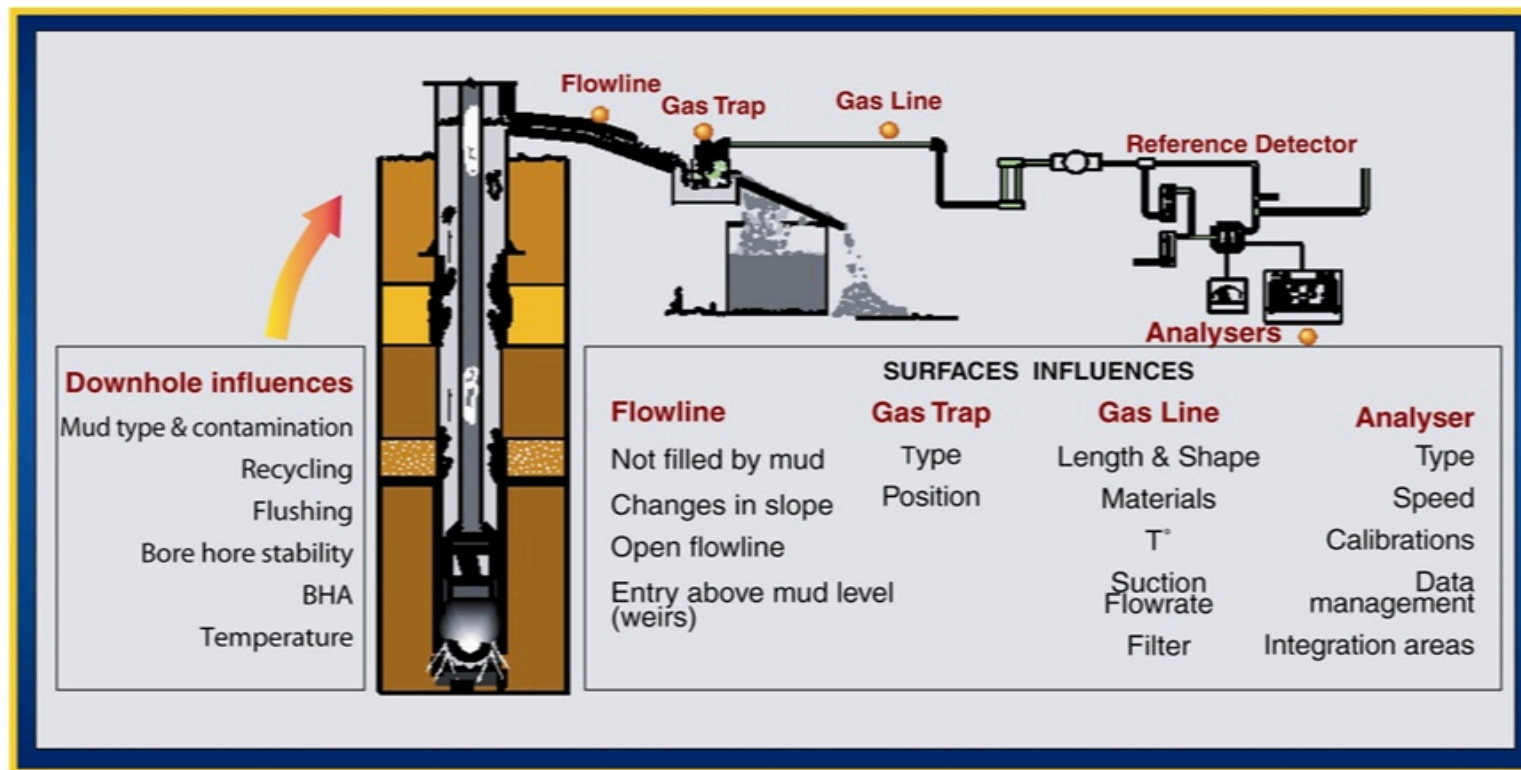
SHOWS



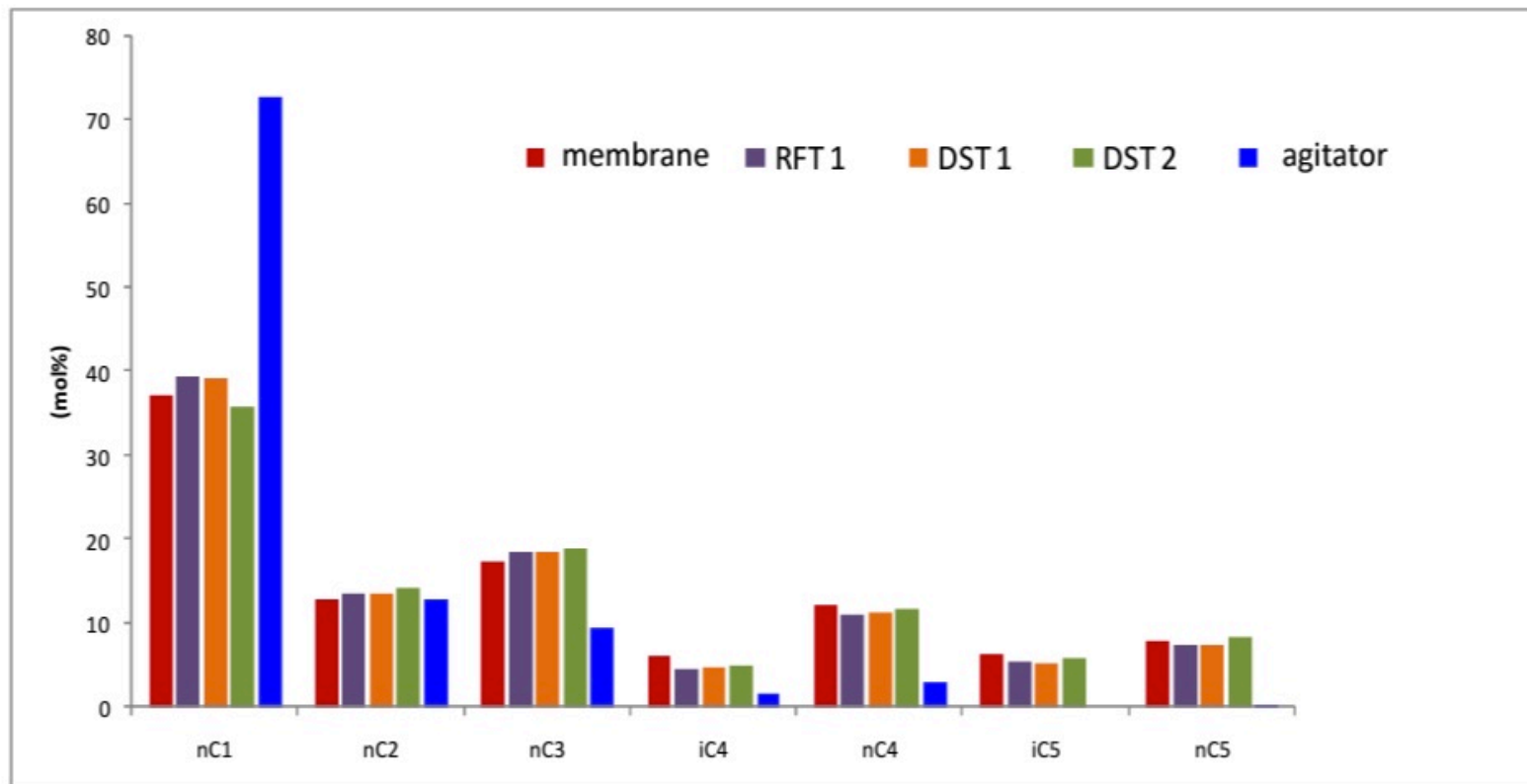
Cuttings fluorescence

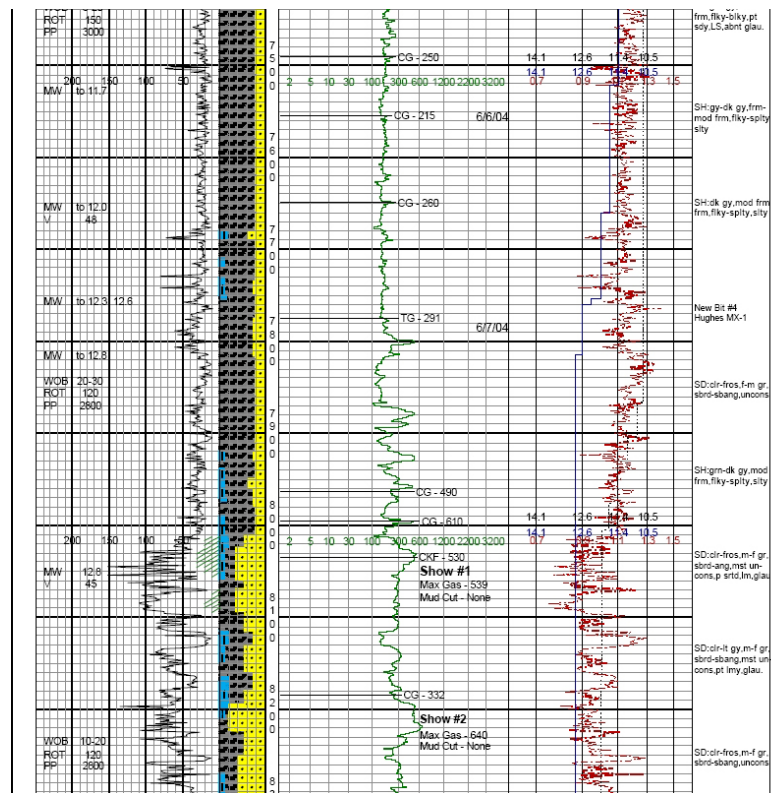
- <https://nightsea.com/articles/oilfield-geology-and-fluorescence/>

Gas Analysis



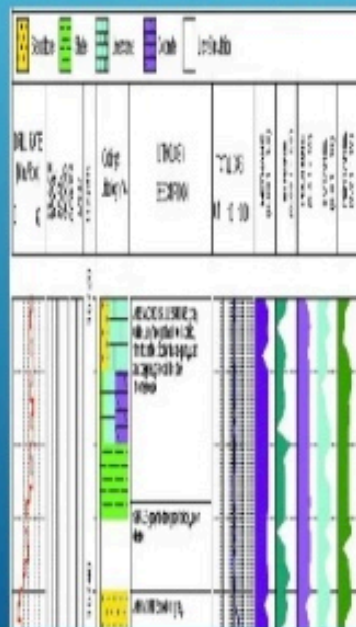
Gases detected



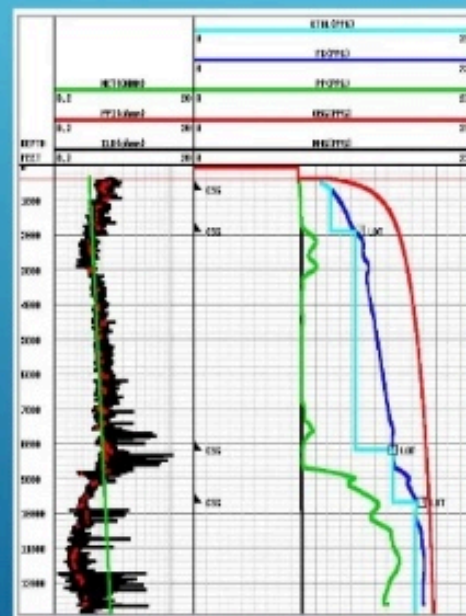


Deliverables of the Mudlogging Contractor

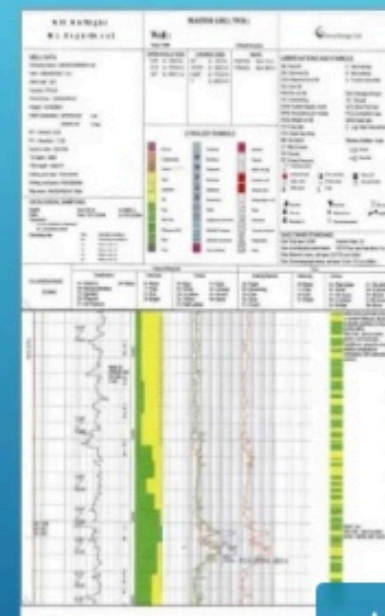
- Mudlogs, gas logs, drilling logs, pressure logs
- Reports (daily, weekly, final)



Gas Log

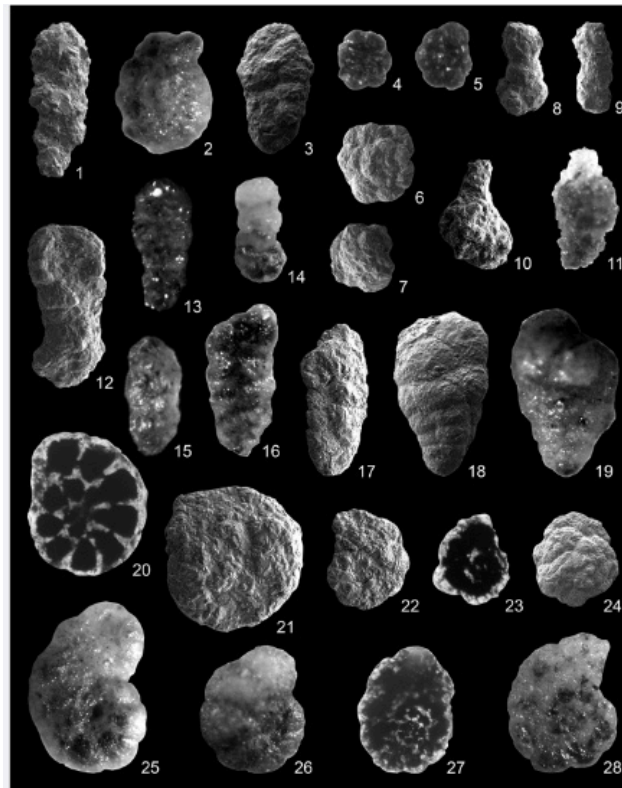


Pressure Log

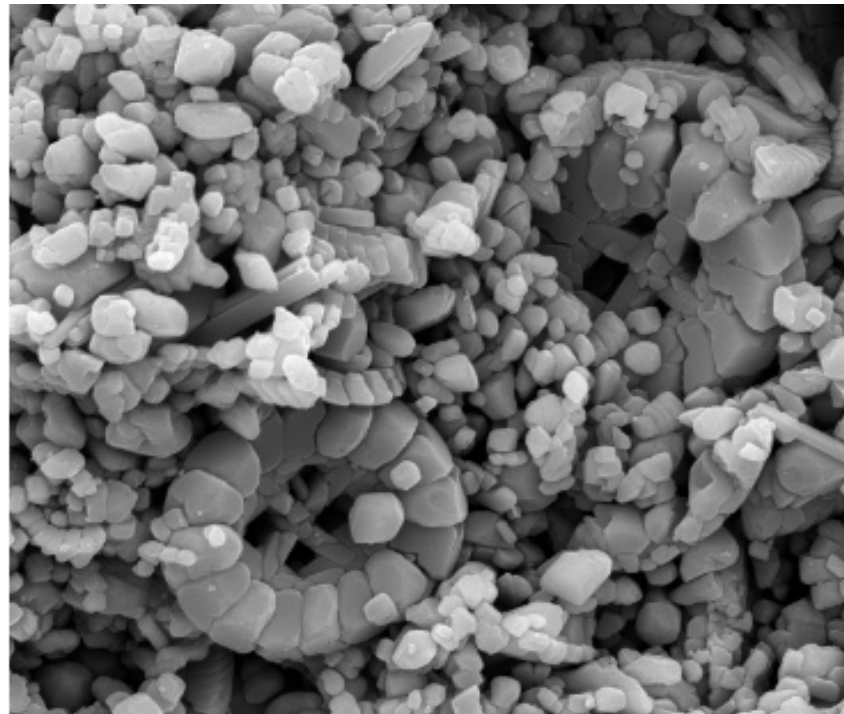


Mud Log

Micropaleontology – drill bit location using forams.



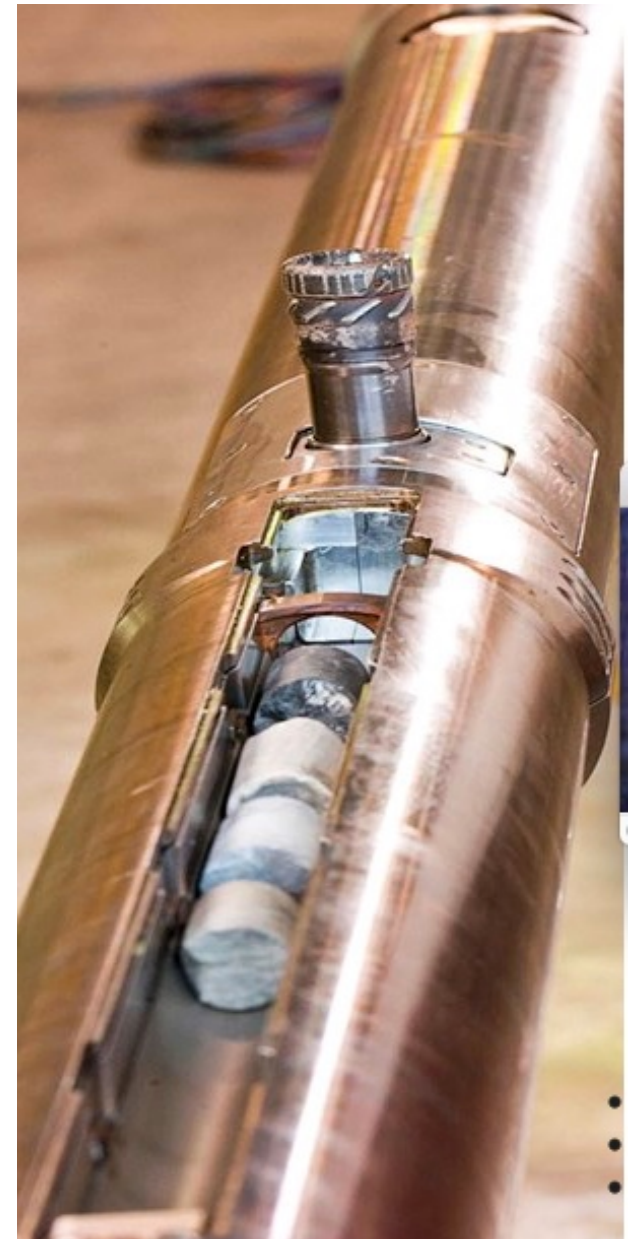
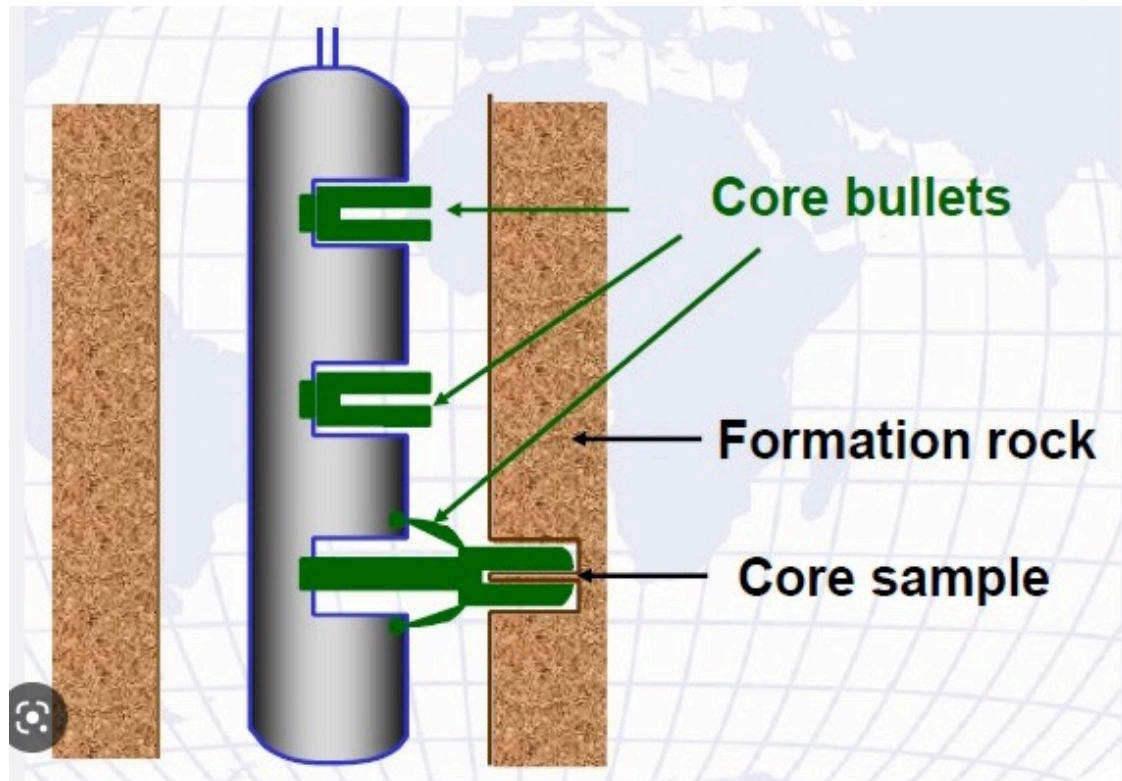
Paleopalynology – used extensively in Chalk reservoirs in Denmark



Coring

- Normal Drilling is stopped and specialized Core bit with an core barrel run to "CUT" a core – usually no more than 5 in in diameter and 30 m long.
- Very Expensive
- However can see sedimentary structures and examine porosity and permeability direct.
- Often done when exploring a new reservoir.

Wireline Sidewall Coring



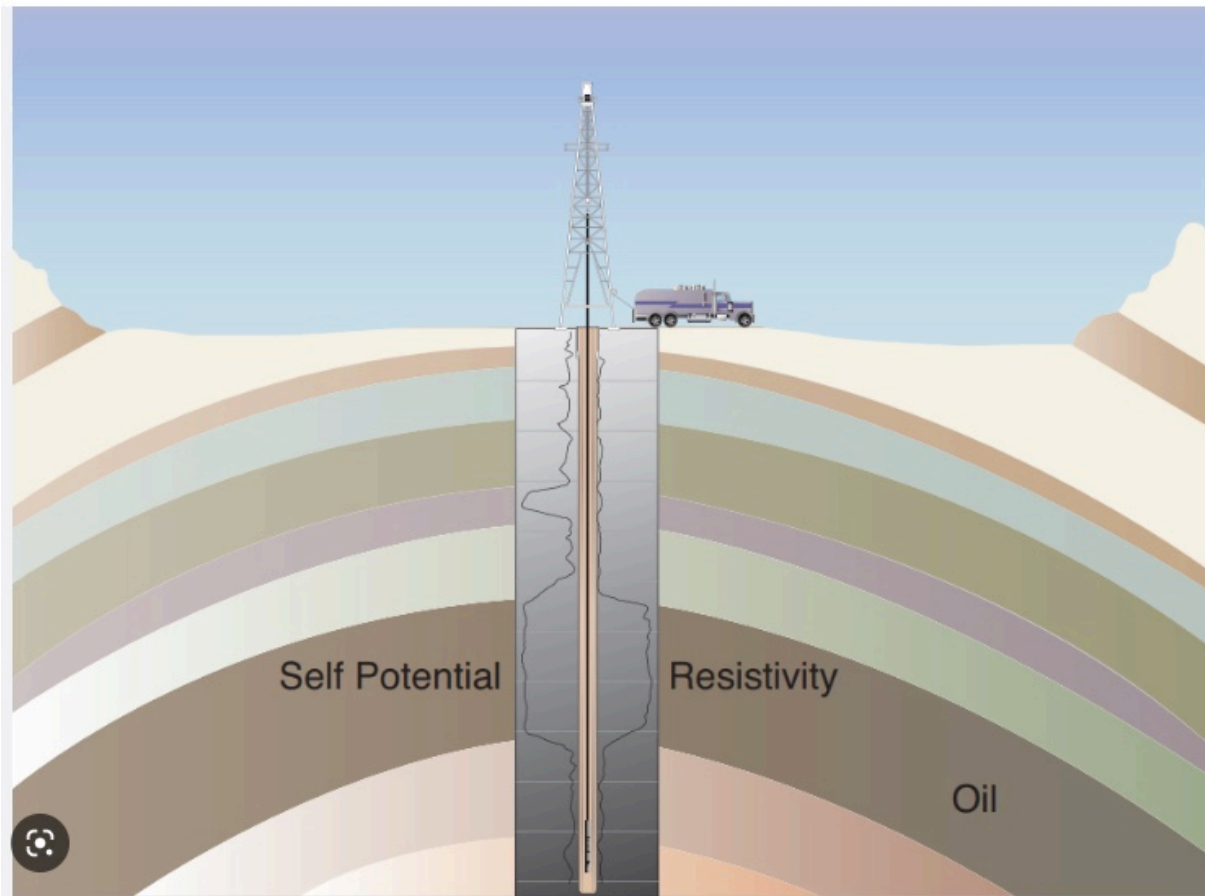


WIRELINING LOGGING

- <https://www.youtube.com/watch?v=jGb3ICfSwZQ>







An electric log measures the degree to which a subsurface formation responds to electric current. The results supply information about the nature of the rock...

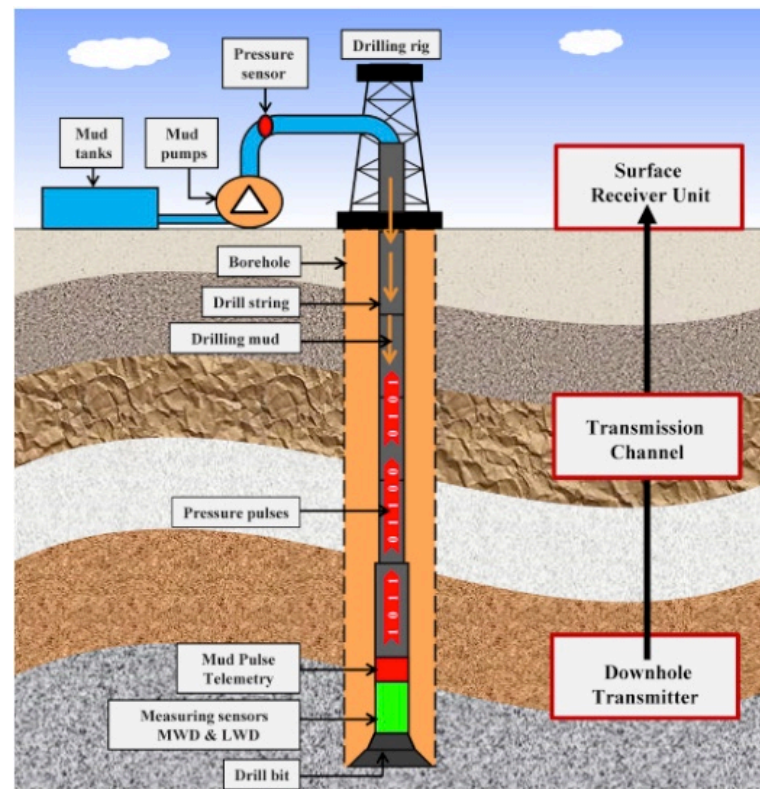
[Visit](#)

- Disadvantages of Wireline Logging .
- Need to stop drilling and pull bit out of hole to run
- Can take several days – therefore using lots of expensive rig time (Drillship can be over \$1m for 24 hours)
- Performed several days after hole section drilled – can get invasion of drilling mud into the formation.

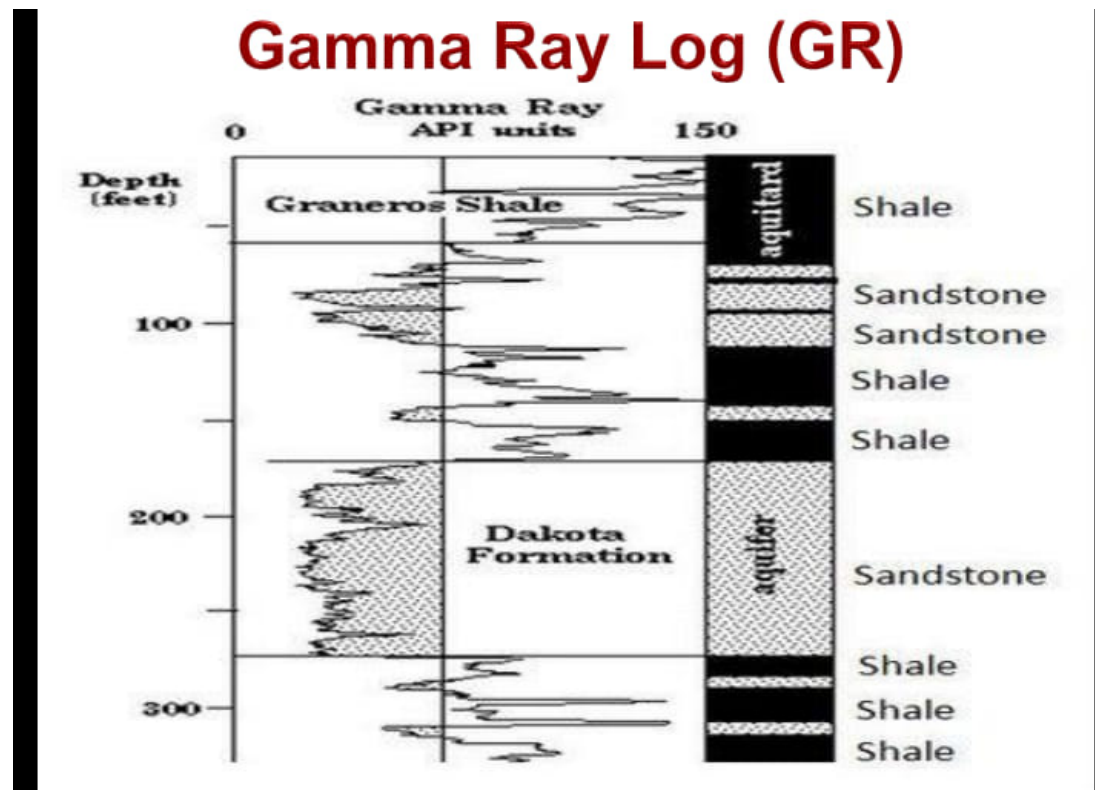
LOGGING WHILE DRILLING - LWD

- Incorporating Wireline Petro physical Logging Methods within the drill string so evaluation can be performed Realtime
- Initiated in the 1980 by increased need to drill directional and horizontal wells.
- Main innovation was developing MUD PULSE TELEMETRY – sending data up to surface by oscilating pressure pulses in the drill mud.
- Initially only Inclination, Azimuth and gamma Ray
- Now includes Nuclear Magnetic Resonance and density Imaging

Mud Pulse Telemetry – over 20 bit/sec Baud rate possible. Considering drilling is often only 5 - 20 m/hr high resolution data logs possible.



Natural Gamma Ray log – differentiates Shale and Sandstone



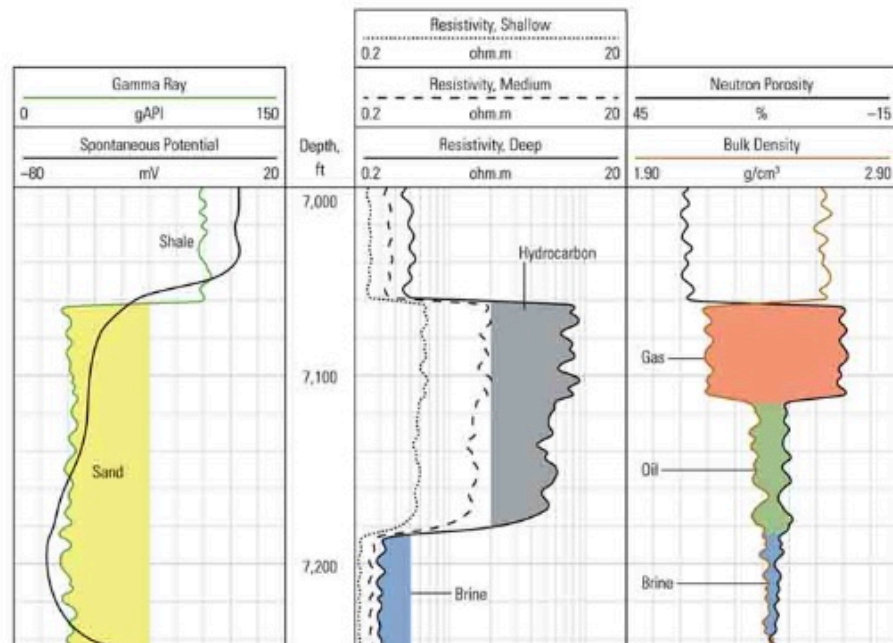
Resistivity Logging – electrical resistance of formation.

Basic Well Log Interpretation

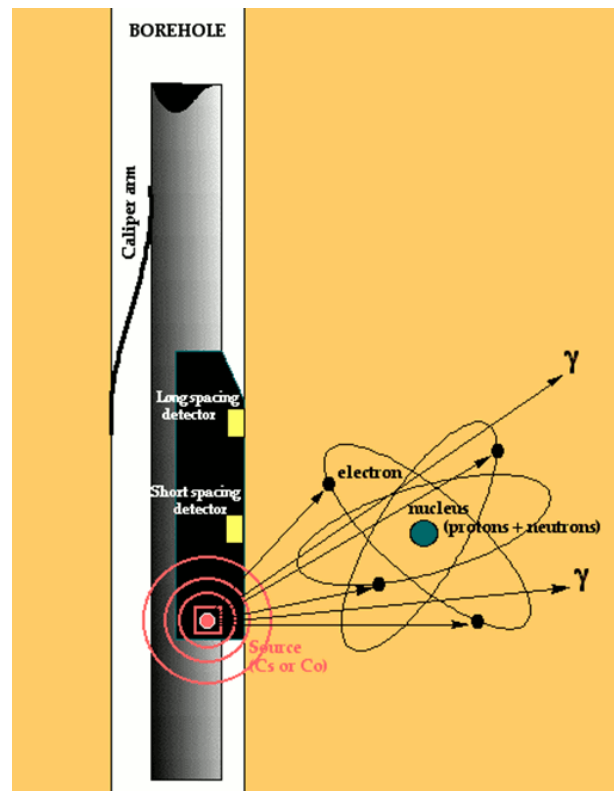
Matt Varhaug
Senior Editor

Well logs present a concise, detailed plot of formation parameters versus depth. From these plots, interpreters can identify lithologies, differentiate between porous and nonporous rock and quickly recognize pay zones in subsurface formations. The ability to interpret a log lies in recognizing the significance of each measurement.

Logging tools record the magnitude of a specific formation property, such as resistivity, measured as the tool traverses an interval defined by depth; a well log is a chart that shows the value of that measurement plotted versus depth. During the early days of commercial well logging, logs were primarily used qualitatively for making formation correlations; within a given field or local geological province.



Density Logging



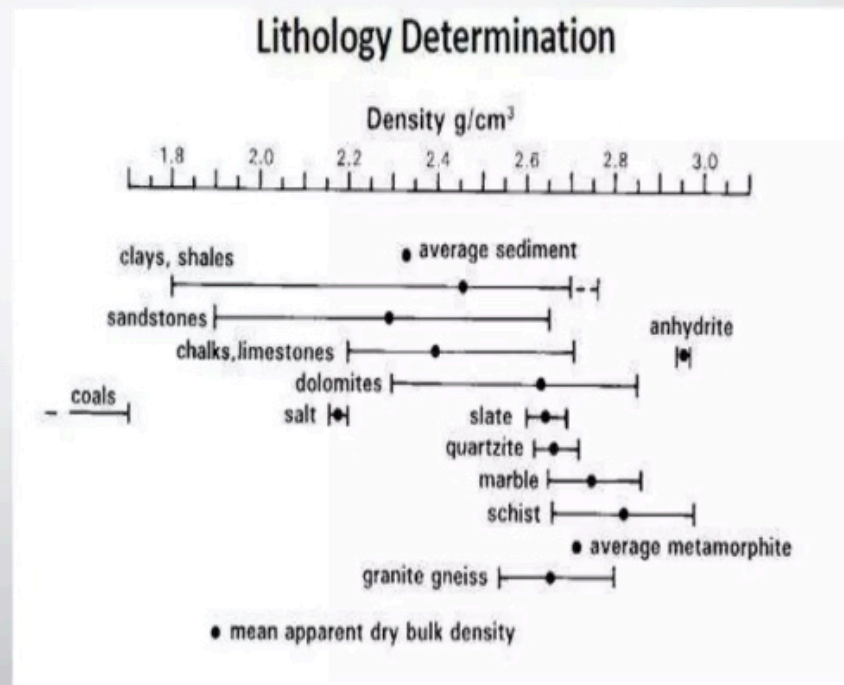
Sandstone with 30% Porosity:

<u>Pore Fluid</u>	<u>Density</u>
Salt Water	2.164
Fresh Water	2.155
Oil	2.095
Gas	1.856

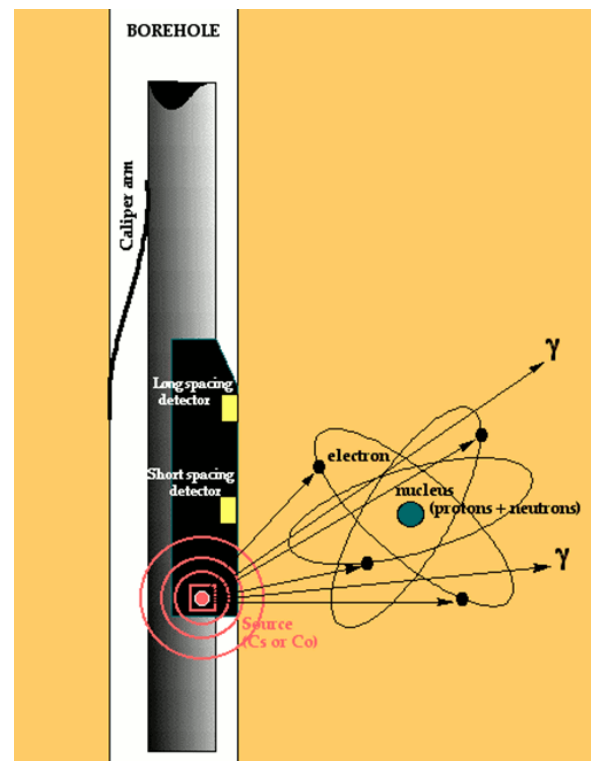
Material	Density(gm/cc)	Fluid	Density (gm/cc)
Quartz	2.65	Fresh Water	1.00
Calcite	2.71	Salt Water	1.15
Dolomite	2.87	Oil	0.85
Anhydrite	2.96		

IDENTIFICATION OF LITHOLOGY

- Formation density is not a useful tool for identifying lithology alone since most sedimentary rocks can have a range of densities that commonly overlap.
- When used in combination with the neutron log, lithology can be determined.
- Evaporites are usually very pure and have consistent densities, making them more easily identifiable than the other sedimentary rocks.

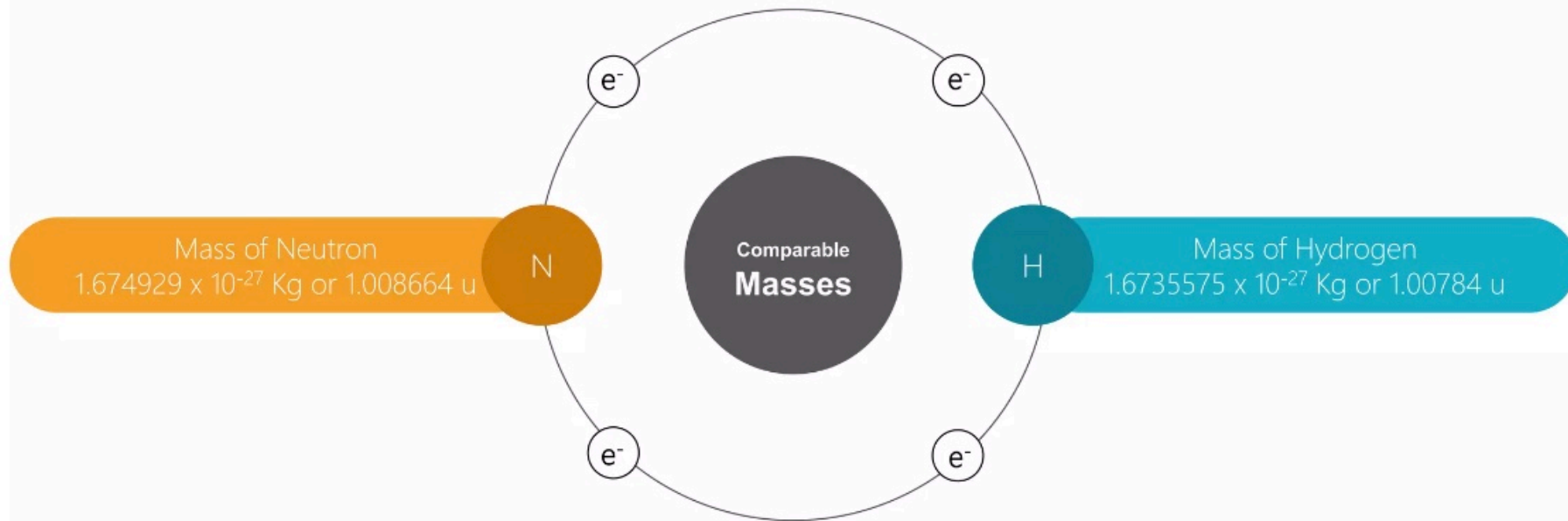


Neutron Porosity Logging



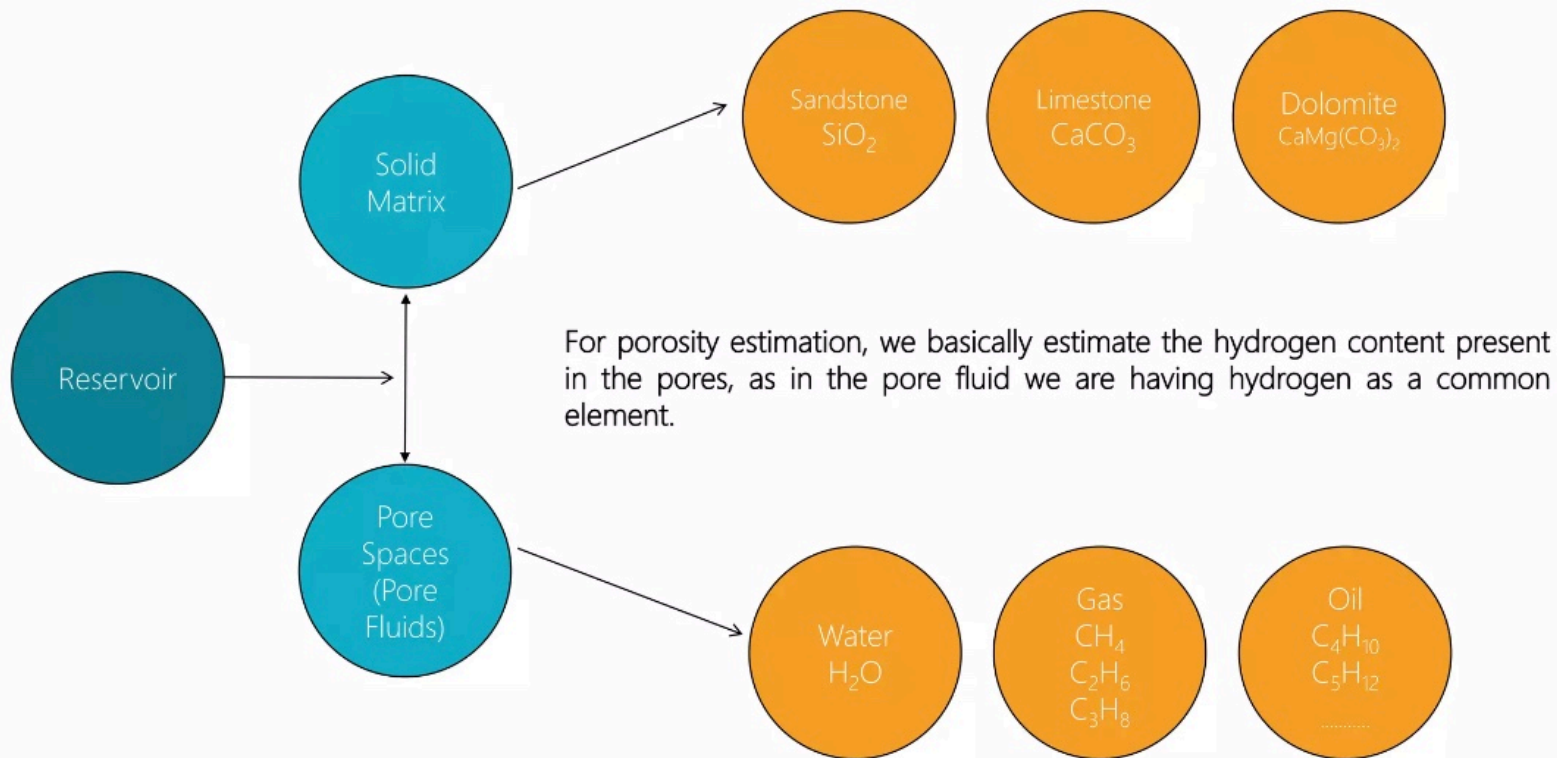
Neutrons sent into formation and are primarily absorbed by Hydrogen – hence indirect measurement of porosity as most Hydrogen in water or hydrocarbons

Masses

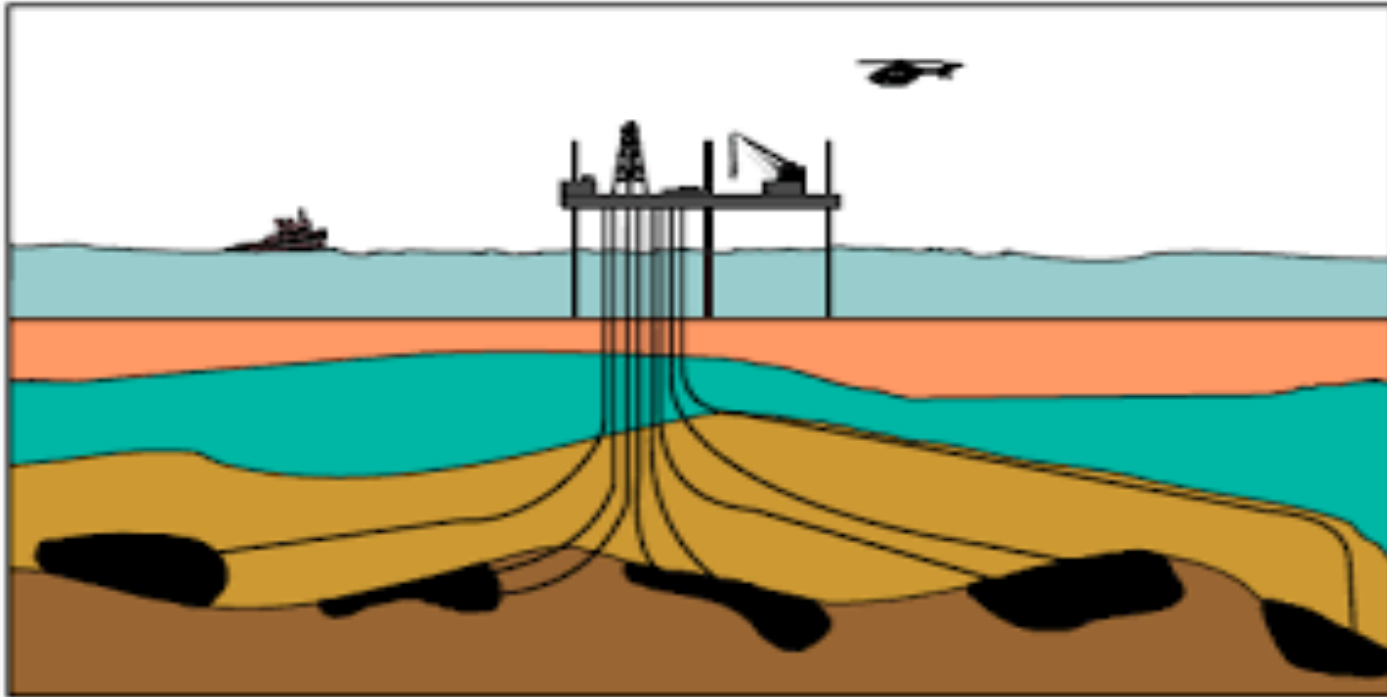


Due to comparable mass, there will be a maximum loss of energy

Matrix



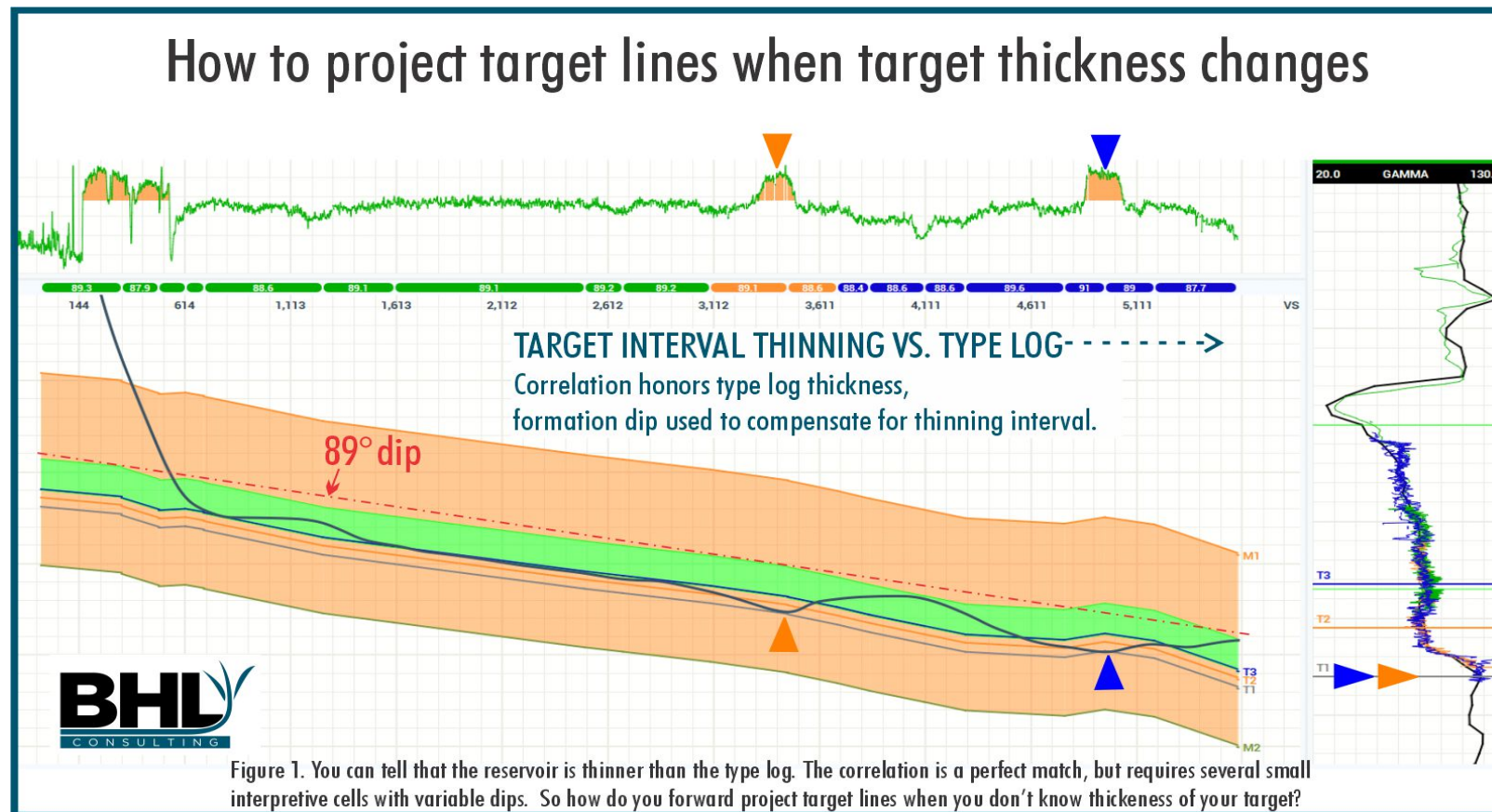
Directional Drilling



Directional drilling

- <https://www.youtube.com/watch?v=nIAsf1g6wQE>

Geosteering



Multi Lateral Wells

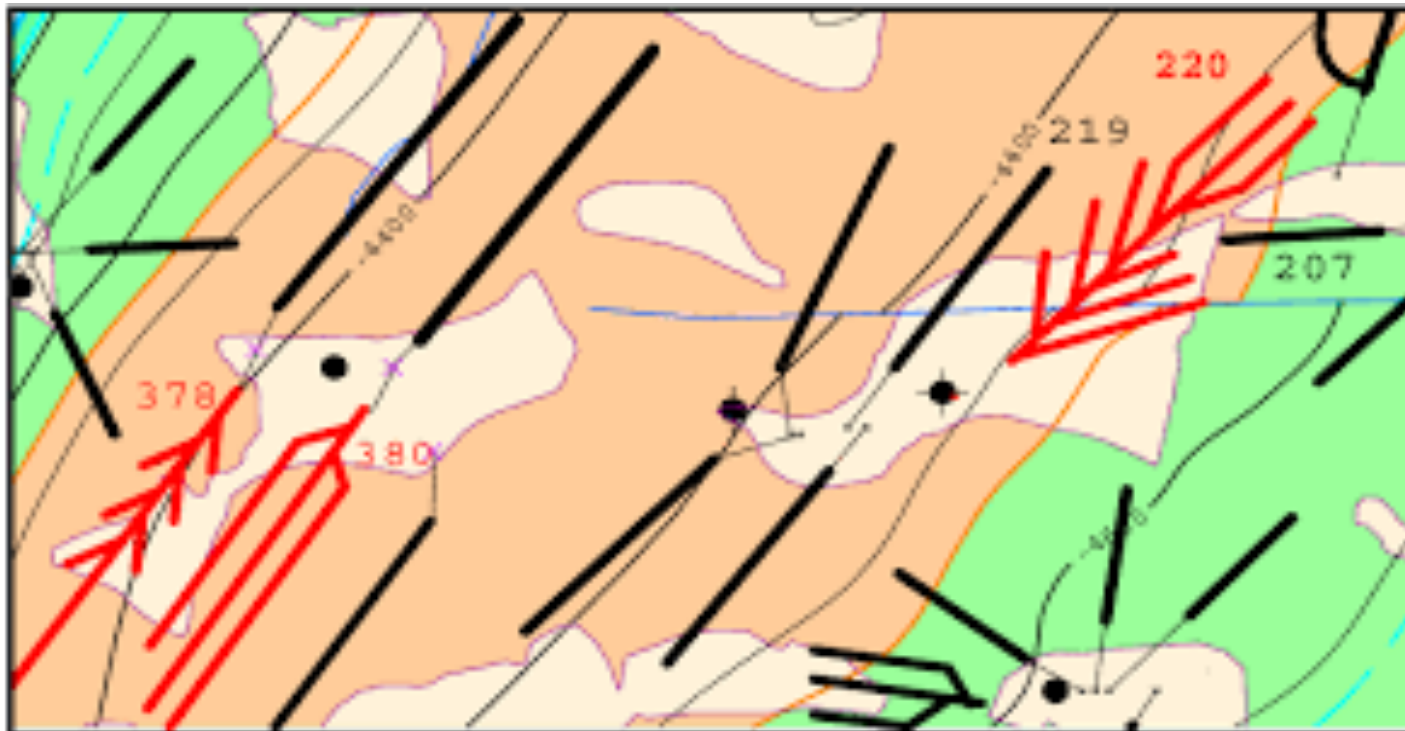


Figure 2- First MRC/Multi-laterals Wells in Shaybah Field

- Example LWD Logs