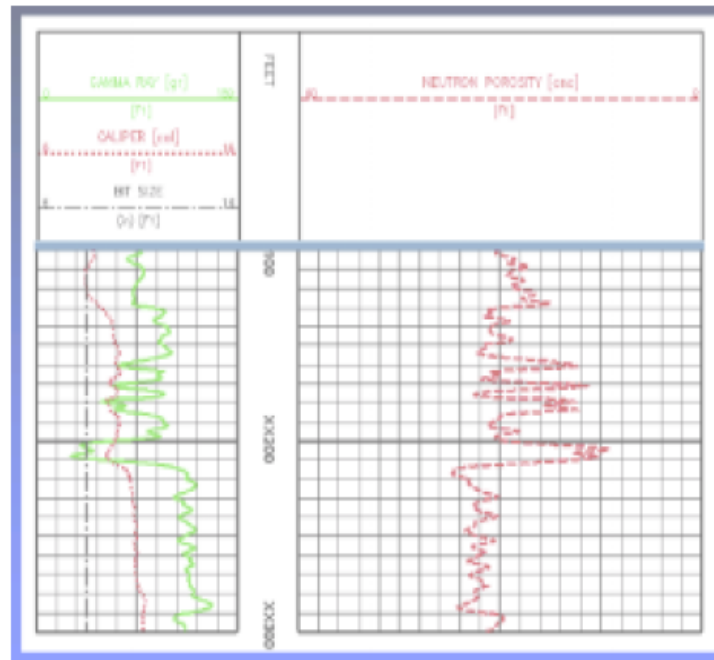


WELL LOG (The Bore Hole Image)

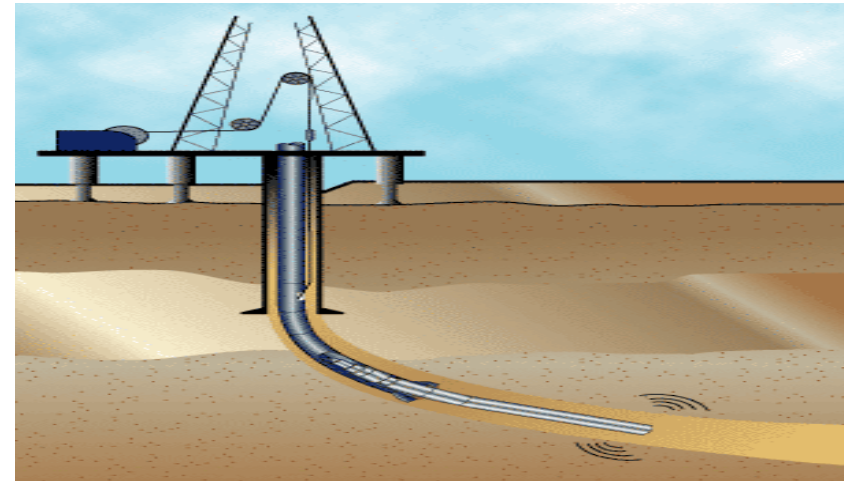
What is well Logging

- Well log is a continuous record of measurement made in bore hole respond to variation in some physical properties of rocks through which the bore hole is drilled.
- Traditionally Logs are display on girded papers shown in figure.
- Now a days the log may be taken as films, images, and in digital format.



HISTORY

- **1912** Conrad Schlumberger give the idea of using electrical measurements to map subsurface rock bodies.
- in **1919** Conrad Schlumberger and his brother Marcel begin work on well logs.
- The first electrical resistivity well log was taken in France, in 1927.
- The instrument which was use for this purpose is called **SONDE**, the sond was stopped at periodic intervals in bore hole and the and resistivity was plotted on graph paper.
- In 1929 the electrical resistivity logs are introduce on commercial scale in Venezuela, USA and Russia
- For correlation and identification of Hydrocarbon bearing strata.
- The photographic – film recorder was developed in 1936 the curves were SN, LN AND LAT
- The dip meter log were developed in 1930
- The Gamma Ray and Neutron Log were begin in 1941



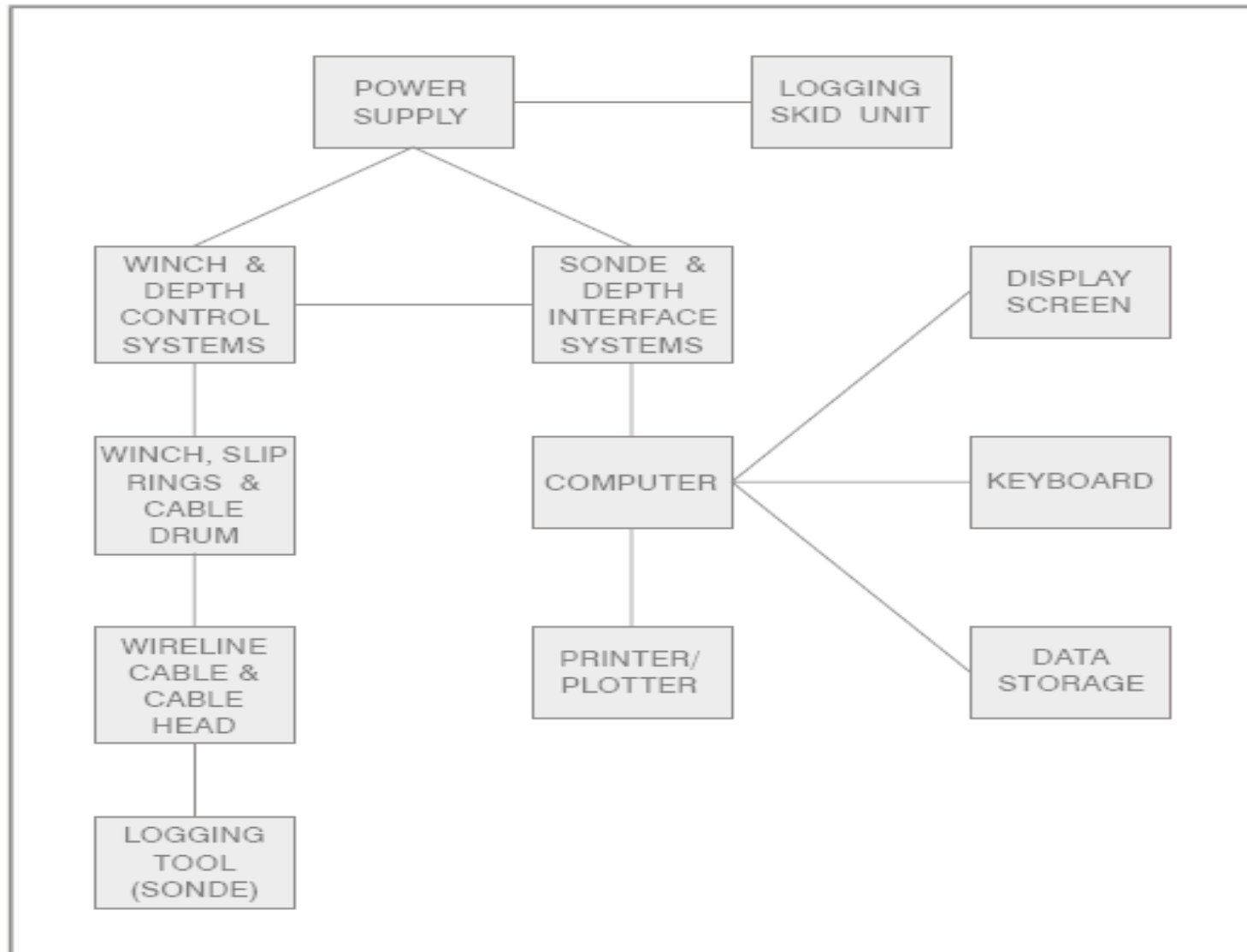
LOGGING UNITS

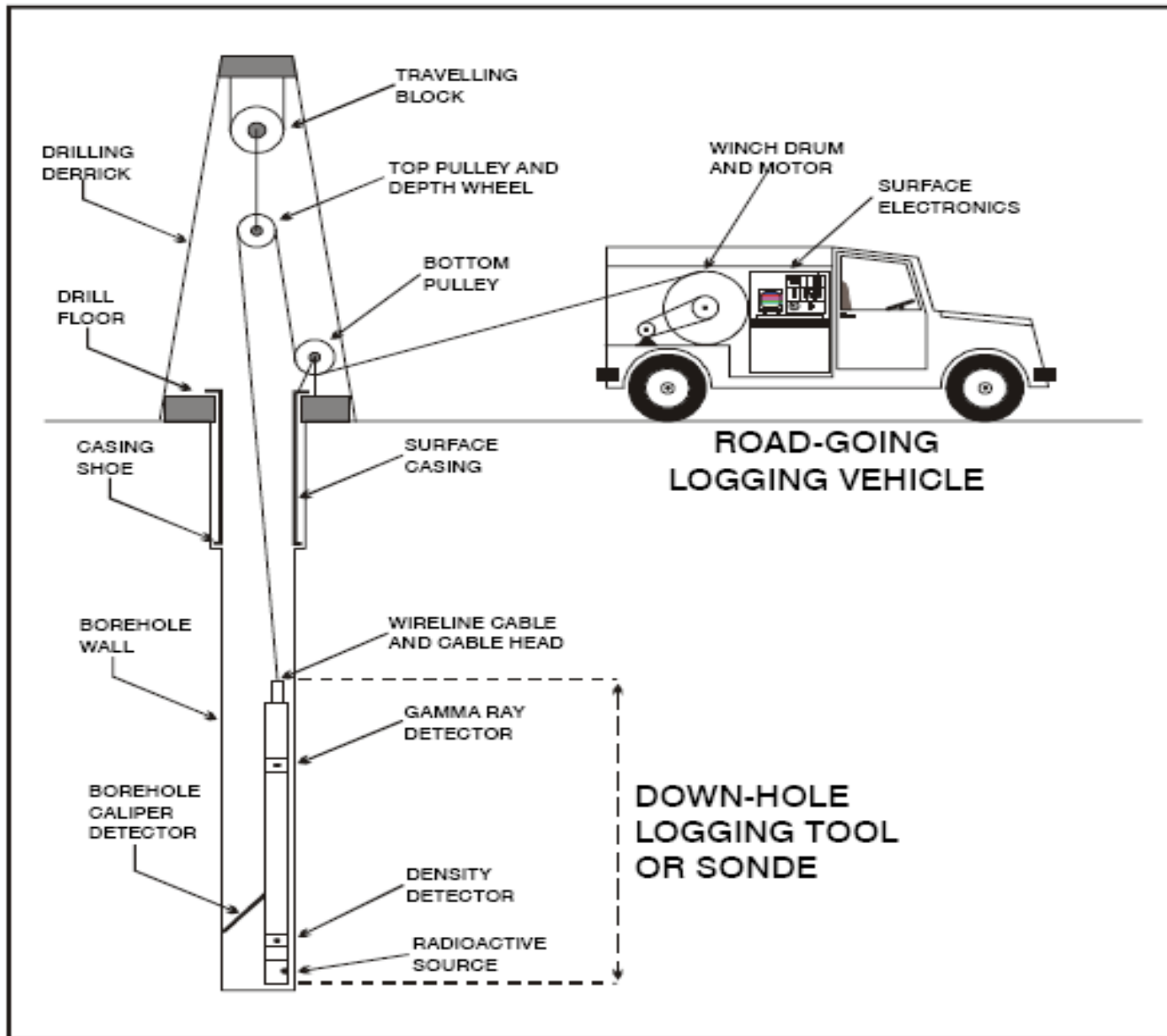
- Logging service companies utilize a variety of logging units, depending on the location (onshore or offshore) and requirements of the logging run. Each unit will contain the following components:
 - logging cable
 - winch to raise and lower the cable in the well
 - self-contained 120-volt AC generator
 - set of surface control panels
 - set of downhole tools (sondes and cartridges)
 - digital recording system



Schlumberger

Work Flow Chart



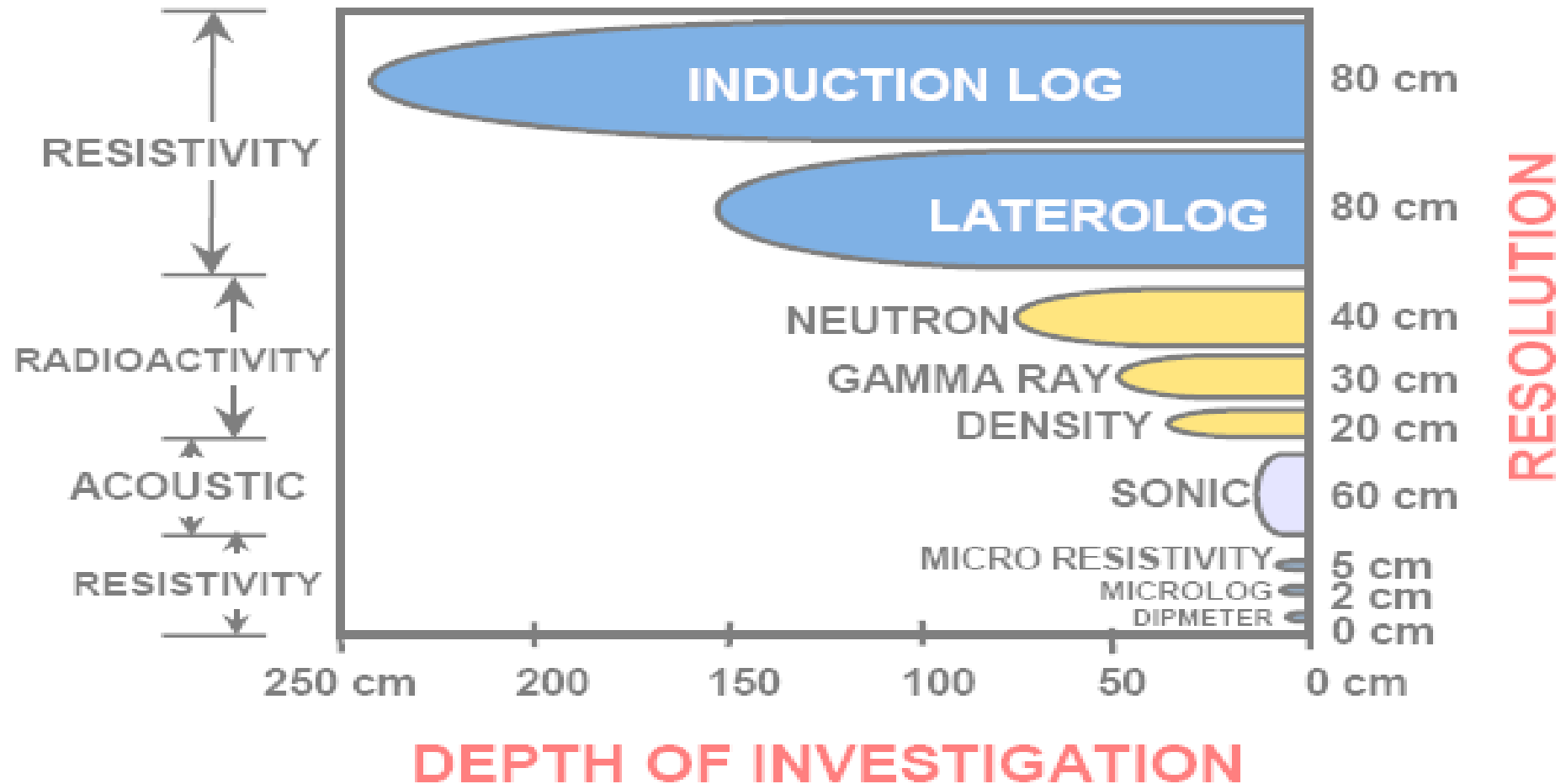


Applications

- depth to lithological boundaries
- lithology identification
- minerals grade/quality
- inter-borehole correlation
- structure mapping
- dip determination
- rock strength
- in-situ stress orientation
- fracture frequency
- porosity
- fluid salinity

Depth Of Investigation Of Logging Tools

Logging Tools



LOG INTERPRETATION OBJECTIVES

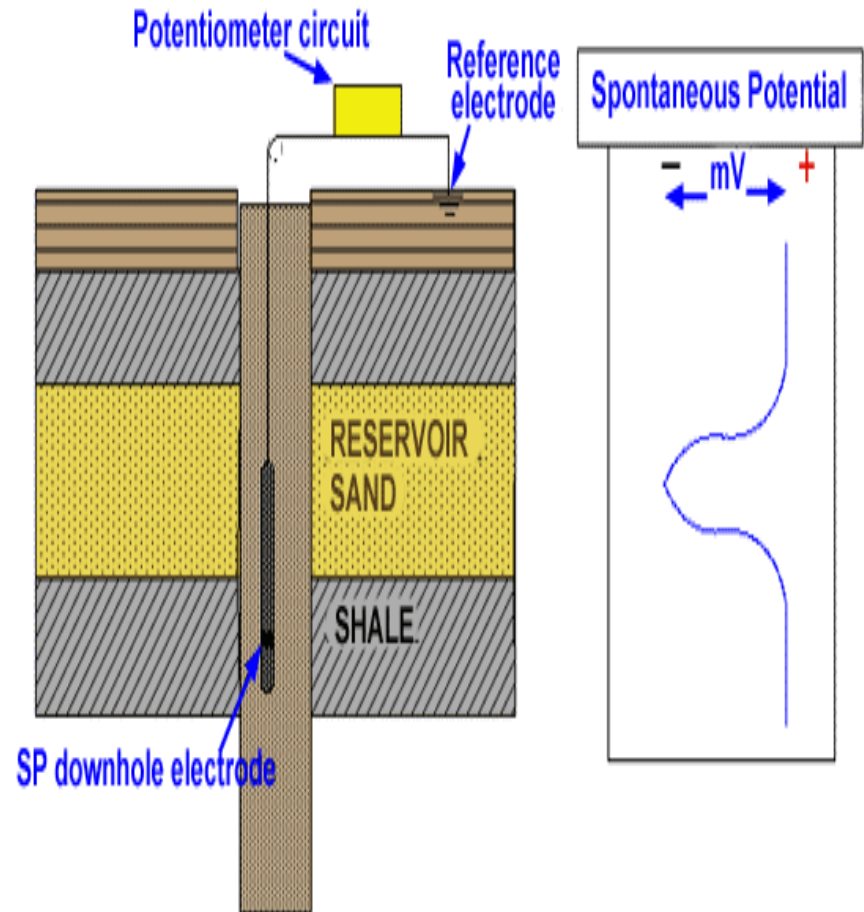
- The objective of log interpretation depends very much on the user. Quantitative analysis of well logs provides the analyst with values for a variety of primary parameters, such as:
 - porosity
 - water saturation, fluid type (oil/gas/water)
 - lithology
 - permeability
- From these, many corollary parameters can be derived by integration (and other means) to arrive at values for:
 - hydrocarbons-in-place
 - reserves (the recoverable fraction of hydrocarbons in-place)
 - mapping reservoir parameters
- But not all users of wireline logs have quantitative analysis as their objective. Many of them are more concerned with the geological and geophysical aspects. These users are interested in interpretation for:
 - well-to-well correlation
 - facies analysis
 - regional structural and sedimentary history
- In quantitative log analysis, the objective is to define
 - the type of reservoir (lithology)
 - its storage capacity (porosity)
 - its hydrocarbon type and content (saturation)
 - its producibility (permeability)

GAMMA RAY LOG

- Gamma Rays are high-energy electromagnetic waves which are emitted by atomic nuclei as a form of radiation
- Gamma ray log is measurement of natural radioactivity in formation verses depth.
- It measures the radiation emitting from naturally occurring U, Th, and K.
- It is also known as shale log.
- GR log reflects shale or clay content.
- Clean formations have low radioactivity level.
- Correlation between wells,
- Determination of bed boundaries,
- Evaluation of shale content within a formation,
- Mineral analysis,
- Depth control for log tie-ins, side-wall coring, or perforating.
- Particularly useful for defining shale beds when the sp is featureless
- GR log can be run in both open and cased hole

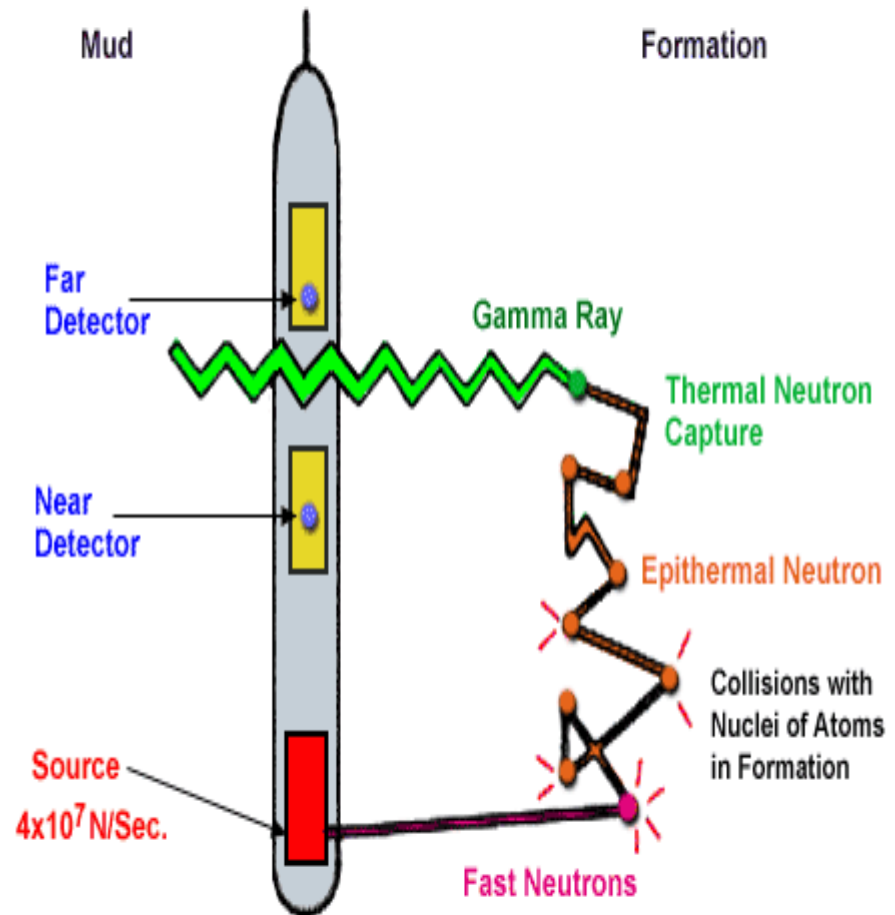
Spontaneous Potential Log (SP)

- The spontaneous potential (SP) curve records the naturally occurring electrical potential (voltage) produced by the interaction of formation connate water, conductive drilling fluid, and shale
- The SP curve reflects a difference in the electrical potential between a movable electrode in the borehole and a fixed reference electrode at the surface
- Though the SP is used primarily as a lithology indicator and as a correlation tool, it has other uses as well:
 - permeability indicator,
 - shale volume indicator
 - porosity indicator, and
 - measurement of R_w (hence formation water salinity).



Neutron Logging

- The Neutron Log is primarily used to evaluate formation porosity, but the fact that it is really just a hydrogen detector should always be kept in mind
- It is used to detect gas in certain situations, exploiting the lower hydrogen density, or hydrogen index
- The Neutron Log can be summarized as the continuous measurement of the induced radiation produced by the bombardment of that formation with a neutron source contained in the logging tool which sources emit fast neutrons that are eventually slowed by collisions with hydrogen atoms until they are captured (think of a billiard ball metaphor where the similar size of the particles is a factor). The capture results in the emission of a secondary gamma ray; some tools, especially older ones, detect the capture gamma ray (neutron-gamma log). Other tools detect intermediate (epithermal) neutrons or slow (thermal) neutrons (both referred to as neutron-neutron logs). Modern neutron tools most commonly count thermal neutrons with an He-3 type detector.

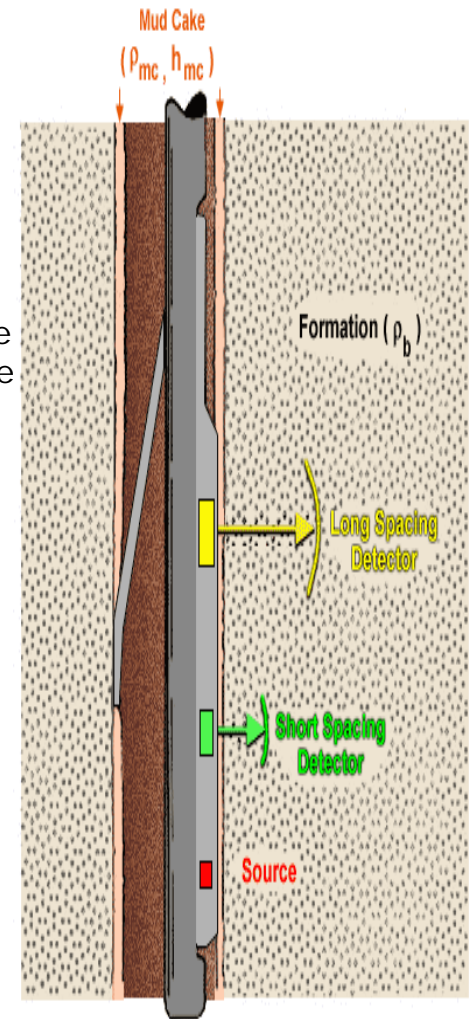


The Density Log

- The formation density log is a porosity log that measures **electron density** of a formation
- Dense formations absorb many gamma rays, while low-density formations absorb fewer. Thus, high-count rates at the detectors indicate low-density formations, whereas low count rates at the detectors indicate high-density formations.
- Therefore, scattered gamma rays reaching the detector is an indication of formation Density.
Scale and units:

The most frequently used scales are a range of 2.0 to 3.0 gm/cc or 1.95 to 2.95 gm/cc across two tracks.

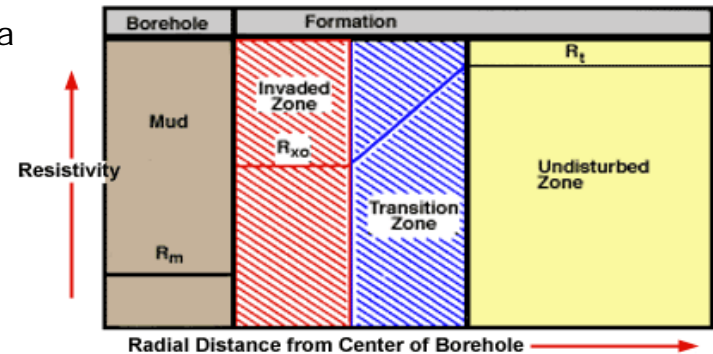
A density derived porosity curve is sometimes present in tracks #2 and #3 along with the bulk density (**rb**) and correction (**Dr**) curves. Track #1 contains a gamma ray log and caliper.



Resistivity Log

- Basics about the Resistivity:**

- Resistivity measures the electric properties of the formation
- Resistivity is measured as, R in Ω per m,
- Resistivity is the inverse of conductivity,
- The ability to conduct electric current depends upon:
 - The **Volume** of water,
 - The **Temperature** of the formation,
 - The **Salinity** of the formation



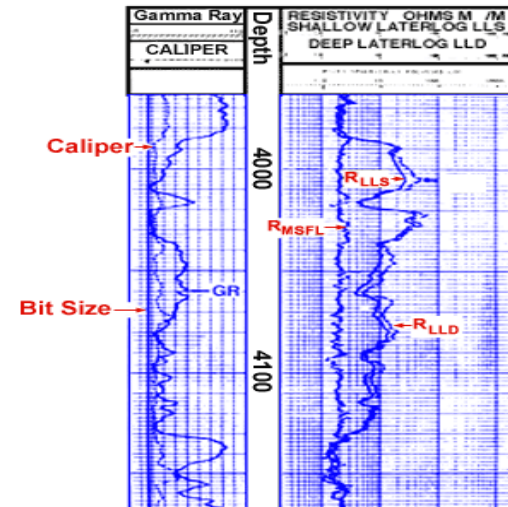
The Resistivity Log:

Resistivity logs measure the ability of rocks to conduct electrical current and are scaled in units of ohm-meters.

The Usage:

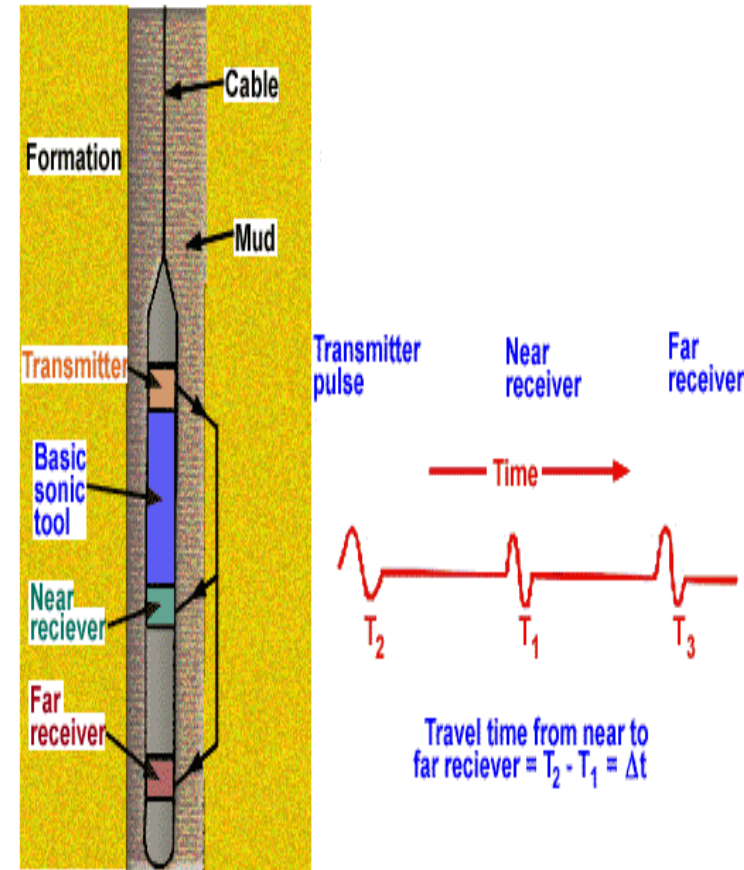
Resistivity logs are electric logs which are used to:

- Determine Hydrocarbon versus Water-bearing zones,
- Indicate Permeable zones,
- Determine Resistivity Porosity.



Acoustic Log

- Acoustic tools measure the speed of sound waves in subsurface formations. While the acoustic log can be used to determine porosity in consolidated formations, it is also valuable in other applications, such as:
- Indicating lithology (using the ratio of compressional velocity over shear velocity),
- Determining integrated travel time (an important tool for seismic/wellbore correlation),
- Correlation with other wells
- Detecting fractures and evaluating secondary porosity,
- Evaluating cement bonds between casing, and formation,
- Detecting over-pressure,
- Determining mechanical properties (in combination with the density log), and
- Determining acoustic impedance (in combination with the density log).



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