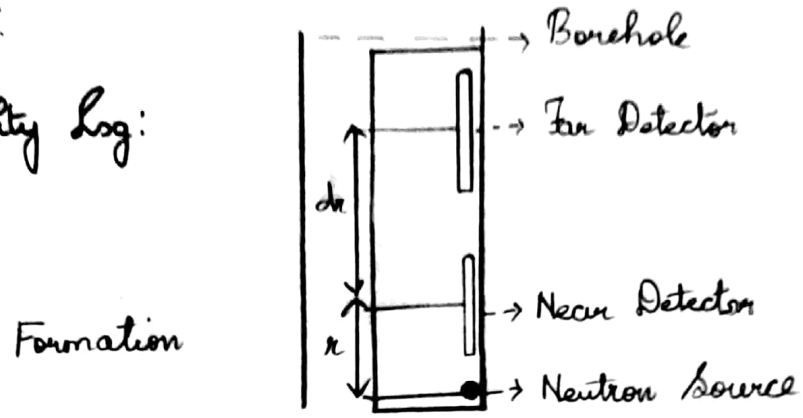
Unit 2) Explain Litho-density log & Nuclear Magnetic log with neat diagram.

Lithodensity Log:



→ It is a typical formation density tool that uses caesium 137 source emitting gamma rays from a short spaced and a long spaced detector.

→ Final density value obtained is more accurate than the basic formation density tool because the harder gamma rays are less prone to attenuation by borehole effects. Soft gamma rays undergo photoelectric absorption

Uses of Litho-Density log:

1. Determination of lithology 2. Determination of heavy minerals & Interwell correlation 3. Fractures

Factors influencing Litho-density log:

→ Mean atomic number of matrix

→ Tool operation

→ Log presentation

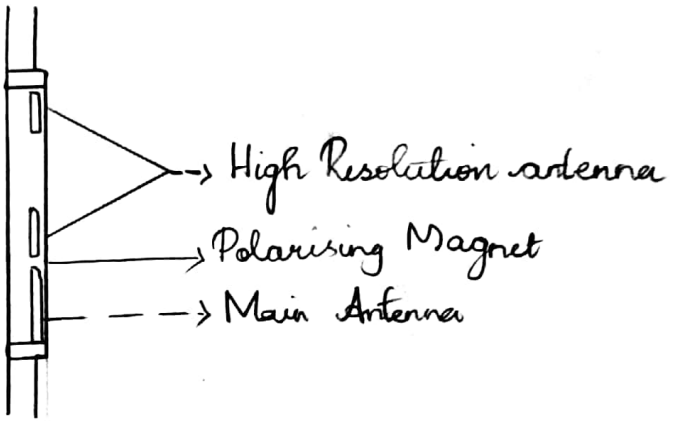
→ Depth of Investigation

→ Vertical Resolution

→ Borehole quality

→ Mud type.

Nuclear Magnetic Resonance log:



→ Hydrogen protons have an electric charge that behave like small magnets, their spin creates a weak magnetic field.

→ Strong static magnetic field spins the nuclei of atoms.

→ As the protons emit a weak but measurable radio signal which is measured by reciever coil of logging tool.

→ NMR tools rephase the signal multiple times to create a echo train. Two important parameters of echo train must be adjusted in Order to obtain reliable measurements. (Waiting time & Echo spacing)

→ NMR measurement consists of four basic steps

1. Polarising the material 2. Tipping the magnetization
3. Detecting the spin echoes 4. Re-polarising the nuclei.

VR of NMRL is equal to sum of antenna length and product of logging speed, cycle time & running average.

Uses of NMRL:

1. Poresize determination & Permeability Estimation
2. Hydrocarbon characterstics & Well Productivity
3. Water Saturation & Reservoir flow.
4. Residual Oil saturation & Textural information.

8) What are various electric logs? Discuss resistivity log & their applica old Electric tools.

→ Old electric tools are used with 2 or 3 electrodes and Dc current. It was discovered that the high quality of readings of resistivities obtained under conditions of small diameter boreholes, high mud resistivities in thick reservoirs.

→ Modern tools can actually cope with high resistivie muds which rely upon electromagnetic coupling & induce alternating current. (Induced log)

→ Modern electric log tool used for measuring resistivity in high salinity solution is called Laterolog, which focuses its current into a thin permeable sheet to improve Vertical resolution & penetration depth.

→ Induction log measures conductivity are also called conductivity logs.

→ Micro resistive logs have same kind of electrode arrangements with spacing of at most of few inches. These penetrate the formation to a small degree but not the mudcake. MSFL (Microspherically focussed log) are placed on centralizers so as to ensure current is focussed quasi spherically.

Resisturity log:

→ Measures natural or spontaneous potential difference that exists between borehole and surface in absence of any artificially applied electric field.

→ Requires only one electrode in borehole & one electrode in surface.

→ Resitivity log has three basic principles:

1. A conductive borehole fluid (water based mud)
2. Sandwich of porous, permeable & low porous, impermeable formation.
3. Difference in Salinity between borehole & formation fluid.

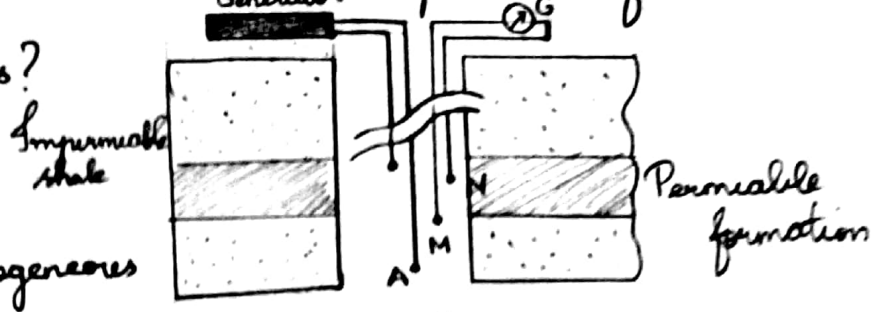
→ SP log has four main Components:

1. Electrochemical components - Diffusional & shale potential
2. Electrokinetic components - Mudcake & Shale wall potential.

Applications of Resistivity log:

1) Detection of permeable beds
2) Detection of R_w
3) Indication of shaliness of formation.
4) Correlation.
5) It has a low Vertical resolution, with a change of 10 mv.

a) Enumerate on the theoritical computation of normal & laterolog responses?



Normal log:

→ Consider a homogeneous & isotropic medium that extends to identify in all directions Now pass a current through electrode A in medium to another electrode B infinitely distant. When we take potential of electrode A, it will be $V_a = V$ & value of electrode at B is $V_b = 0$

→ Current flows spherically & generate equipotential surface with electrode A at its centre. If we place 3rd electrode M near A, which also lie near equipotential surface whose radius is r. If we connect electrode M to a voltmeter through electrode B, then value of potential is V_m.

Resistance of material between A & M is given by

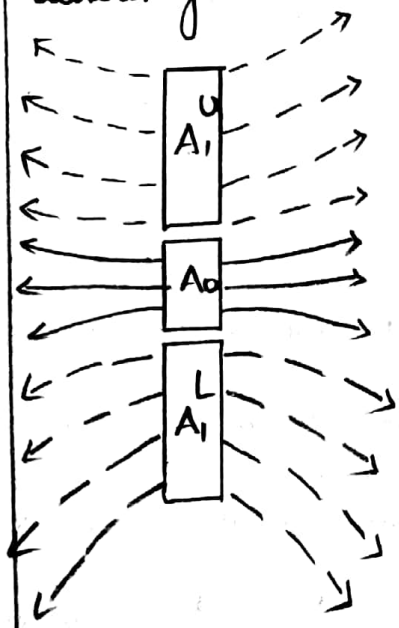
$$R = \frac{4\pi r (V_a - V_m)}{I}$$

→ Distance between A & M is called spacing that is basis for normal logging tools.

→ Short normal spacing is 16 inches; Long normal spacing is 64 inches.

→ Longer the spacing, greater the depth of penetration of current but with lono vertical resolution.

Laterologs:



Laterolog (LL_3 Configuration)

→ Laterologs (Eg: LL_3 & LL_7) have a number of electrodes.

→ LL_3 has 3 current emitting electrodes. Middle one emits main current & other two electrodes emit supporting current.

→ This is called Bucking current & electrodes are guard electrodes.

→ Potential is measured from the centre of electrode to potential at infinity of formation. This potential difference & current from central electrode gives formation resistivity.

→ Strongly focussed beam of current is slightly affected by hole size as it also invades formation ending up measuring resistivity at Virgin Zone.

→ Return electrode is placed very far from main central electrode.

10) Explain the natural gamma ray log & thermal neutron capture techniques?

Gamma ray log:

→ Gamma ray measures the total natural gamma radiation emanating from the formation. This originates from potassium 40 and the isotopes of Uranium - Radium & Thorium. Gamma ray also called GR logs.

→ As gamma rays are emitted from an isotope in the formation, they progressively reduce in energy as the result of collisions with other atoms in rock. This effect is called Compton Scattering.

→ Gamma ray intensity is a measure of

1) Initial intensity of gamma ray radiation
2) Amount of Compton scattering.

→ GR tool consists of high sensitive Gamma ray detector in form of Scintillation counter.

→ When a gamma ray strikes a crystal, a small light is produced & amplified using a photomeltiplier that consists of photo cathode and photo anodes in series.

→ Flash of light hits photocathode that produces no. of primary

electrons. Every electron hits anode & produces a no. of secondary electrons. This process is repeated for every 10 anods. This produces an electric current equal to 6^{10} electrons.

→ Whole process repeats till the photomultiplies saturates.

Thermal Neutron Capture Technique:

→ Induced gamma ray spectrometry tool generates neutrons at 14 Mev of energy.

→ At these high energies, class of interactions occur known as fast neutron scattering occur between atomic nuclei of borhole

→ Incident neutrons raise to higher level & hit the ground state with emission of radiation. Some fast nuclei interaction results in gamma ray emission.

→ Three types of fast neutron interactions are

1. Inelastic Scattering - (Fast neutron collides with nuclii with emission of gamma rays)
2. Nuclear reaction - (Fast neutron collides with nuclii with gamma ray measured by nuclear Rxn.)
3. Radioactivation - (Target Nucleus is transformed to another atom with Neutron-Nuclei interaction)

Thermal Neutron capture happens at small neutron flux, as in nuclear reaction, a single neutron captured by nucleus. If thermal neutrons are used, it is thermal neutron Capture.

12) What are Radioactive logs? What are Gamma ray logs and explain their importance.

Radioactive logs:

→ Radioactive logs are logs that measure the natural radiation generated by formation. such as total & spectral gamma ray &. those that the response of formation to radiation generated by tool such as neutron, density & litho density log.

Gamma ray logs:

→ Gamma ray measures the total natural gamma radiation emanating from the formation. This Originates from radiation of potassium 40 & isotopes of Uranium-Radium & Thorium. Also called GR logs.

→ As gamma rays are emitted from an isotope in formation, they progressively reduce in energy as result of collisions with other atoms in rock. This effect is called Compton Scattering.

→ Gamma ray intensity is a measure of

1. Initial intensity of gamma ray radiation
2. Amount of Compton scattering.

Factors defining GR log:

→ VR of GR log depends on: Size of detector, logging speed, hemispherical Zone of sensitivity

→ GR signal suffers with caved formation & denser mud.

→ Barite mud will give low gamma ray reading.

→ k-cl mud has a natural radioactivity.

Gamma Ray log Uses:

→ Determination of Lithology.

→ Determination of Shale Content

→ Depth Matching.

→ Cased hole correlations.

→ Recognition of Radioactive mineral deposits.

→ Facies & Depositional Analysis.

Importance of Gamma ray log:

→ Gamma rays are most important in petrophysical logging because they have high penetration of all radiation except neutrons. Their penetration ability means that they can detected through several cms. of cement casing.

Alpha & beta have very limited penetration ability being stopped immediately by any solid material.

13) Explain Density log? Write its principle, operation, interpretation & log presentation.

Density logging:

Density logging is a well logging tool that provides a continous record of formation bulk density along the length of borehole. Bulk density is a function of density of minerals formig a rock matrix & fluid enclosed in pore space.

Principle:

→ A density logging tool sends gamma rays into formation & detects those that are scattered back.

→ Average electron density in volume of formation probed by tool controls the scattered gamma ray count rates at detectors. Average electron density correlates strongly with effects of measurement. Average atomic number sets the amount of PE absorption that a formation exhibits

operation:

→ Density tool uses two detectors at progressively longer distance from the source.

→ Distance between near & far detector sets the Vertical resolution.

→ Correction is by spine & rib technique. Spine is normal calibrated relationship between density measured by near & far spaced detectors in absence of any gap between tool & borehole wall.

→ This correction is presented as a curve with density log.

Log interpretation:

Simple clean reservoir model,

$$\rho_b = \phi \rho_{fl} + (1-\phi)\rho_{ma}$$

$$\phi_T = \frac{\rho_{ma} - \rho_b}{\rho_{ma} - \rho_{fl}}$$

For shaly reservoir model,

$$\rho_b = \phi_e \rho_{fl} + (1 - \phi_e - V_{sh})\rho_{ma} + V_{sh}\rho_{sh}$$

Log presentation: