PORTRAYAL (CHARACTERIZATION) OF LITHOLOGICAL PROPERTIES BY USING SELF POTENTIAL LOG AND GAMMA RAY LOG

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ABSTRACT

The petrophysical assessment and lithological chacterisation of the Formation are practiced dependent on the anylysis of well logs. lithology is utilized as a gross recognizable proof for a stone layer in the subsurface and utilizations well-known names, for example, Sandstone (sand), Limestone, Dolostone (dolomite) ,Claystone (dirt), Chert, Coal, Shale (mudrock), Diatomite, Halite, Anhydrite, Gypsum, Tuff. The recognizable proof of a bed's lithology is key to all repository portrayal on the grounds that the physical and substance properties of the stone that holds hydrocarbons or potentially water influence the reaction of each instrument used to quantify arrangement properties. To make precise petrophysical estimations of porosity, water immersion (Sw), and penetrability, the different lithologies of the store interim must be recognized and their suggestions comprehended.

To decide all components of the lithology well log examination is significant. Well logs give a for all intents and purposes persistent study of the arrangements crossed by a well. The report contains every one of the techniques utilized for lithological examination by well logs.

Keyword: - *Petrophysical Property1, Gamma Ray Log2, Self, Potential log3.*

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1. Introduction

Subsurface lithology is commonly chosen from focus or cutting examination. Focuses are usually not endless and in this manner don't give a complete depiction of improvements crossed by a well. It might be difficult to restore the fragments and the thickness of the lithologic ,portion from cuttings. This is an immediate aftereffect of mud whirling, effect of surrendering (tumble down of divider areas), loss of specific constituents (salts and residue), or even the outright loss obviously. In this way, the lithologyof the segment subject to those data isn't sufficiently correct and correct for quantitative use.

Well logs give an in every practical sense reliable survey of the partical courses of action crossed by a well. They license estimation of apparent thickness and of veritable thickness if dipmeter data are considered. Burke et al. likewise, Clavier and Rust have demonstrated that well log responses can give a keen idea of the lithology. With the development of physical parameters recorded by flow logging gadgets e.g., parameters recorded by present day logging instruments e.g., photoelectric cross region, trademark or started gamma bar photoelectric cross portion, normal or induced gamma shaft spectrometry (GRS), and dielectric consistent it ends up being progressively clear that their mix can give a not too bad lithologic portrayal of the plans. This verification was the explanation behind the possibility of "electrofacies" described as "the position of log responses which depicts a bed and permits it to be perceived from various beds" .Applied to openhole logs, this electrofacies is a resemblance the lithofacies that, as indica ted by Moore, is the "finished entire of the lithological traits (tallying both physical and normal characters) of a stone." It isn't continually plainly obvious, regardless, to translate this electrofacies to the extent geologically noteworthy rocks type. A methodology merging present day wireline estimations with a lithofacies data base produced using logs (cautiously, an electrolithofacies data base) has wind up being convincing in this translation.[1]

The lithofacies are as of late portrayed from petrographic data and deciphered similarly as log responses. This structures a data base of rocks (sandstone, limestone, etc.) rather than minerals (quartz, calcite, etc.). Levels of log data are consigned to a given lithofacies by usage of the data base and an isolate work.

2.SELF POTENTIAL LOG

The SP curve is a continuous recording vs. depth of the electrical potential difference between a movable electrode in the borehole and a surface electrode.[1] Adjacent to shales of the formation type, SP readings usually define a straight line known as the shale baseline. Next to permeable formations, the curve departs from the shale baseline; in thick permeable beds, these excursions reach a constant departure from the shale baseline, defining the "sand line." The deflection may be either to the left (negative) or to the right (positive), depending on the relative salinities of the formation water and the mud filtrate. If the formation-water salinity is greater than the mud-filtrate salinity (the more common case), the deflection is to the left.

The relevant features of the SP curve are its shape and the size of its departure from the shale baseline. Because the absolute reading and position of the shale baseline on the log are irrelevant, the SP sensitivity scale and shale-baseline position are selected by the logging engineer for convenience. The SP log is typically scaled at 100 mV per log track. If the resistivities of the mud filtrate and formation water are similar, the SP deflections are small and the curve is rather featureless. An SP curve cannot be recorded in holes filled with nonconductive muds, such as oil-based muds.

2.1. Origin of the SP

Deflections of the SP curve are the result of electrochemical and electrokinetic potentials in the formations that cause electric currents to flow in the mud in the borehole.

2.2 . Electrochemical component

2.2.1. Membrane potential

The structure of clay minerals in shales and the concentration of negative electric charges on the clay particle surfaces give shales a selective permeability to electrically charged ions. Most shales act as "cationic membranes" that are permeable to positively charged ions (cations) and impermeable to negative ions (anions).[3]

The saline formation water in a sandstone formation and mud in the borehole separated by shale. Sodium chloride, which is usually present in both the formation water and the drilling mud, separates into charged ions (Na^+ and $Cl^–$) in solution in water. The Na^+ and $Cl^–$ ions tend to migrate from a more-concentrated to a less-concentrated solution, but because the intervening shale is a cationic membrane, impervious to $Cl^–$ ions, only the Na^+ ions can migrate. If, as usual, the formation water is a more concentrated NaCl solution than the mud, there is a net flow of positive ions through the shale from the sandstone to the borehole. This corresponds to a positive electric current in the same direction (indicated by the curved arrow) driven by an electric potential, or electromotive force (EMF), across the shale. Because the shale acts as an ion-selective membrane, the electric potential is known as the membrane potential.

2.2.2. Liquid-junction potential

At the edge of the invaded zone, where the mud filtrate and formation water are in direct contact, Na^+ and $Cl^–$ ions can move freely from one solution to the other. But $Cl^–$ ions are smaller and have greater mobility than Na^+ ions, so the net diffusion of ions from the more-concentrated formation water to the less-concentrated mud filtrate includes a greater number of $Cl^–$ ions than Na^+ions. This is equivalent to a positive current flow in the opposite direction (indicated by the straight arrow at A in The current flowing across the junction between solutions of different salinity is driven by an EMF called the liquid-junction potential. The magnitude of the liquid-junction potential is only approximately one-fifth of the membrane potential.

In case if permeable formation contains some shale or dispersed clay, the total electrochemical potential, and therefore the SP deflections, is reduced.

2.3. Electrokinetic Component

An electrokinetic potential (E_k, also called the streaming potential or electrofiltration potential) is produced when an electrolyte flows through a permeable medium.[3][4] The size of the electrokinetic potential is determined mainly by the differential pressure producing the flow and the resistivity of the electrolyte.

In the borehole, the electrokinetic potential E_{kmc} is produced by the flow of mud filtrate through the mudcake deposited on the borehole wall opposite permeable formations. Little or no electrokinetic potential is generated across the permeable formation itself because the differential pressure is usually low. The electrokinetic potential E_{ksh} may, however, be produced across a shale if it has any permeability.

Typically, E_{kmc} and E_{ksh} are similar in magnitude, and the net electrokinetic contribution to the SP deflection is negligible. If the formation water is fairly saline and the differential pressure is in the normal range of only a few hundred psi, the contribution of the electrokinetic potential can usually be ignored.

Electrokinetic effects may be significant in highly depleted formations or when heavy drilling muds are used because of unusually large differential pressures. Significant electrokinetic effects may also occur in very-low-permeability formations, where an appreciable part of the pressure differential occurs in the formation itself, especially if little or no mudcake is formed. If the formation water is brackish, the mud is resistive, and the low-permeability formation is clean and has some porosity, the electrokinetic effect could be as large.

2.4. SP and permeability

The movement of ions, essential to develop an SP, is possible only in formations with some permeability, however small—a small fraction of a millidarcy is sufficient. There is no direct relationship between the magnitude of the SP deflection and the value of either the formation’s porosity or permeability.

2.5. Static SP

The lower part shows SP currents in the borehole and formations. The current directions indicated correspond to the more usual case of formation-water salinity greater than mud-filtrate salinity, producing a potential by the permeable bed lower than the potential by the shale. This corresponds to a deflection to the left on the SP log by the permeable bed.

If the mud-filtrate salinity is greater than the formation-water salinity, the currents flow in the opposite direction, producing positive SP deflections. If the salinities of the mud filtrate and formation water are similar, no SP is generated.

The SP currents flow through four media:

- Borehole fluid
- The invaded zone
- The uninvaded part of the formation (permeable)
- shales

The SP log measures only the potential drop from the SP currents in the borehole fluid, which may not represent the total SP because there are also potential drops in the formation. If the currents could be interrupted by hypothetical insulating plugs the potential observed in the mud would be the total spontaneous potential. This idealized SP deflection is called the static SP (or SSP). The SP deflection practically reaches the SSP in a thick, which is a clean formation in type.

The borehole presents a much smaller cross-sectional area to current flow than the formations around it, so the resistance of the borehole part of the SP current loop is much higher than the formation part of particular zone. Nearly all the SP potential drop, therefore, occurs in the borehole if formation resistivities are low-to-moderate and formation beds are thick, so, in practice, the recorded SP deflection approaches the static SP value in thick beds which are considered to be permeable.

2.6. Determination of Static SP

To determine the Static SP, a sand line is drawn through the maximum excursions of the SP curve adjacent to the thickest permeable beds. A shaly baseline is drawn through the SP through the intervening shale beds. The separation of the sand line from the shale baseline, measured in mV, is the SSP. Any SP anomalies are discounted.

If there are no thick, clean, permeable invaded beds in the zone under study, the SP reading can be corrected for the effects of bed thickness and invasion to estimate the SSP by using charts available from various different service companies.

2.7. Shape of the SP curve

The slope of the SP curve is proportional to the intensity of the SP currents in the borehole at that depth. Because the current intensity is highest at the boundaries of the permeable formation, the slope of the SP curve is at a maximum, and an inflection point occurs at these bed boundaries.

The shape of the SP curve and the amplitude of its deflection in permeable beds depend on the following factors: thickness and true formation resistivity of the permeable bed, resistivity of the flushed zone (R_{xo}) and diameter d_i, resistivity of the adjacent shale bed (R_s), and resistivity of the mud and the diameter of the borehole (d_h).

2.8 SP anomalies

The SP curve may be difficult to interpret and use for R_w determination because it does not always behave ideally. The following are the possible cases of apparently anomalous SP responses.

- Extremely resistive formations
- Shale-baseline phase shifts

3. Gamma ray logs

The radioactivity of rocks has been used for many years to help derive lithologies. Natural occurring radioactive materials (NORM) include the elements uranium, thorium, potassium, radium, and radon, along with the minerals that contain them. There is usually no fundamental connection between different rock types and measured gamma ray intensity, but there exists a strong general correlation between the radioactive isotope content and mineralogy. Logging tools have been developed to read the gamma rays emitted by these elements and interpret lithology from the information collected from different source.

Conceptually, the simplest tools are the passive gamma ray devices. There is no source to deal with and generally only one detector. They range from simple gross gamma ray counters used for shale and bed-boundary delineation to spectral devices used in clay typing and geochemical logging,borehole and environmental effects, such as naturally radioactive potassium in drilling mud, can easily confound them.

3.1. Relating radioactivity to rock types

The distributions of radiation levels observed by Russell[2] are plotted for numerous rock types. Evaporites and coals typically have low levels. In other rocks, the general trend toward higher radioactivity with increased shale content is apparent. At the high radioactivity extreme are organic-rich shales and potash (KCl). These plotted values can include beta as well as gamma radioactivity (collected with a Geiger counter). Modern techniques concentrate on gamma ray detection.

3.2. Radioactive isotopes in rocks

The primary radioactive isotopes in rocks are potassium-40 and the isotope series associated with the disintegration of uranium and thorium. On the other hand, both thorium (Th) and uranium (U) break down to form a sequence of radioactive daughter products. Subsequent breakdown of these unstable isotopes may produces a energy levels. Standard gamma ray tools measure a very broad band of energy including all the primary peaks as well as lower-energy daughter peaks.

The radionuclides, including radium, may become more mobile in formation waters found in oil fields. Typically, the greater the ionic strength (salinity), the higher the radium content. Produced waters can have slightly higher radioactivity than background. In addition, the radionuclides are often concentrated in the solid deposits (scale) formed in oilfield equipment. When enclosed in flow equipment (tanks, etc.) this elevated concentration is not important.

3.3. History of gamma ray tools

The gamma ray tool was the first nuclear log to come into service, Gamma ray logs are used primarily to distinguish clean, potentially productive intervals from probable unproductive shale intervals. The measurement is used to locate shale beds and quantify shale volume. Clay minerals are formed from the decomposition of igneous rock. Because clay minerals have large cation exchange capacities, they permanently retain a portion of the radioactive minerals present in trace amounts in their parent igneous micas and feldspars. Although shales are usually more radioactive than sedimentary rocks as per their predictive properties. The movement of water through formations can complicate this simple model. Radioactive salts (particularly uranium salts) dissolved in the water can precipitate out in a porous formation, making otherwise clean sands which can appear to be radioactive.

3.4. Gamma ray logging tool

Before getting into how to use the log readings, let go through the workings of the tool. Unlike all other nuclear tools it is completely passive. It emits no radiation. Instead, it simply detects incoming gamma rays from the formation and (unfortunately) the borehole. Gamma rays are electromagnetic radiation, generally in the energy range 0.1 to 100 MeV. As light, this would correspond to very short wavelengths indeed. The difference between gamma rays and X-rays is largely semantic because they overlap in energy.

Originally, the detector was a Geiger-Müeller tube, just as in the Geiger counter. More recently, the detectors have been switched to solid-state scintillation crystals such as NaI. When a gamma ray strikes such a crystal, it may be absorbed. If it is, the crystal produces a flash of light. This light is "seen" by a photomultiplier standing into the end of the crystal. The photomultiplier shapes the light into an electrical pulse that is counted by the tool. Hence, like all nuclear tools, the raw measured quantity in a gamma ray log is counts. This means that the precision of gamma ray log measurements is determined by Poisson statistics. The precision is the square root of the total number of counts recorded at a given depth. Counts recorded are basically proportional to the volume of the detector crystal times its density times the length of time counted. As with all nuclear-logging measurements, the only part of this that the logger controls is the counting time. Because log measurements are depth driven, the length of time the logger counts is inversely proportional to the logging speed.

Gamma ray sondes have recorded the total flux of gamma radiation integrated over all energies emanating from a formation as a single count rate, the gamma ray curve. Logging tools are not uniform in their energy sensitivity. No detector responds to all the gamma rays that impinge on it. Many pass through with no effect. The sizes of a detector, the solid angle it subtends, and its thickness, and its composition (particularly its density), all affect its efficiency for detecting gamma rays. The tool housing around the detector, the casing, and even the density of the borehole fluid can all filter the gamma rays coming from the formation. All these factors not only lower the overall tool efficiency, they also lead to variations in efficiency for gamma rays of different energies. In short, the count rate recorded in a particular radioactive shale bed is not a unique property of the shale. It is a function of tool design and borehole conditions as well as the actual formation of the radioactivity.

3.5. Factors affecting readings

As gamma ray logs as relatively measures, precise calibration is not very important except as a visual log display feature. Environmental effects are much more important. Radioactive volume of rock traversed by a borehole. Considerably only the geometry, the count rate opposite a given rock type will be much lower in a larger borehole in which the detector is effectively farther from the source of gamma rays. In an open hole, borehole size almost always has the greatest effect on the count-rate calibration. This problem can go well beyond changes in bit size. If shales or sands are selectively washed out, borehole size can imprint itself of the expected gamma ray contrast between shales and sands. If the borehole is large enough, the density of the fluid filling the borehole can also impact the calibration by absorbing some of the gamma rays before they get to the tool.

Barite in the mud which compiles complication, filtering the incoming gamma rays. Therefore the gamma ray borehole size and fluid corrections are often very important and should be made if at all possible. Obviously, casing absorbs a large fraction of the gamma rays traversing it on their way to the borehole, so if the tool is run in a cased hole, casing corrections are very important. Tool design has a large impact on environmental corrections. The housing and location of the detectors all filter the incoming gamma rays. It is important to use the right environmental corrections for the tool being run. This is especially true for LWD tools that may consist of multiple detectors embedded in large, heavy drill collars that filter the incoming gamma rays in unique ways.

3.6. Environmental distortion

The simple consideration of the discussion of radiation transport helps clarify which environmental effects most seriously distort the gamma ray log. Imagine what happens as borehole size increases. There is less of the radiating radioactive material near the detector, and the measured count rate goes down, even though the actual level of radioactivity in the formation remains the same. Further imagine the rather typical case in which the shales are eroded and broken out while the sands remain in gauge. This would suppress the apparent gamma ray count rate in the shales Which are eroded much more than in the sands, suppressing the gamma ray contrast between eroded shales and sands. One of the largest environmental effects on the gamma ray count rate. Again from the discussion of radiation transport, heavier materials in the path that the gamma rays must follow from the formation through the detector will absorb more gamma rays than lighter material.

3.7. Applications

Gamma ray logs have a numerous applications in use. For example, injected fluids can be tagged with radioactive tracers and their progress through a field monitored with gamma ray logs in wells adjacent to the injection site. The following are the most common possible applications;

- Determining lithology
- Identifying shale volumes
- Correlating cores with logged depth

4. CONCLUSIONS

The interpretation of lithologies from geophysical well logs is necessarily subjective in nature. This is occasionally true when individual type of geophysical well logs is interpretated without regard for the response of other types well logs in used for the same purpose. Adequate interpretations must rely on combinations of well log data that best characterize each individual lithology. The final interpretation must also agree with the available geologic data (that is, core descriptions, log chart by driller). Moreovera good geophysical well-log interpretation is one that adds detailed information to the geologic information obtained from rock samples taken from the well. The study presented in this report illustrates that only a limited lithologic interpretation can be made when only one type of well log is used for the interpretation. A more consistent and accurate interpretation of the geologic section can be made by interpreting the product and ratio values of more than one type of well log for the particular purpose.

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