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Hydrocarbon Reservoir Characterization of Oli Field in Niger Delta Using Well Logs

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ABSTRACT

A petrophysical well log was employed in a study of the Oli Field's onshore Depobelt reservoir in Nigeria's Niger Delta Basin. There were many things learned about the reservoir from the well logs, such as information about the lithology and depositional environments, as well as the Net-to-Gross ratio, porosity, permeability, saturation levels of water and hydrocarbons. A reservoir's quality can be influenced by a variety of factors. The analysis identified two (2) hydrocarbon bearing reservoirs (L and F) from the correlation of four wells using four well log types (4) namely; Gamma ray log, Resistivity log, Neutron log and Density logs. These logs were interpreted using Petrel Seismic to Simulation Software to evaluate the petrophysical properties which include; porosity, permeability, net- to- gross, water saturation and hydrocarbon saturation as 21.7%, 1433.22md, 43.1%, 40.8%, 59.2% respectively for reservoir F and 22.5%, 1517.4md, 43.7%, 40.8%, 59.2% respectively for reservoir L. As a result, we discovered that Oli's reservoir has a low saturation level based on the petrophysical parameters we estimated. So the reservoir has a lot of hydrocarbons because there aren't many of the empty spaces filled with water. Furthermore, quantitative porosity testing shows that the Oli field is porous and has pores that communicate with each other. Due to how the Oli field's reservoirs are constructed, there is enough hydrocarbon production potential. Reservoirs L and F have sand beds that are 21,2598 meters and 22,288 meters thick, respectively.

I. INTRODUCTION

The reservoir is the first and most critical component of a petroleum storage facility. It is critical to determine and understand the petrophysical and mechanical properties of the rocks that comprise the reservoir. Hydrocarbon-based products have seen a dramatic rise in demand since the turn of the 20th century. Because of this, oil and gas deposits in reservoir rocks have been discovered and are now being investigated. A long search in the Benue Trough's Cretaceous sediments failed, so researchers turned their attention to the Niger Delta's depo centers (Doust, and Omatsola, 1989 and 1990). It has been demonstrated by geophysicists and geologists that the Niger Delta is a suitable location for the production, release, and collection of oil. This information is contained in their work. Planning is required for both hydrocarbon exploration and extraction. To create an accurate reservoir model, a variety of data must be combined during the characterization process. The reservoir's structural and stratigraphic features can be better described using seismic data. Seismic interpretations must be more detailed because the most important geophysical seismic data is accrued over time. It is possible to obtain information about the oil's physical properties by inserting various sensors into an oil well (or borehole) via wireline logging. This occurs during the wireline logging process (or sonde). Petrophysical properties include the following terms: porosity, lithology, permeability, water saturation, resistance, hydrocarbon saturation, and density. Wireline logs are used in petrophysics to measure and analyze rock properties. In the petroleum industry, they are used to connect zones and map structural. They can be put to other uses as well (Picketh, 1970).

Reservoir characterization is an important aspect in hydrocarbon exploration. It is carried out directly by the use of core sample analysis or indirectly by the application of the various petrophysical parameters obtained from wireline log. Logs are generally used for; Identification of geology formations, identification of formation fluids, evaluation of Petrophysical parameters of rock formations, correlation between boreholes, evaluation of the productive capabilities of reservoir formations and determining the depth and thickness of productive zones for hydrocarbon (Telford et al., 1990).The major parameters to be determine in the evaluation of a reservoir are its porosity, permeability, water or hydrocarbon saturation, and reservoir thickness. Just few of these parameters can be measured directly from the available data. Not only most reservoir rocks, but also the rocks in which oil was formed, were created by erosion.Most of these source rocks(such as black shales) were deposited in an ocean environment,but some were probably formed in fresh water. Most of the Niger Delta oil production is based on sandstones and unconsolidated sands from the Agbada Formation. Between the Eocene and the Pliocene, it is thought that the rocks that make reservoirs were formed. More than half of these rocks are less than 15 meters thick, and less than 10% of them are more than 45 meters thick (Evamy et al. 1978). Reservoir thicknesses are controlled by growth faults, with the downthrown block having a thicker reservoir. This depends on the size and quality of the reservoir (Weber and Daukoru, 1975).

Oil and gas exploration and extraction must use a method that is both technically sound and financially sound due to the large sums of money required for a complete geophysical survey and the well drilling and extraction process that follows. This rule is impossible to break because of the nature of the business. To ensure that resources aren't wasted, it's critical to accurately assess a reservoir's hydrocarbon potential, porosity, permeability, and water saturation before drilling even begins. To ensure that resources are not lost or wasted, this is necessary. Hence this study is aimed at estimating Petrophysical properties from well logs that lack core-measured porosity and permeability values, also to know the water saturation of the reservoir.

Location of Study Area

Oli-field is located in the continent of Africa. It is located in the Niger Delta's southern province. The Niger Delta is a depositional complex that has grown in size over time in the Cenozoic rocks of southern Nigeria. Between 30 and 60 north latitude and 50 and 80 east of the equator, it is found in Equatorial West Africa. The Gulf of Guinea lies off Africa's southeast coast. Figure 1 depicts its path from the Calabar flank to the Atlantic Ocean in the south. In this basin, sediments accumulate and tectonic features change their original shape (Corredor et al., 2005).

Located in the Gulf of Guinea, Niger Delta is a peninsula. Benue Trough and Anambra Basin are two of its provinces. Crossing Okitipapa highland, the Delta complex empties into the western Dahomey embayment. There is a line of volcanic rocks that runs from Cameroon to the border of Guinea in the Dahomey embayment in the southeast. Over time, the tertiary Niger Delta has grown to a total area of approximately 75,000 square kilometers, and the thickest part of the sequence is 9,000 to 12,000 meters in depth (Reijers, 1996).

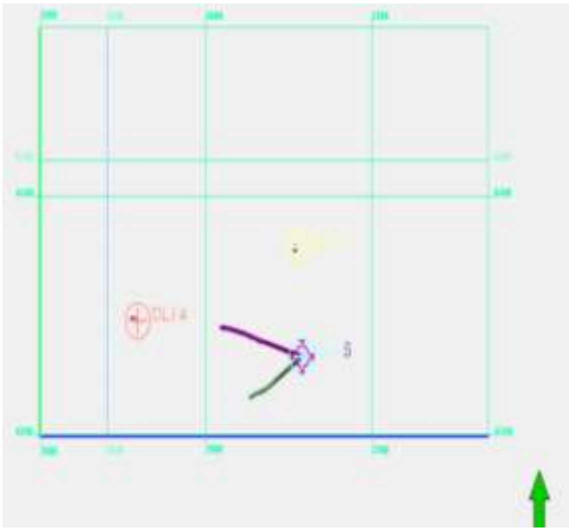

Figure1: Base Map of Study Area

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II. LITERATURE REVIEW

Due to the high demand for hydrocarbon in the world and in Nigeria due to its high economic potential, many individual geologists and co-operate bodies had carried out survey(wireline logging) in the Niger Delta region to map out areas rich with hydrocarbon reserves. There are a substanstial number of articles, papers that have been published covering some of the themes under this research. Some of the works include; Sneider and King(1978) discussed the integration of core data and log data in formation evaluation.Amafuleet al (1998) defined reservoir characterization as "combined efforts aimed at discretizing the reservoir into subunits, such as layers and grid blocks and assigning values to all pertinent physical properties to these blocks".When it comes to integrated reservoir studies, Paul discusses the use of cutoffs in his article published in 1998. More accurate reservoir characterization and better cooperation between static and dynamic reservoir models are two major advantages, according to him, of using a well-tuned set of petrophysical cut-offs. As a result, an energy company can maximize the value of its assets.

Integrated reservoir studies make use of cutoffs, according to an article Paul wrote and had published in 1998. Static and dynamic models of the reservoir can more easily interact with each other when they are based on well-tuned petrophysical cut-offs, according to him. These are the two most important reasons for considering it. As a result, an energy company can make the most of its resources. A number of notable authors, including Stoneley (1966), Burke et al. (1972), and others, have extensively studied and debated the Niger Delta magatectonic setting (Evamy et al., 1978). The tertiary Delta's synsedimentary tectonics have been extensively documented (Evamy et al., 1978). An excellent tertiary oil delta, the Niger Delta is located in West Africa. These deltas contain 5% of the world's oil and gas reserves and account for 2.5% of the basin's total area (Reijers et al., 1997).

There are three main ways sediment is deposited in Nigerian coastal sedimentary basins (Short and Stauble, 1967, Weber and Daukoru 1975). The Albian-Marine invasion marked the beginning of the first deposition cycle, which lasted until the end of the Santonia period. The Paleocene ended the first cycle, which began with the Proto-Niger Delta in the late Cretaceous. In Africa, both of these events occurred. Throughout the Eocene and into the present day, the Niger Delta grew as a result of the third and final cycle ending. Uplift and erosion frequently halted sedimentation in the late Quaternary. Underwater canyons were formed as a result of many cycles of cutting and filling channels. Researchers Evamy et al. (1978) and Burke et al. (1972) found that the flooding of river mouths during the late Wisconsin sea level drop cut into the continental shelf and caused these landslides. Afam canyon and Qua Iboe clay fill may have formed in the South-Eastern Delta during the Miocene period as a result of this (Evamyet al., 1978; Burke et al., 1972).

Geology of Niger Delta

For centuries, the Niger Delta has been buried beneath layers of calcareous marine clastic sediment and sedimentary particles. The Akata Formation, the Agbada Formation, and the non-marine alluvial continental sands of the Benin Formation comprise the three major lithofacies in this sequence (Short and Staubles 1967 and Doust and Omotsola 1990). During 1974, Oomkens studied modern-day Niger Delta sediments from the land and water. To determine their origin, he classified the sediments into five broad categories, collectively referred to as "lithofacies." Reijers (1995) reorganized the lithofacies into twelve standard units based on the lithological properties of sediment. Despite the addition of additional sedimentary characteristics. These lithofacies are known as sandstone, heterolites, and mudstone after a closer examination. The Agbada Formation, which is located in the clastic wedge of the Niger Delta, has numerous signs of oil. Using the sequence stratigraphy of a few petroleum-rich belts in the Niger Delta region, (Doust and Omotsola, 1989) and (Stacher, 1995) construct a hydrocarbon habitat model and provide a brief summary of basin-, trap-, reservoir-, and source rock and hydrocarbon characteristics. The oil-rich regions of the Niger Delta served as the inspiration for this model. One oil system was found in the Tertiary Niger Delta by researchers like (Kulke 1995) and (Ekweozor and Daukoru 1994). This arrangement is known as the Akata-Agbada Petroleum system.

Shale from the Eocene and Miocene Akata and Agbada Formations makes up the majority of the raw material (Ekweozor and Okoye, 1980; Ejedawe and Okoli, 1981; Nwachukwu and Chukwura, 1986; Evamyet al., 1978; Weber and Daukoru, 1975; Bustin, 1988). They came to the conclusion that some of the oil could have come from the marine Akata shale and the Cretaceous shale beneath it. The Agbada Formation sandstone reservoirs in the Niger Delta basin contain the majority of the region's oil and gas reserves. These reservoirs are held in place by rollover anticlines and growth faults most of the time. For example, point bars of distributary channels and coastal barrier bars that are cut by sand-filled channels are the most important types of reservoirs, according to Avbovbo 1978, Stacher, Kulke (1995). This new class of stratigraphic barriers is comprised of growth fault-related barriers, as well as barriers associated with paleochemical filling and regional sand pinching out.

The rate of sedimentation and subsidence in the Delta has been increasing since the Miocene epoch and continues to this day. Static sea level fluctuations, tectonic activity, and the loading of unstable shale all had an impact on these processes (Doust and Omatsola, 1990). As a result of these events, sequences and their ends were formed. For each sequence boundary (SB), there is an erosional truncation, a change in facies toward the basin, and the greatest number and variety of foraminifera. The sequence boundary is associated with a sudden change in sea level, whereas the maximum flooding surface is associated with a gradual rise in sea level. Both of these shifts are depicted in the following graph. Depending on how long it lasts, the sea-level cycle is divided into several categories. Small changes in sea level have an impact on parasequences and their limits (Vail et al., 1977 a&b).

Source Rock

There has been a long debate about the possibility of petroleum source rocks in the Niger Delta. Many authors have contributed to this debate. Akata Formation marine shales and Lower Agbada Formation shales interbedded with parallic sandstone were considered by Evamyet al. to be the oil-producing rocks in the Niger Delta (1978). They arrived at their conclusion based on the composition of the rocks and the amount of organic matter (OM) they contained. Ab-hopanes and oleananes were used by Ekweozo et al. (1979) to determine the source of crude oil. The shale of the Agbada formation or the Akata marine-parallel source on the eastern side of the delta may have provided the source. The same thing was reported by each source. Geochemical evidence of age was used by Ekweozor and Okoye (1980) to further narrow this hypothesis. Vitrinite's ability to reflect light revealed that rocks younger than the lower parts of the parallic sequence were still young. In 1990, Doust and Omatsola discovered that organic matter comes from the delta off-lap sequences and the sediments of the lower coastal plain. The Agbada Formation and the Akata Formation are both likely to contain layers of dispersed source rock, but the Agbada Formation is expected to contain the majority of these layers. Akata Formation delta slope and deep turbidite fans are good source rocks in deep water when they are found. As bacteria decomposed the organic matter in these locations, it's possible that amorphous hydrogen-rich matter attached itself to it. However, the organic matter in these places still bears traces of Earth.

Akata Formation is the only known source rock with a significant amount of rock at a depth that matches the oil window, according to Stacher (1995). The interbedded shale in the Agbada Formation, the marine shale of the Akata formation, and the underlying Cretaceous shale could all be considered potential source rocks in the Niger Delta (Evamyet al., 1978 and Doust and Omatsola, 1990). The marine shale of the Akata Formation and the Cretaceous shale beneath the interbedded Agbada Formation in the Niger Delta could all be considered possible sources of rocks (Evamyet al., 1978 and Doust and Omatsola, 1990). Proximal shallow ramp seating deposits of high stand and transgressive systems tracts are thought to contain reservoir intervals in the Agbada formation (Evamyet al., 1978). Between 45 feet and 150 feet deep, the reservoir is possible. The most important reservoir units, according to Kulke (1995), are the point bars of distributaries channels and the coastal barrier bars that are sometimes cut by sand-filled channels. According to Weber and Daukoru (1975), grain size of reservoir units varies from one to the next; the reservoir may thicken along growth faults that have been downthrown. Fluvial sandstone typically has larger grains than delta front sandstone. According to Kulke (1995), Anatomy and Physiology High-stand and transgressive systems tracts in shallow ramp seating in the Agbada formation have been viewed as reservoir intervals (Evamyet al., 1978). A reservoir can be as shallow as 45 feet or as deep as 150 feet, depending on the design. The most important reservoir units, according to Kulke (1995), are the point bars of distributaries channels and the coastal barrier bars that are sometimes cut by sand-filled channels. Along the coast, you can find both types of bars. According to Weber and Daukoru (1975), the grain size varies by reservoir type. It is possible that the reservoir will thicken on the sinking sides of the growth fault. In fluvial sandstone, the grains of sand are larger than in delta front sandstone, but this is not always the case. Some of the sandstone is not solidified, according to Kulke (1995), and siliceous and argillaceous cement are the two most common types.

Reservoir Rocks

In the oil and gas industry, reservoir rock

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is a type of porous and permeable rock that can hold a lot of hydrocarbon. Most of the Niger Delta oil production is based on sandstones and unconsolidated sands from the Agbada Formation. Sedimentary environment and depth of burying determine what reservoirs in the Agbada Formation are like based on how they were formed. Miocene parallic sandstone, which is 100 meters thick and has holes that are 40% of the time, forms the bulk of the Niger Delta's main reservoirs, according to Edwards and Santogrossi (1990). Darcy is also receptive to new ideas and willing to adapt to them. The thickness of the reservoir changes dramatically depending on the location of growth faults. The reservoir inside the down-throw block grows in size as it approaches the fault (Weber and Daukoru, 1985) The reservoir's sandstone grains are a wide range of sizes. The delta front sandstone is typically finer than the fluvial deposit sandstone. Barrier bars sort grains the best on average, while point bars get finer as they rise. The sediment's porosity does not change rapidly with depth due to the delta complex's cool temperature and the sediment's young age. Argite-silicic cement is rare in sandstone, and the majority of them are almost completely unconsolidated (Kulke, 1995).

Traps and Seals

A trap is formed when the capillary forces of a sealing medium are greater than the buoyancy forces that cause hydrocarbons to rise through permeable rock.. The most critical factor in the formation of a reservoir is the relationship between the time at which oil is made and moved and the time at which traps form. Traps can be divided into three broad categories based on their geological characteristics:

Structural Traps

Folding and faulting can alter the subsurface structure, resulting in the formation of domes, anticlines, and folds. These changes to the structure may result in structural traps. This type of geological entrapment can be seen in the salt dome trap, anticline trap, and fault trap. More oil reserves are found in structural traps, which are easier and more likely to be discovered, than in stratigraphic traps.

Stratigraphic Traps

Thickness, texture, porosity or lithology changes in the reservoir rock can lead to the formation of stratigraphic traps. Both horizontal and vertical shifts are taking place. The lens trap, reef trap, and unconformity trap are all examples of this type of device.

Hydrodynamic Traps

Hydrodynamic traps aren't used as frequently as other types of traps. Hydrocarbons and water come into contact at an angle because of differences in water pressure caused by the flow of water.

Seals

Because it prevents hydrocarbons from rising further, the seal is an essential part of the trap.

- During a capillary seal, the capillary pressure across the pore throats is greater than or equal to the hydrocarbon buoyancy pressure. Because of this, the hydrocarbons are unable to penetrate the pores. Until their integrity is breached, fluids are unable to get through them. They begin to leak when this occurs. Based on how they leak, capillary seals fall into two categories. Hydraulic seals and membrane seals are included in this set. These capillary seals come in a variety of sizes.
- There will be a leak if there is a difference in pressure between the two sides of the membrane seal that is greater than the threshold pressure. To avoid a leak in the membrane seal, it is necessary to keep the seal's pores open. A small amount of leakage will be enough to bring the pressure difference down to the displacement pressure. After that, it will reseal.

Rocks that have a much higher pressure for fluid displacement than for tension fracturing are more likely to experience a hydraulic seal. Evaporites and very tight shales, for example, require a much higher fluid displacement pressure than do tight shales. When the pore pressure is greater than the rock's minimum stress and tensile strength, the rock cracks and then seals up again as the pressure decreases and the cracks shut.

Description of Wireline Logs

While drilling or after drilling, a borehole's depth and the properties of the geological formation it reaches are recorded in the process of "well logging." A log is the name given to this record. An instrument that can be attached to the end of a cable and lowered into a well to obtain suitable downhole readings is the SONDE. They can record a wide range of information. The logging cable's winch is usually connected to power sources and other equipment when it is being used. There are numerous parameters that can be logged as a sonde travels through a borehole. The signals from the sonde are transmitted to the surface via a cable that contains

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electric conductors. Petrophysical parameters such as porosity, hydrocarbon saturation, permeability, rock type can be derived from log interpretations (Asquith and Gibson, 1982). Tools used in well logging are designed to be able to look very deep. This is a critical consideration.

Petrophysical Parameters Needed For Hydrocarbon Reservoir Estimation

A reservoir rock's porosity and ability to permit the passage of oil and gas are considered paramount by a petroleum engineer. Other factors are Resistivity of formation water, water saturation, shale volume, formation temperature and pressure, reservoir geometry, and lithology. These parameters play a significant role in reservoir characterization.

Porosity

It is possible to think of porosity as a measure of reservoir capacity. It's the ratio of unfilled space to total volume. A percentage or a fraction can be used to express it. Having a lot of empty space is a sign of something being less dense.

In equation form:

ϕ=Void space/ bulk volume

ϕ=(bulk volume - grain size)/ bulk volume

Reservoir rocks usually have 10% to 30% porosity (Telford et al., 1976). Porousness of the material is an indicator of the reservoir's capacity. That's how much space is taken up by nothingness. Whether you prefer the term "percentage" or "fraction," the concept is the same. It is said to be less dense if it has a lot of empty space.

Sonic Log

$\phi sonic = \Delta_t - \Delta_{tma}/\Delta_{tf} - \Delta_{tma}$

where:

Δ_t=sonic travel time recorded by log

Δ_{tm}=sonic travel time for the matrix mineral grains (with no porosity)

Δ_{tf}=Sonic travel time for fluid in the pore space

Density Log

$\phi_{den}=(p_{ma}- p_b)/(p_{ma} - p_{ft})$

where:

p_{ma} = the matix density

p_b= the density log reading

p_{ft}= fluid density at the depth of interest

Resistivity

From Archie's (1942) experiments, the resistivity of water filled formation R_0), filled with water having a resistivity of R_w is related to the formation resistivity factor(F) by:

$R_0 = F * R_w$

The formation resistivity factor is related to the porosity (ϕ) by the Humble's formula:

$F = a/\phi^m$

where m is the cementation factor whose value varies with grain size

a= the tortuosity factor which is determined from local experience,

a is 0.81 and 0.1 in soft and hard formations respectively.

Permeability

Permeability is the ability of a rock to allow fluids to pass through it. Porousness is a consideration, but it is not a requirement in all cases. "Poor throats" or "capillaries" are inversely related to the permeability of a material because they are the passages between the pores. The darcie or millidarcy is the unit of measurement, and the symbol for it is K.

Estimating permeability from logs is possible using empirical rules, but the results are only accurate by an order of magnitude. The SP log is a good indicator of how permeable the ground is most of the time. Permeability values for hydrocarbons can be calculated using Timurs' equations:

For oil:

$K = [250(\phi^3/S_{wirr})]^2$

For gas:

$K = [79(\phi^3/S_{wirr})]^2$

where:

S_{wirr} = Irreducible water saturation

The unit of K is Darcies (D).

Water Saturation

Forming water occupies a specific amount of pore space in rocks. The symbol Sw represents the saturation water percentage.

S_w= Formation water occupying pores/ Total pore space in the rock

Hydrocarbon saturation and water saturation are related with the formular:

$S_W + S_H = 1$

The following equation can be used to calculate the amount of water in the formation based on the water-filled resistivity (R_w) and the true resistivity (R_t) of the formation:

$S_w= [R_o/R_t]^{1/n}$

where**n** is the saturation exponent whose value varies from 1.8 to 2.5, but is most commonly taken as 2.

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The water saturation formular can also be rewritten as;

$S_w = [F * R_w/R_t]^{1/n}$

This formula is mostly common and is referred to as the Archie equation for water saturation (1942).

Saturation levels can range from 100% to 0%, but they will never fall below 0%. A small amount of capillary water or water that the grains have taken up is always present in an oil reservoir, and it is impossible for the oil to remove it completely. This water will not be removed by the oil. IRREDUCIBLE OR CONNATE WATER SATISFACTION is the technical term for this type of water saturation (Swirr).

Net To Gross

This gives the ration of the producing sand to the total sand of the reservoir. It is calculated using; NTG=If(Vsh>=0.25, 0,1).

METHODOLOGY

Quality Checking of Data

Quality checking of data is carried out on the available data to check if the data is complete before loading it into the petrel software. The major things to look out for when performing quality checking is to;

- Check if the well header is given
- Check the value of the starting depth and stopping depth
- Check the unit of measurement
- Check the type of logs given

By carrying out quality checking we are able to know if the logging was done when drilling or after drilling. However interpretation of data cannot be carried out on a data without the well head information.

Data Used

The materials used in this project work comprises of:

1. well positioning,
2. well log data of four wells,
3. Petrel seismic to simulation software.

Well Positioning

Well positioning is the arrangements of the well from the continental environment to the marine, which is essential for well correlation. The continental environment is known to be Coarse thus will have a higher porosity than the marine environment which is known to be Fine.

Well Log Data

The four wells where characterized using four types of well log data namely:

- **Gamma Ray Logs:** was used to distinguish between sand and shale.
- **Resistivity Logs:** was used in delineating hydrocarbon zones and oil water contact.
- **Density And Neutron logs:** was used to delineate gas oil contact.

Petrel Seismic To Simulation Software

The Petrel seismic to simulation software was used to digitize the logs and also to determine the Petrophysical properties which are Porosity, Net to Gross, Water Saturation and Permeability of the reservoir rocks. Petrel was developed in 1996 by Schlumberger with an attempt to combat the interpretation of subsurface geology.

Basic Method Of Log Interpretation

1. To locate the permeable zones; Scan the logs in track 1 we identify the baseline on the right called the Shale baseline(indicates shale lithology which is the impermeable zone) and to the left the clean zone(sandstone). Thus the interpreter focus his attention on the permeable zone.
2. To scan the resistivity logs on track 2 to see which of the zones of interest gives high resistivity values(high resistivity values is a potential hydrocarbon indicator).
3. Scan the porosity logs on track 3 to see which of the zones have good porosity against the high resistivity.

Evaluation Of Petrophysical Properties

The Petrophysicalproperties(Porosity, Permeability, Net to Gross, Water Saturation) was generated in Petrel Software using the syntax below:

- IGR=(GR-10)/(140-10)
- IGR=If(IGR<=0, U, IGR)
- Vsh=0.083*(Pow(2 , (3.7*IGR))-1)
- Porosity=(2.65-RHOB)/(2.65-1)
- Porosity=If(Porosity<=0,U , Porosity)
- EffectivePorosity=(1-Vsh)*Porosity
- EffectivePorosity =If(EffectivePorosity<=0,U,EffectivePorosity)
- Sw=0.082/Porosity
- Sw=If(Sw>1,U ,Sw)
- Facies=If(GR<50,0 ,If(GR>=50 and GR<90,1 , 2))
- NTG=If(Vsh>=0.25, 0,1)
- Perm=307+(26552*Pow(Porosity,2))-(34540*Pow((Porosity*Sw), 2))

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- Facies=If(GR<50,0 ,If(GR>=50 and GR<90,1 , 2))

These syntax is calculated on each well, because there are no cored or hard data available and some of the parameters like permeability cannot be logged (The Technology is not available)

Key To Syntax

- IGR = Gamma ray index
- GR = Gamma log reading
- 10 = Minimum gamma ray reading from gamma log
- 140 = Maximum gamma ray reading from gamma log
- Udegbunam et al., 1988gave the relationship between porosity and water saturation as $øS_w$ = 0.082
- Matrix densities of common lithologies constants presented here are used in the density porosity formula (Schlumberger, 1972). sandstone matrix is 2.65, rhob is bulk density,1 density of fluid
- Using the Larinov unconsolidated volume of shale formula;$V_{sh}=0.083(2^{3.71GR} - 1)$
- A Niger Delta correlation; by Owolabi et al., 1994, $K=307+26552ø^2-34540(ø*S_{wi})^2$

It is applicable for unconsolidated sand of the Eastern Niger Delta.

Well Correlation

Well correlation is the process of establishing connection between wells of same petrophysical parameters. Thus tie similar reservoirs of all the wells. It is significant to correlate wells in order to estimate reservoir thickness.

III. RESULTS AND DISCUSSION

Interpretation of Well Log

Among all the Petrophysical Properties Porosity and Permeability are regarded as the most important petrophysical properties of a reservoir rock because of if a reservoir does not have the capacity to hold and conduit fluid it's not regarded as a reservoir and also have a vital impact on the evaluation processes at all stages. This project involves the characterization of well logs [Well-1, Well-2, Well-4, Well-5] from a field in the Niger Delta by identifying two sand formations in each well sand L and sand F and then calculating petrophysical parameters for these potential reservoirs.The study identified two sands in the wells using Gamma ray log (GR), Resistivity Log (ILD), Density (RHOB) and Neutron log (NPHI) data. Well positioning; the arrangements of the well from the continental to the marine, which is essential for well correlation.

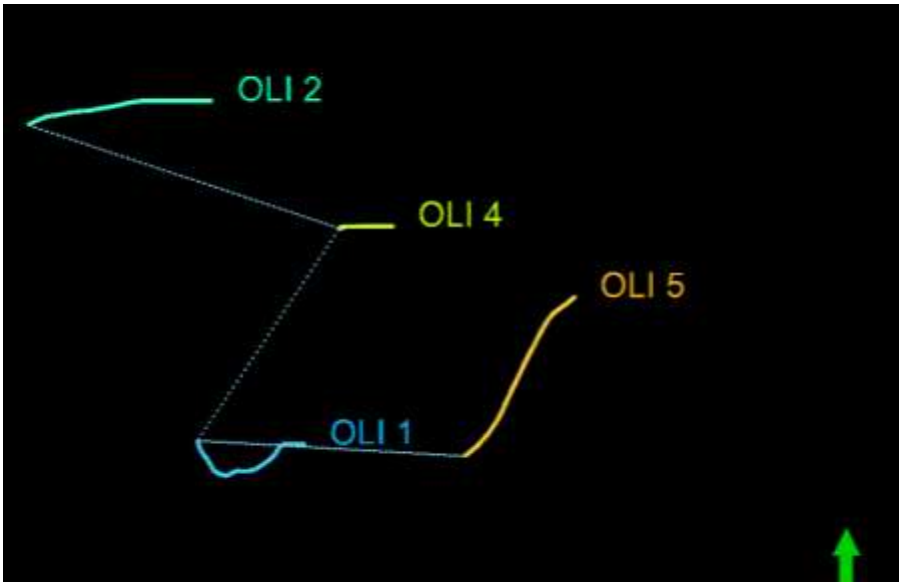

Figure 2: Well Positioning of the Four Wells

Petrophysical Evaluation

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Two reservoirs (F and L) each were delineated for Well-1, Well-2, Well-4, Well-5, using the gamma ray, Resistivity, Density, and Neutron logs.

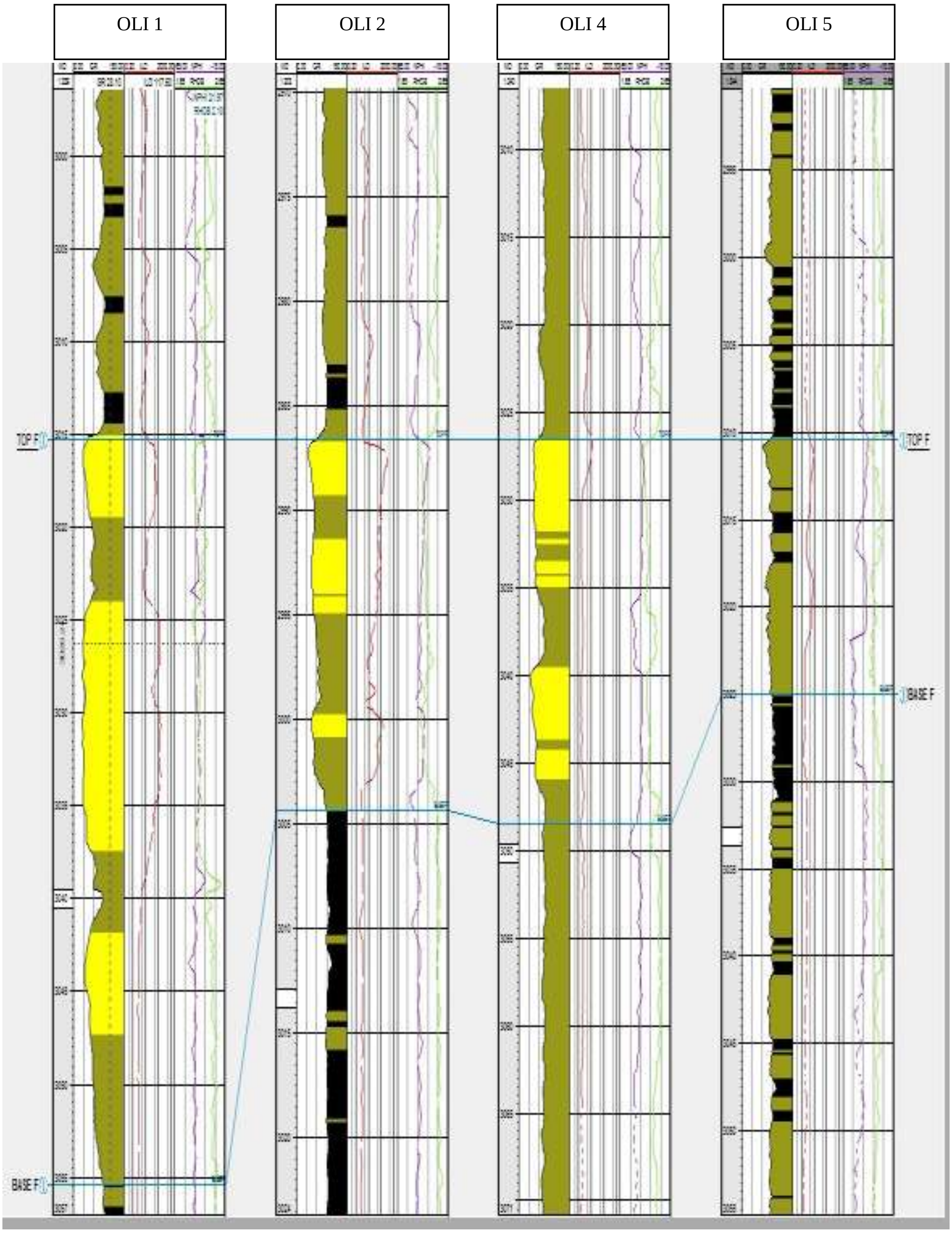

Fig 4.3 Well Correlation of Reservoir L

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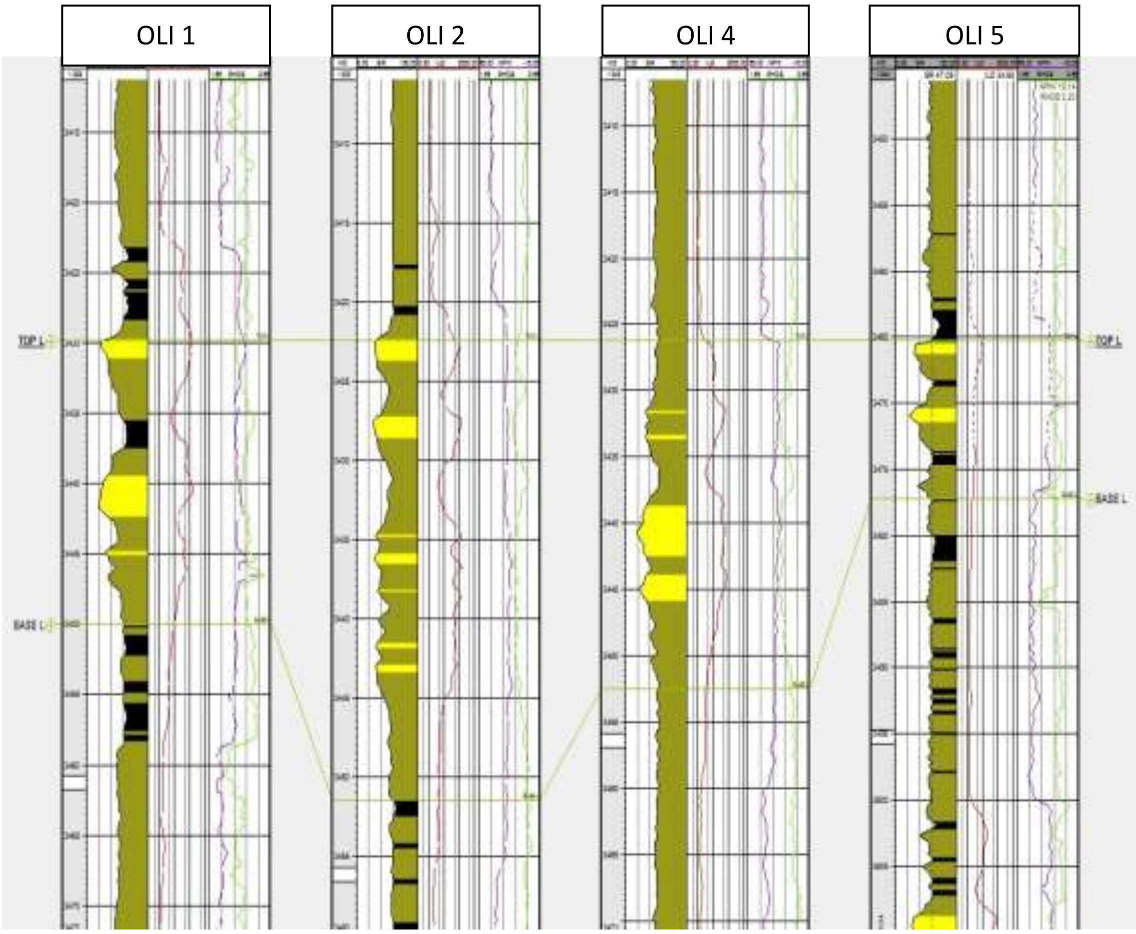

Figure 4: Well Correlation of Reservoir L

Table1: The Average Thickness of the Reservoirs

RESERVOIR	WELL 1	WELL 2	WELL 4	WELL 5	Average
RESERVOIR F (m)	30.48	16.9164	22.86	14.7828	21.2598
RESERVOIR L (m)	23.9268	30.7848	26.8224	7.62	22.2885

Table 2:Average Petrophysical Properties for Well-1, Well-2, Well-4, Well-5(Reservoir F) And Well-1, Well-2, Well-4, Well-5 (Reservoir L)

RESERVOIR	Parameter	WELL 1	WELL 2	WELL 4	WELL 5	Average
RESERVOIR F	NTG	0.431159	0.560877	1	0.102041	0.523519
	POR	0.217164	0.227182	0.173836	0.188279	0.201615
	PERM	1433.322	1635.568	922.33	1036.067	1256.822
	Sw	0.408389	0.419516	0.471253	0.445278	0.436109
RESERVOIR L	NTG	0.436709	0.35468	0.988701	0.132075	0.478041
	POR	0.224602	0.175412	0.174575	0.200653	0.19381
	PERM	1517.431	935.0023	910.5077	1151.047	1128.497
	Sw	0.408389	0.491743	0.48767	0.410564	0.449591

Table 3: Reservoirs Top and Base Marker

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RESERVOIR	WELL 1	WELL 2	WELL 4	WELL 5
Top of Reservoir F	3015.15	2988.10	3026.50	3010.50
Base of Reservoir F	3056.10	3004.50	3048.25	3025.00
Top of Reservoir L	3430.50	3422.50	3426.25	3465.50
Base of Reservoir L	3450.20	3451.50	3457.25	3477.25

IV. DISCUSSION

Figure 2 shows the arrangement of the well from the continental environment to the marine environment. The left hand side and the top side indicates continental environment while to the right hand side and the bottom side indicates marine environment, thus indicate the flow of sediments from the continent to the marine environment.

Reservoir F

Reservoir F was found to have the following Petrophysical properties;

- The average Net to Gross (NTG) of reservoir F across the Wells is 0.523519. This value indicates that reservoir F contains approximately 52% of sand and 48% of shale.
- The average estimated Porosity for reservoir F across the wells is 0.201615(20%), which indicates a good porosity(Rider; 1986).
- The average water saturation (Sw) is 0.436109 which suggests that the reservoir is a hydrocarbon bearing reservoir, with hydrocarbon saturation of about 56%.
- The hydrocarbon saturation was estimated from the water saturation by using the equation;S_{hc}=1-Sw; S_{hc}=1-0.436109; S_{hc}=0.563891

Resistivity logs are used to calculate water saturation from which the hydrocarbon saturation is calculated. When water saturation (S_w) is not 100% ,implies the reservoir rock contains hydrocarbon.

- The average estimated Permeability (k) of reservoir F across the wells is 1256.822 Darcy, which indicates a good permeability and has the capacity to allow fluid flow.

Reservoir L

Reservoir L was found to have the following Petrophysical properties;

- The average Net to Gross (NTG) of reservoir F across the Wells is 0.478041, which indicates 48% sand and 52% shale.
- The average estimated Porosity for reservoir F across the wells is 0.19381, which indicates a good porosity.
- The average water saturation (Sw) is 0.449591 which suggests that the reservoir is a hydrocarbon bearing reservoir, with hydrocarbon saturation of about 55%.
- The hydrocarbon saturation was estimated from the water saturation by using the equation;S_{hc}=1-Sw; S_{hc} =1-0.449591; S_{hc} =0.550409
- The average estimated Permeability (k) of reservoir F across the wells is 128.497 Darcy, which indicates a good permeability and has the capacity to allow fluid flow.

The estimated Porosities and Permeability's for each stratigraphic unit showed quality reservoirs. The average porosity values are moderate and approximately the same, but have high permeability indicating that the sands can store fluid and permit flow. The thickness of**Reservoir F** and **Reservoir L**was estimated to be **21.2598 m** and **22.288m** respectively.Also from the results, there are indications that Reservoir L is a continuous sand body; reason is because the sand bodies have similar porosity values, similar formation thickness and their depth values are close. In all, the part of the OLI field under study have good prospect for further development because of the high level of estimated porosity values in the reservoirs and consequently the Permeability values. The gamma ray log shows the Oli reservoir is a sandstone with low gamma ray reading, and high gamma ray reading indicates the presence of shale.The resistivity log shows higher resistivity thus indicating the presence of sandstone containing hydrocarbon.

V. CONCLUSION

The characterization of Oli field from the correlation and interpretation of four wells showed that; the sands in reservoir F and reservoir L are interlaminated with clays towards the base and become progressively clay free sand upward. The formation is medium - coarse grained, well to well sorted sand that occur in upper continental environment. Reservoir L has a Net-to-Gross value of 0.478041 with thickness of 22.288m while reservoir F has a Net-to-Gross value of 0.523519 with thickness of 21.260m.Better quality of petrophysical properties were determined in Reservoir L when compared to Reservoir F due to the depositional process or the age of the rock since

Reservoir L was delineated below Reservoir F.Oli well reservoirs are both porous and have pores that are close to each other, according to a quantitative porosity test. Because of the low water saturation in the Oli well reservoir, there are many voids that remain unfilled. To put it another way, the reservoir is overflowing with hydrocarbons. Analysis of reservoir fluids was done using the neutron and density log signatures. Water, oil, and gas were the three most common. Due to their low water saturation, high porosity, moderate permeability and moderate hydrocarbon saturation, all of the studied parts of the OLI field have an excellent chance of further development. There are many holes in the rock, which makes it difficult for water to permeate through. Hydrocarbons can be produced to a large extent thanks to the unique design of Oli well reservoirs. Hydrocarbon production should be carried out on Reservoir L because it has a better petrophysical property than reservoir F.

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