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Reservoir Characterization of the D7.000 Sand, 'Eme' Field, Niger Delta, Nigeria

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Abstract: This research work focuses attention on the Reservoir Characterization of a hydrocarbon bearing sand in 'Eme' field of the Niger Delta. The environment of deposition is examined and the type produced as a model of the sub-surface reservoir. To achieve this, an integrated analysis of cores from wells, as well as biostratigraphic data and wireline logs of the D7.000sand were used for the study. The D7.000 sand of study comprises one major depositional sequence. From the petrophysical study carried out through use of composite logs, amalgamated sand is found to be more porous and more permeable than the tidal channel. Core analysis revealed the existence of ten lithofacies. These lithofacies are grouped into facies association in a vertical sequence with a genetic significance using primary structures and shape of wireline logs.

Keywords: Sequence, Stratigraphy, Niger Delta, paleoenviromental, Eme, D.7000 sand.

I. INTRODUCTION

D7.000 sand comprises multi-storey sand bodies and heterolithic mixture of sand shale. These sand bodies have good reservoir quality, while the heterolithics have reservoir quality and act as baffles to vertical flow of hydrocarbon.Thus, this cause production problem in the D7.000 sand. The research work is intended to unravel the sequence stratigraphy of the D7.000 sand through the existing approach of use of cores and wireline logs. The overall depositional character of the D7.000 reflects the Petrophysical problems. Production problems could be field wide or peculiar to the Niger Delta depobelt. Porosity and permeability in the D7.000 sand are affected by the grain size distribution, clay composition, bioturbation, cementation and compaction. For example, there is a decrease in porosity and permeability in the area where shale content is relatively high. Therefore, the top and bottom parts of the D7.000 sand a baffle to flow of hydrocarbon. Different depositional environments are characterized by a peculiar Petrophysical identity which varies with the rock type, lithofacies type and reflect variety of pore geometry present.

II. AIM AND OBJECTIVES

The objectives of the study are: To provide a detailed Reservoir Characterization of the reservoir (D7.000) sand. Ascertain the permeability and porosity values and evaluate the reservoir potential of' D7.000 sand and to reconstruct the environment of deposition and provide a depositional model suitable for the reservoir sand.

III. LITERATURE REVIEW

Tertiary Niger Delta is an extremely prolific hydrocarbon province and is one of' world's largest Tertiary delta systems. Various works have been carried out on the basin. Previous authors that have investigated, worked and summarized basic geology, structural setting, lithology and depositional environments of the er delta include Olaleye, et al. [11], Reijers, Amajor [1,13], Ejedawe et al. [4] , Avbovbov [2], Evamy et al. [6], Franki and Cordy [7] in their study of the Central Swamp depobelt of the Niger Delta,recognized a deep water environment associated with offshore Miocene delta, which received prodelta sediments that were overlain by a prograding complex-slope fan wedge deposited in outer neritic to upper bathyal paleoenvironment. However, Gary Nichols [8], identified reservoir heterogenities as a controlling factor to the abnormal production performance of an oil field, North East, Niger Delta. Furthermore, he used an integrated wireline log and core data in reconstructing depositional models while Amajor and Agbaire [1] used the process response method to propose a depositional model for the reservoir sandstones of Akpor and Apara Oil fields in the Niger Delta. Also, Evamy et al. [6] and Ejedawe [4] analysed the distribution pattern of oil and gas in the Niger Delta [3,5]. The source rock of the Niger Delta was investigated by Frank and Cordy [7], while the syn-sedimentary tectonics of the Niger Delta was investigated by Merki [9] and Avbovbo [2]. Meki [9] worked on the

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paralic Agbada Formation and established a sequence comprising cyclically alternating successions of sandstones and shales.

A. Niger Delta Tectonic Setting

The Tertiary Niger Delta basin is located in southern Nigeria at the continental margin of the Gulf of Guinea between latitudes 3^0 and 6°N and longitudes 5^0 and 8°E [13]. It is bounded by the Calabar *flank*, in the east, Benin Flank, in the west, and in the south by the Gulf of Guinea and in the north by older (Cretaceous) tectonic elements e.g the Anambra basin and Afikpo syncline. The formation of the Niger Delta is related to the separation of Africa and South America resulting in the opening of the Atlantic Ocean. A triple junction developed at the outer Niger Delta with Anambra-Benue rift valley as a failed arm of this triple structure. There was a progradational fill southwards into deep waters which accounts for the Delta complex in the Oligocene-Miocene times. Growth faults, rollover anticlines and diapir are the three major structural features in the Niger delta. Growth faults and rollover anticlines are comtemporaneous with sedimentation and are therefore syngenetic in origin. The complex growth faults are clearly related to Akata mud diaprism. They are gravity slump faults contemporaneous with sedimentation as a result of tectonic effects caused by density contrast and growth instability which develop in regressive deltaic sequences [9]. The progradation of sandy deposits over an uncompacted delta marine clays results in gravity slumping initiated by underlying low shear strength clays as a reaction to the density contrast. Sedimentary deposits arch upwards towards the growth faults, consequently, giving rise to the development of rollover anticlines . Multiple reservoir systems occur in any field with rollover anticlines or related structures. Four main types of oil field structures are recognized [11]. They are; Simple rollover structures, Complex growth faults, Antithetic faults and Collapsed crestal structure [10].

B. Location of the Study Area

The hydrocarbon bearing (D7.000) sand is located in the 'Eme' field of the central depobelt of the Niger delta. The field is very close to the Nun river, about 110 west of Port Harcourt. It lies between latitudes 5^0 and 6° N, and longitudes 6^0 and 7° E.

IV. MATERIALS AND METHODOLOGY

There are three methods of study used in the analysis of the D7.000 sand. They are core description, the use of wireline logs and biostratigraphic data interpretation.

A. Core Description:

The analysis of the reservoir (D7. 000) sand involves the use of integrated cores from the well taken from the top to bottom of the D7.000 sand. The total length of cores described for the well are about 292ft. Core is described in terms of the primary sedimentary structures, bioturbation, grain sizes, sorting, colour, diagenetic processes as well as lithology.

B. Primary Sedimentary Structures

Pettijon and Potter [10] defined primary sedimentary structures as those formed at time of deposition or shortly thereafter and before consolidation of the sediments in which they are found. These sedimentary structures are as a result of physical, chemical and biological processes occurring in an environment. Based on the processes of formation of these sedimentary structures, lithofacies are classified.

C. Wireline logs

Use of wireline log data is to guide and aid the sedimentological interpretation of the cored sequences employed. In order to ascertain the porosity and permeability values of the reservoir sand, a composite log is used. These include gamma ray log, bulk density log and resistivity log.

VI. RESULTS/INTERPRETATION

A. Core Result

Core results of well indicate that the lithofacies are commonly sandstone/shale alternations or sequences. See (Plate 1-2), some of the parameters used in identifying the lithofacies are as follows:

(1) Grain Sizes: Visually, the grain size distribution falls within the range of very fine to coarse grain hence, bedding surfaces are recognized mostly by abrupt vertical changes in sizes and sometimes gradational changes occur. One of the

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intervals where abrupt vertical changes occur is seen in well 6 at a depth of 12256ft. Generally, there is mostly a decrease in grains sizes with an increase in depth from the lower half of the reservoir sand as seen in the well at a depth of (12312-12442) ft.

(2) Sorting: This is the tendency of mineral grains in a particular rock to approach uniformity in size. However, it ranges from well sorting to poor sorting in the field of study. For example, there is well -sorted very fine grain materials between (12438- 12443) ft. Conversely, poorly sorted grains are seen at the upper part of the same well at a depth interval of (12299-12305) ft. The well -sorted zone in the wells contains shales, while the poor sorted parts constitute a mixture of different sizes of grain materials.

(3) Colour: There are varieties of grey colours seen while examining the cores. Colour ranges from light grey to dark grey. For example, at the distal end of the two cored wells, the colour is found to be dark grey shale which is an indication of the presence of organic matter.

B. Lithofacies Description

Various kind of sedimentary structures are seen through physical examination of cores from well. These include, planar cross bedding, current ripple marks, lenticular bedding, rootlets, hummocky cross stratification, reactivation surface Bioturbation Structures and many more. These inorganic primary sedimentary structures are produced as a result of interactions between the physical and biological characteristics of the sediment and the fluid, gravity, as well as the hydraulic environment.

Lithofacies are identified based on core description and log shape of the reservoir D7.000 sand in ‘Eme’ field. Individual lithofacies are composed of different types of sedimentary structures and may be distinguished by the presence of bedding units with a characteristic sedimentary structure, a limited grain size range, a certain bed thickness, perhaps a distinctive texture or colour.

Plate 1- Planar laminated sandstone

1. Planar laminated sandstone. The lithofacies, planar laminated sandstone comprises fine to medium sand particles. It is moderately to well sorted, grey in colour and consists of planar grain lineation of coarse and medium grains which form laminae on foresets (Plate 1). The lithofacies is about 2cm to 4cm thick, it has an erosional relationship with overlying lithofaices coarse grained cross bedded sandstone and gradational relationship with underlying lithofacies wave rippled sandstone. However, very fine grains of mud are conspicuously absent and there is no presence of bioturbation activities in this lithofacjes. In essence, it is an indication of high energy or shallow marine environment.

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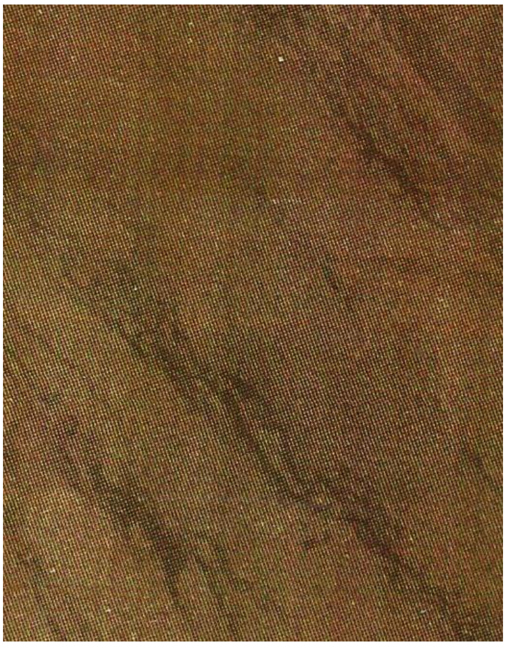

Plate 2-Current rippled sandstone

2 Current-rippled sandstone. The lithofacies consists of fine to medium grain sandstones with some coarse grain materials found at the base. It is moderately sorted. There are no wavy beds and has a clay content but low angle cross-beds exist. The rippled sandstone is draped by wavy, dark grey mudstone which is assymetrical with a gentle slope, an indication of current direction. (Plate 2). The lithofacies contains a sporadic bioturbation traces though traces of Planolites and ichnofacies is common with scanty Skolithos traces. This type of lithofacies is likely to occur in fluvial or shallow marine environment. Hence, tidal channel or tidal flat are the likely potential origin of this facies.

3. Bioturbated sandstone. Sandstones in this lithofacies constitute very fine- to- fine grains. Though, medium gains are encountered sporadically. It is well sorted with discontinuous carbonaceous laminae. There is also very little clay content with the absence of primary sedimentary structures as a result of intensive Bioturbation activities. Furthermore, the dominance of interpenetrating burrows of Ophiomorpha nodosa and Planolites are identifiable together with rare fossil shell remains . The presence of the aforementioned ichnofacies characterizes the influence of tidal or stressed estuarine environment. Also, the intensive bioturbation is an indication of lower shore face environment.

4 Fossiliferous Sandy heterolitlih. This sediment is observed in fine to very fine grained sandy strata. There is abundant shells debris which makes the lithofacies to be poorly sorted and is a major characteristic of the lithofacies. The clay content is high and could be noticed from the greyish-dark colour of the sandy heterolith. The lithofacies consists of climbing ripple lamination. Bioturbàtion activity is moderate to high, though the trace fossils encountered in the lithofacies include Ophiomorpha and Skolithos traces which occur sparingly. The very fine- to- fine grain size is an indication that it is deposited under low energy condition. The abundant shell debris shows the presence of shoreline setting while the trace fossils indicate shallow marine environment.

5. Wave rippled sandy Heterolith. The lithofacies is composed of fine to very fine grained sand intercalated with draped dark grey mudstones. It is well sorted and well cemented. Bioturbation is moderate. There is the dominance of Paleophycus trace fossils; intercalation of sand with mud is an indication of bed load and suspension depositions. Wave ripple structure is an indication of low energy setting while marine assemblages of Paleophycus indicate a lower shoreface environment

6. Current rippled sandy Heterolith. In this lithofacies, the sediments are well sorted. The grain sizesrange from fine to very fine with current ripple bedding. These rippled sandstones are draped by wavy dark grey mudstones. The clay content in this lithofacies is observed to be moderate. There is a moderate occurrence of bioturbation activities, although there are restricted burrow traces of Planolites and Skolithos. Presence of well -sorted sand is an indication of low energy transportation while intercalation of sand and mud is a sign of bed load and suspension type of transportation and deposition. However, the restricted assemblages or burrows of the trace fossils is an indication of stressed environment as could be seen in mouth bars channels.

C. Reservoir Characterization

The reservoir (D7.000) sand is composed of some good quality sandstones interbedded with mudstones. These mudstones act as permeability barriers to the vertical flow of hydrocarbon for this reservoir. The depositional sequence in the D7.000 sand is differentiated by change in grain sizes marked by mudstone facies. However, the occurrence of' sandy heterolith in some parts of the reservoir could cause a differential flow in the lithological units. These lithological

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units may be in pressure communication with each other as a result of density contrast of the depositional environment. From petrophysical property of the D7.000 sand obtained in well 6. Porosity and permeability values of the D7.000 sand are calculated using wireline logs. A very high decrease in porosity and permeability is an indication of low sand/shale ratio in the environment of deposition. High water fraction is an indication that the environment is not a potential for oil. From the gamma ray log of the D7.000 sand, the zone shows a gradation with the shelf mud. Hence, it is inferred to be part of the basal area (bottom seal) of the D7.000 sand or source of hydrocarbon. Finally, the rank of the interpreted depositional environments in terms of porosity and permeability from the best to the poorest is as follows: amalgamated channel, tidal channel, tidal deposit, upper shoreface and lower shoreface.

(1) Petrophysical properties of D.7000 Sand, Eme Field **.**Plot of permeability against porosity is essentially a straight line in semi logarithmic paper. There is a high concentration of these petrophysical values as porosity and permeability increase. However, from the mathematical relationship, permeability increases with increase in porosity. Environmental and depositional factors influencing porosity such as grain size distribution, bioturbation and diagenesis also influence permeability and often there is a relationship between the two. Typically, increase in permeability is accompanied by increase in porosity. The relationship varies with Formation and rock type and reflects the variety of pore geometry present. Constant permeability accompanied by increase in porosity, indicate the presence of more numerous but smaller pores. Post depositional processes in the sand including compaction and cementation result in shift to the left of the permeability-porosity trend line. The D7.000 sand is composed of intercalation of sand and shale. The shale is probably composed of authigenic and detrital clay minerals which are often found in lithofacies such as bioturbated sandy heteroliths (SMb). These minerals can greatly influence porosity and permeability as well as Formation productivity. The degree of influence depends on the type of clay present, it's morphology, it's location within the system and to a lesser extent, it's relative abundance.

(2) Interpretation of the cross plot of petrophystcal properties against the depth D7.000 sand: Having a critical examination, a depth range of about 1218010 12220 ft taken from the gamma ray log signature of well of the D7.000 sand, confirms the depth range as the tidal channel environment. A relationship exists between these petrophysical properties and their depth of occurrence. Hence, from the description of the cross plot, resistivity and bulk density values in the environment decrease with depth while porosity and permeability increase with depth in the same environment. Taken the minimum and maximum porosity and permeability values in this environment as 11% and *25%*, 6MD and 11 39MD respectively. The average porosity and permeability is calculated to be about 19% and 573MD respectively. Also, at this depth range, there is a high oil saturation value 0.8 as against water saturation of 0.2.

From the core description of well, the lithofacies in the tidal channel environment grades from coarse grained cross-bedded sandstone at the base to very fine sandy heterolith at the top. Thus, the increase in clay content upward in the tidal channel is responsible for the upward increase in resistivity and bulk density and upward decrease in porosity and permeability as well. The decrease in grain sizes is also another reason for the reduction in permeability. Thus, channel top is expected to form baffle to vertical flow of hydrocarbon in the D7.000 sand. It grades into the flood plain environment which forms the top seal of the reservoir D7.000) sand. The high oil fraction relative to the water fraction in the tidal channel at a depth range of 12180 to 12220ft is an indication that, this part of the D7.000 sand is a potential for hydrocarbon accumulation. We recommend that more exploration activity be carried out in this part of the D7.000 sand.

Most part of the D7 is inferred as stacked channel using gamma ray log of the D7.000 sand from well. In the description of the petrophysical properties of this depth range, there is a high resistivity value, low bulk density, very high permeability as well as very good porosity values. Taking the mean of the sum of the porosity and permeability values in the stacked channel of petrophysical properties, then the average porosity and permeability is 22 % and 1220 MD respectively. Furthermore, the stacked channel shows a very high oil fraction close to one and a water fraction close to zero. The high resistivity value of this part of the reservoir with respect to the tidal channel described earlier is attributed to the fact that, it has a lesser clay content than the tidal channel. This may be as a result of larger grain size sand iion in the environment of deposition. Example is seen from the lithofacies containing cross-bedded sandstones and planar laminated sandstone . However, a very high oil fraction with little or no water fraction in this environment relative to other parts of th reservoir makes it an ideal part to explore in the D7.000 sand more than other Sections of the reservoir. The poor petrophysical properties in this part of the reservoir relative to the stacked channel environment is attributed to the clay composition or sandstone inter-bedding with mudstone.

The point where oil fraction mixes with water fraction is inferred to be the oil/water contact (OWC). Unequal variation in the porosity and permeability is an indication of sand/shale intercalation in this part of the D7.000 sand. Therefore, the mode of deposition in the environment is through bed load transportation and suspension fall-out. Thus, the characteristic of the lithofacies with respect to the sand/shale ratio and grain size distribution affect the petrophysical properties as well as the depositional environment. Example, fine to very fine grain particles are deposited mostly in a quiet environment while coarse grain materials are properties of fluvial to wave dominated shallow marine setting. Below the D7000 in the reservoir, that is, at a range of 12360 to l2400ft, core porosity and permeability decrease more than that of the tidal deposit above. Resistivity decreases while bulk density increases. Water fraction exceeds the oil

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fraction. Also at a depth range of about 12328 to 12350ft, porosity and permeability show unequal variation downward in the D7.000 reservoir sand. Resistivity shows a variable signature as well as bulk density downward. In the plot, oil fraction co-exists in equal proportion with water fraction and at 12340ft, oil fraction mixes with water fraction, this part of the reservoir coincides with the tidal deposits.

Due to progradation and retrogradation of sediments which result in the depositional styles of reservoir sandbodies, three main sandstone body types are recognized in the D7.000 sand of study. They are according to decreasing reservoir quality named as follows:

(a) Ribbon to multi-storey channel sandstone bodies. (b) Lobe-shaped sandstone bodies and (c) Sheet-like sandstone bodies.

These sandstone bodies are expected to have different reservoir properties since they are characterized by different depositional structure and shape. Ribbon to multi-storey channel sandbodies consist of tidal channels and amalgamated channels. These channels occupy greater part of the D7,000 sand. However, the amalgamated channel has a higher dimension than the tidal channel. Ribbon to multi-storey channel sand body occupy most of the reservoir of study. The reservoir properties of the two channel types are expected to vary. This is not unconnected to the fact that tidal channel which fines upward, consists of very fine grain materials of clay at the upper part and fine to medium grain sandstone beneath. There is heterogeniety as a result of bioturbation and cementation. Interbedded. shale/heterolithics at the upper part will therefore form a baffle to vertical flow. Conversely, the amalgamated channel contains no clay materials and shows a blocky shape in gamma ray log with a good vertical permeability than the tidal channel. Generally, the single to multi-storey channel sandstone forms the best reservoir in the D7.000 sand of study and cut into tidal mouth bar/shoreface sandstone types. The lobe-shaped sandstone bodies are made up of estuarine mouth bar/shoreface and tidal flat sandstones. About 20% of the entire reservoir sand is made up of this sandstone body type. They are less laterally extensive than the sheet-like sandstone but have similar properties. Their porosity ranges from 15% to *23%* and permeability ranges from 50MD to 100MD. It is characterized by a moderately sorted fine grained sandstone beds with carbonaceous

(3) Depositional Model Of The D7.000 Sand From the gamma ray log of the reservoir (D7.000) sand of study; the reservoir could be divided into two sequences based on the mode of deposition. These are the upper and lower part, i.e. the transgressive and regressive sections. Consequently, they are demarcated by an uncored mudstone layer at a depth of about 12352ft in the well. However, the core gamma ray signature shows that the upper part of the lower D7.000 sand and the lower part of the upper D7.000 sand are not cored due to the muddy nature. Therefore, the reservoir model is considered along this line. The upper part which ranges in depth from 12352 to about l2l50ft, consists of the following facies associations, namely from the base; tidal deposit, amalgamated channel, tidal flat, tidal channel, and marine shale. Therefore, the model will be that of transgressive estuarine system. Some of the sedimentary structures associated with the estuarine deposits are reactivation surfaces as a result of the influence of flood and ebb currents (bipolar current) on the sedimentary deposits. Couplets of sand and shale in heterolithic sequence and sporadic trace fossil assemblages with an increase in faunal diversity upward. Furthermore, the lower regressive part of the reservoir sand of study ranges in depth from 12352 to 1252 ft. This lower part which forms a progradational sequence consists of the following facies associations starting from the base of the reservoir sand, offshore marine mud, lower shoreface and upper shoreface. The lower depositional sequence of D7.000 sand are deposits of a prograding wave dominated shallow marine shoreface setting. This interpretation is supported by the abundance of hummocky cross stratification structures, abundance of diverse marine trace fossils, and the upward decrease in diversity and population of these trace fossils. However, the two channel sandstones in the D7.000 reservoir have different geological properties and should be identified with different geological models. The tidal channel has a transgressive property, that is, it exhibits a fining upward sequence. Also, it has a gradational and erosional upper and lower contact respectively. Furthermore, in gamma ray log, it has a bell shape structure, while in the amalgamated channel of the upper retogradational sequence, it has abrupt upper and lower erosional boundaries respectively, blocky gamma ray log signature and shows little or no separation in neutron-density logs.

In summary, the depositional model of the reservoir sand of study consists of the upper transgressive estuarine deposits and the lower progradational shallow marine sequence which is being influenced by the presence of bipolar currents involving wave/fluvial processes. A decrease in accommodation space results in a progradation of the facies belt across the shelf thereby giving rise to shelf deposits. Regression is consequently followed by a transgressive phase which resulted in the deposition of the upper part of the reservoir sand or the estuarine deposits. Hence, succession of sediment depositions in the reservoir sand of study involves a transgressive estuarine deposit overlying a progradational shallow marine shoreface deposits.

V.CONCLUSION

The D7.000 sand comprises sand body units. Each of these units is characterized by distinct lithofacies composition. However, some of the lithofacies appear in more than one sand body unit and are attributed to the transgressive and regressive movement of the sea. Reading et al [12] observed the lithofacies composition of both lower and upper shorefaces to be a range from fine sand to silty particles and fine to medium grain sand particles respectively. This is comparable to the lithofacies composition of the lower and upper shorefaces of the D7.000 sand. The lithofacies hummocky stratified sandstone present in the D7000 is absent in the equivalent sand body unit. This may be as a result of the absence of stormy weather condition which forms part of the tidal channel. Amajor et al [1], in their study of Viking reservoir sandstone observed the vertical facies sequence of the marine facies from base to the top as prodelta facies, lower shoreface and upper shoreface, while the upper part of the reservoir constitutes transgressive estuarine deposits influenced by tidal current.

The same depositional sequence is observed in the D7.000 sand and the prodelta facies is characterized by massive rnudstone. The massive mudstone forms the bottom seal of the D7.000 sand. Miall et al [3,11] shows that the prodelta facies is as a result of suspension fallout in a low energy regime. Ichnofacies serve as water depth indicators and are valuable aid to the interpretation of sedimentary environments [8]. Hence, from the different sand body units in the D7.000 sand, distinct trace fossil assemblages are observed. For example, vertical burrows of Ophiomorpha and Skolithos trace fossils occur in the D7000 sand unit. The animals that formed these trace fossils may have moved up and down in the sediment with the changing water level of the foreshore. There is no biotubation activity seen in the massive mudstone of the bottom seal of the D7.000 sand. This may be attributed to the unfavorable conditions for organisms to thrive such as absence of light, food and oxygen in the environment.

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REFRENCES

[1] L.C Amajor and J. F Lerbekmo. The Viking (Albian) Reservoir Sandstones of Central and South-Central Alberta, Canada. Journal of Petrol. Geol. Vol. 13(4), Pp. 421-436 Oct. 1990.

[2]A.A Avbovbovo .Tertiary lithostratigraphy of the Niger Delta AAPG Bull. Vol.62, pp.293-300, 1978

[3] R.G Bromley. Trace fossils. Blackwell Science publishers, Glasgow, UK.1996

[4] J.E Ejedawe, Patterns of incidence of Oil Reserves in Niger Delta Basin.1981 AAPG Bull., Vol. 65, Pp. 1574- 1585,1981

[5] D. Emery and K. Myers.Sequence Stratigraphy. Blackwell Science Publ., Massachusets , USA,1996

[6] D. Evamy . Hydrocarbon Habitats of Tertiary Niger Delta. AAPG Bull. (62), Pp. 1-39, 1978

[7] F.J Franki and E.A Cordy . The Niger Delta Oil province- Present Developments Onshore and Offshore. Proc. 7th World Petroleum Congress. Mexico City, Vol. 2.Pp 195-209,1967.

[8] G. Nichols. Sedimentology and Sequence Stratigraphy. Blackwell science. Publi. London,1999.

[9] P. Merki. Structural Geology of Cenozoic Niger Delta. In T.F.J. Dessauvagie., A. J., Whitenian (eds): African Geology -Geol. Dept. Ibadan, Nigeria,1972.

[10] F.K North . Petroleum Geology. First edition. Publ. by Unwin Hyman Inc. USA,1985.

[11] Olaleye B, Nwaufa WA and Iwobi OC (2000). Hydrocarbon Exploration in a Middle Miocene Lowstand Facies Tract in the Central Niger Delta. NAPE Bulletin, Vol.15. Pp. 61-67, 2000.

[12] H.G Reading. Sedimentary Environment and Facies. 2nd Edition, by Blackwell Scientific Publishers,1985.

[13] J.A Reijers. Selected Chapters on Geology; Sedimentary Geology and sequence Stratigraphy in Nigeria and a Field Guide,1996.