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Lithological Characteristics of XY Field, Shallow Offshore Niger Delta Basin, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author AYB designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors JNCO and OOO managed the analyses of the study. Author TMO managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The purpose of this study is to delineate litho-stratigraphic sequences penetrated by well 01, 02 and 03 within the XY field and also to describe the litho-stratigraphic characteristics of the sequences delineated using ditch cuttings, textural/lithological attributes and the distribution of the index minerals (ferruginous material, glauconites, carbonaceous detritals and shell fragments.
Study Design: The result of the lithostratigraphic analysis carried out on three wells from the XY field are presented and discussed.
Place and Duration of Study: The study was carried out in the shallow offshore Western Niger Delta, Nigeria from wells 01, 02 and 03 of XY field from July 2018 to September 2018.

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Methodology: The ditch cutting samples for the three wells were lithologically analysed under a stereo-binocular microscope Olympus model SZ 2 ILST. The dominant and secondary rock types, colour, average grain size, roundness, sorting and accessory minerals, sand-shale percentage, fossil and nature of cement and stage of diagenesis were the parameters used for the assessment of the samples. The lithologic descriptions were complemented using logs analyses.
Results: Lithological investigation of the three wells reveals that the lithofacies are generally made up of grey to dark grey shale and mudstone/siltstones interbedded with fine-medium and coarse-grained sandstones. Two units of lower paralic sequence and upper paralic sequence were assigned to the studied section of the three wells, based on their lithologic characteristics. The lower unit is composed mainly of shale and mudstone/siltstone interbedded with sands, while the upper unit is dominantly sanded alternating with shales/mudstones. On the basis of the foregoing, only one of the three formational units of Niger Delta was encountered.

Keywords: Lithostratigraphy; Agbada Formation; sandstones; shale; paralic sequence.

1. INTRODUCTION

The territory of Niger Delta Basin that cover covers an area of about 140,000 sq.km, is situated on the continental margin of the Gulf of Guinea on the west coast of Africa [1]. The basin lies between the longitudes 3° and 9° E and latitudes 4° and 6° N in the South-south geopolitical region of Nigeria [2]. The area of study (XY field) lies between latitudes 5° 36' N and 5° 36'4" N and longitudes 4° 42' 2" E and 4° 42' 5" E located within the coastal swamp II and shallow western offshore Niger Delta (Fig. 1)

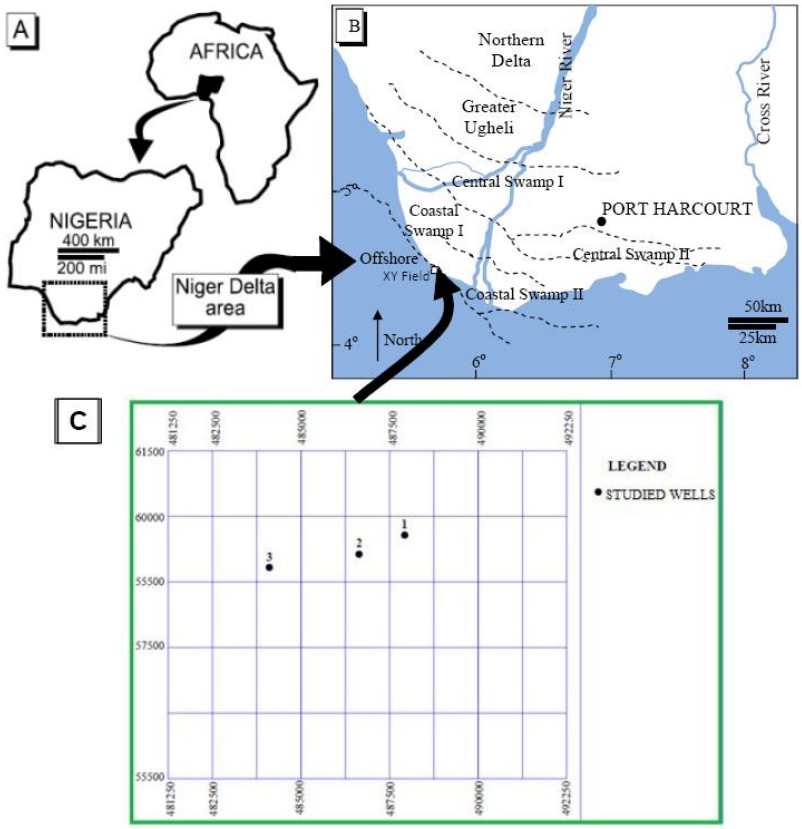


Fig. 1. (A). Location of Niger Delta along the west coast of Central Africa (B). Location of XY field. Modified from [3] (C). Base map location posting of XY field

The regressive wedge of clastic sediments which it comprises is thought to reach a maximum thickness of about 12000 m in the central part [3,4].

A large amount of data from several thousands of drilled wells have led to a considerable understanding of the stratigraphy and regional geology of the delta. The information has been published on the petroleum geology and sedimentology [5,6,7,8,9,10,11,12,13,14].

Accumulation of marine sediments in the basin commenced in Albian time after the opening of the South Atlantic Ocean between the African and South American continents. True delta development, however, started only in the late Paleocene/Eocene, when sediments began to build out beyond troughs between basement horsts blocks at the northern flank of the present delta area. Since then, the delta plain has prograded southward onto oceanic crust gradually assuming a convex to the sea morphology [15,16,17].

Throughout the geological history of the delta, its structure and stratigraphy have been controlled by the interplay between the rate of sediment supply and subsidence [18]. The Niger Delta Basin stratigraphy is further subdivided into three formations; Akata Formation (pro-delta shales, Palaeocene to Recent), Agbada Formation (deltaic and paralic facies, Eocene to Recent) and Benin Formation (fluviatile facie Oligocene-Recent). In cross-section, it is a large arcuate sediment wedge and constructive wave-dominated delta. The purpose of this study is to delineate lithostratigraphic sequences penetrated by well 01, 02 and 03 within the XY field and also to describe the lithostratigraphic characteristics of the sequences delineated using ditch cuttings, textural/lithological attributes and the distribution of the index minerals (ferruginous material, glauconites, carbonaceous detritals and shell fragments).

2. METHODOLOGY

The ditch cutting samples for the three wells were lithologically analysed under a stereo-binocular microscope Olympus model SZ 2 ILST. The dominant and secondary rock types, colour, average grain size, roundness, sorting and accessory minerals, sand-shale percentage, fossil and nature of cement and stage of diagenesis were the parameters used for the assessment of the samples. The lithologic descriptions were complemented using logs analyses.

3. RESULTS AND DISCUSSION

3.1 Lithostratigraphy of XY Field

Sedimentological deductions which were guided by paleo-bathymetric determinations were based on the integration of the wireline log motifs, textural/lithological attributes and the distribution of the index minerals (ferruginous material, glauconites, carbonaceous detritals and shell fragments.

These have permitted the assignment of the entire section of the wells to Agbada Formation. These criteria further enabled the delineation of two sequences: the transitional paralic and paralic across the field. Lithostratigraphy and subdivision of the studied well is presented in Figs. 2 - 4. Lithologic characteristics and of the studied sections of the three wells are discussed within the framework of the identified lithofacies sequences as follows:

3.1.1 The lower paralic sequence

The intervals delineated as a paralic sequence in the wells are 10,000- 11260 ft, 9050-11000 ft, 10300 - 12420 ft. for well 1, well 2 and well 3 respectively. The lithofacies sequence of wells 1 and 2 generally consists of interbedded sands, shales and siltstones. The sands and shale/siltstones have a thickness ranging between 10-260 ft and 10-230 ft, respectively. The sand and shale alternations of the sequence suggest frequent alternation of high and low energy sedimentary regime while well 3 is essentially a heterogeneous sequence of alternating sand and siltstone units. The sand and shales have thicknesses ranging between 10-270 ft and 20-360 ft, respectively.

The sands are milky white, dominantly medium to fine-grained, occasionally coarse to very coarse-grained and predominantly moderately sorted and subangular to subrounded. The shales are dark grey to brownish grey, silty, blocky to platy and moderately hard. The accessory mineral suite is dominated by ferruginous materials and mica flakes with spotty occurrences of shell fragments and pyrites. Glauconite pellets are rare and scattered throughout the sequence but abundant towards the lowermost part of the sequence. The predominately shaly character of the sequence

and the ubiquitous occurrence of ferruginous materials, presence of glauconite and carbonaceous detritus suggest deposition in low energy, sufficiently oxygenated, inner shelf settings [19]. The sedimentological characteristics such as sand/shale ratios being generally uniform almost throughout the sequence suggest a high degree of uniformity in sedimentation pattern. This also suggests that the sediments were deposited in environments in close lateral proximity.

The significant sand occurrences, the prevalence of ferruginous materials and carbonaceous detritals over the sequence are consistent with high energy, the oxygenated regime of sedimentation. This was, however, equally alternated by periods of low energy regime, represented by the shales /silt. This alternation is probably related to the well-documented frequent shift of depositional axis in the Niger Delta.

3.1.2 The upper transitional / paralic sequence

The intervals 6040 -10000 ft, 6040 – 9050 and 5980 - 10300 ft represent the transitional/ paralic sequence of wells 1, well 2 and well 3 respectively. The thick sand sequence with few interbedded shales varying in thickness from 10-210 ft. Generally, the sands are medium to fine-grained, occasionally coarse to very coarse-grained, subangular to subrounded and poorly to moderately well sorted. The shales are dark grey to brownish grey, platy to occasional blocky and moderately hard.

Ferruginous materials are ubiquitous throughout the sequence. Glauconite pellet, carbonaceous detritus, shell fragments and pyrite are fairly regular over the upper part of the sequence with rare mica flakes. The predominantly sandy nature of the sediments, the presence of ferruginous materials, carbonaceous detritals

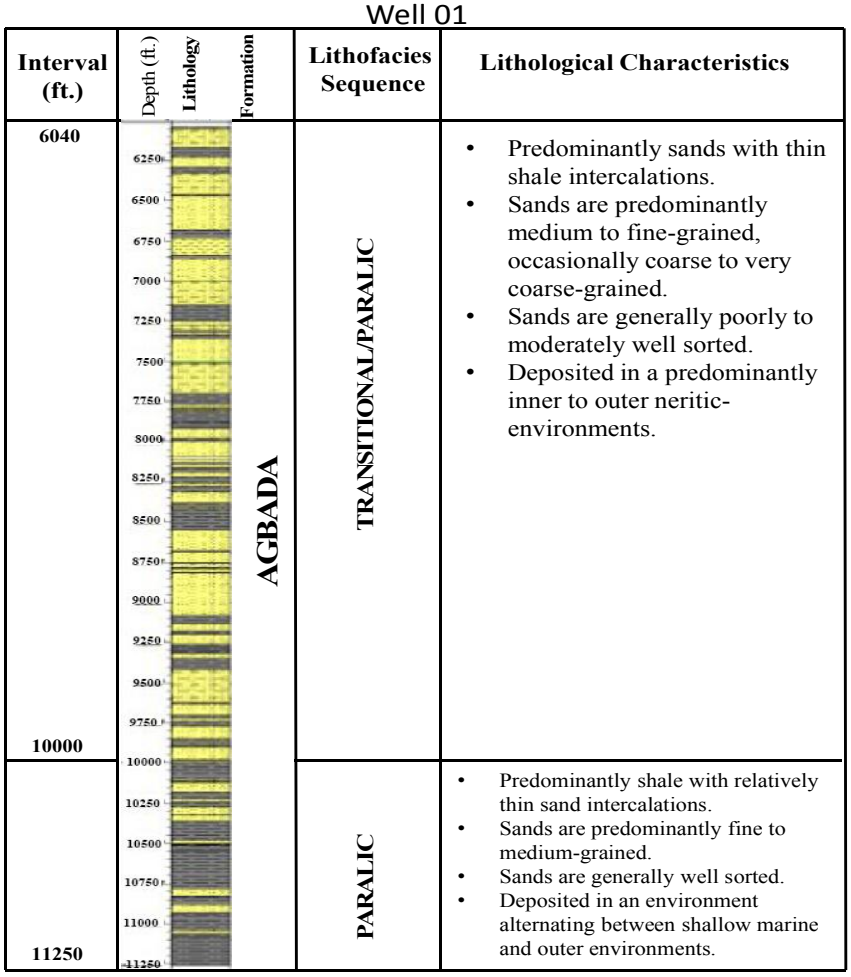


Fig. 2. Lithostratigraphic description and subdivision of well 1

and glauconite suggest deposition in high energy, marine settings [20]. This sequence is composed of dominant sands with shale intercalations. The sand/shale alternations of the sequence suggest frequent alternation of high and low energy sedimentary regime.

The predominantly sandy nature of the sediments, the presence of ferruginous materials carbonaceous detritals and glauconites suggest deposition in a well oxygenated, high energy, marine settings [21]. The occurrences of pyrites within the shale are consistent with low energy (sub-ware to sub-oxic to anoxic) depositional settings. This represents periods of low energy alternation in an otherwise high energy environment. Sediments of this sequence are believed to have been laid down in an environment fluctuating between coastal deltaic and shallow inner neritic.

Well 02

Interval (ft)	Depth (ft) Lithology Formation	Lithofacies Sequence	Lithological Characteristics
6040 – 9050	6250, 6500, 6750, 7000, 7250, 7500, 7750, 8000, 8250, 8500, 8750, 9000 — AGBADA	TRANSITIONAL/PARALIC	• Predominantly sands and shale intercalations. • Sand/shale ratio in near equal proportion at the upper section. • Sands are generally fine to medium-grained, occasionally coarse-grained. • Sands are generally well sorted. • Deposition in an environment alternating between inner and outer neritic.
9050 – 11000	9250, 9500, 9750, 10000, 10250, 10500, 10750, 11000 — AGBADA	PARALIC	• Predominantly shale and sands intercalations. • Above 9580ft, sands are dominantly medium to fine grained and moderately sorted. • Below 10150ft, sands are predominantly very fine to medium grained, occasionally coarse-grained and well sorted. • Deposited in an environment fluctuating between inner neritic and outer neritic.

Fig. 3. Lithostratigraphic description and subdivision of well 2

Well 03

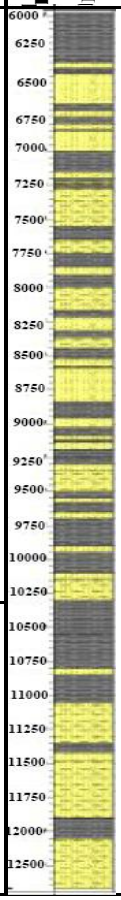
Interval (ft.)	Depth (ft.) / Lithology / Formation	Lithofacies Sequence	Lithological Characteristics
5980 – 10300		PARALIC/TRANSITIONAL	• Predominantly thick homogeneous shale/siltstone with interbeds of relative sands. • Sands are predominantly fine to medium grained, occasionally coarse to very coarse-grained. • Sands are poorly to well sorted. • Deposited in an environment alternating between inner to outer neritic.
10300 – 12420		PARALIC	• Homogeneous sequence of alternating very thick sand and very thick to thin shale/siltstone units. • Sands are predominantly medium-grained occasionally coarse-grained. • Sands are generally well sorted. • Deposited in an environment fluctuating between inner neritic.

Fig. 4. Lithostratigraphic description and subdivision of well 3

4. CONCLUSION

Lithological investigation of the three wells reveals that the lithofacies are generally made up of grey to dark grey shale and mudstone/siltstones interbedded with fine-medium and coarse-grained sandstones. Two units of lower paralic sequence and upper paralic sequence were assigned to the studied section of the three wells, based on their lithologic characteristics. The lower unit is composed mainly of shale and mudstone/siltstone interbedded with sands, while the upper unit is dominantly sanded alternating with shales/mudstones. This alternation is probably related to the well-documented frequent shift of depositional axis in the Niger Delta.

The sedimentological characteristics such as sand/shale ratios being generally uniform almost throughout the sequence suggest a high degree of uniformity in sedimentation pattern. This also suggests that the sediments were deposited in environments in close lateral proximity. Sediments of these sequences are believed to have been laid down in an environment fluctuating between inner neritic to outer neritic. On the basis of the foregoing, only one of the three formational units of Niger Delta was encountered.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Obaje NG. Geology and Mineral Resources of Nigeria. Springer-Verlag, Berlin Heldelberg. 2009;109 -113.
2. Ojo EA, Fadiya LS, Ehinola OA. Biozonation and correlation of BDX-1 and BDX-2 wells of deep offshore Niger Delta using calcareous nannofossils. Search and Discovery Article, Association of American Petroleum Geologist. 2009;50194:8.
3. Doust H, Omatsola E. Niger Delta, In: Edwards, J. D. & Santagrossi, P. A. (eds.), Divergent/passive margin basins. American Association of Petroleum Geologists, Tulsa Oklahoma, Memoir. 1990;45:201-238.
4. Bodunde SS, Enikanselu PA. Integration of 3D-seismic and petrophysical analysis with rock physics analysis in the characterization of SOKAB field, Niger delta, Nigeria. Journal of Petroleum Exploration and Production Technology. 2018;1-11.
5. Miall AD. Markov chain analysis applied to an ancient alluvial plain succession: Sedimentology. 1973;20:347-364.
6. Miall AD. A review of the braided river depositional environment: Earth Sci. Revs. 1977;13:1-62.
7. Miall AD. The geology of fluvial deposits: Sedimentary facies. Basin analysis and petroleum geology, Springer-Verlag, New York. 1996;2:1-3.
8. Short KC, Stauble AJ. Outline of geology of Niger delta complex. Sedimentology. 1967;2:195-222.
9. Weber KJ. Sedimentological aspects of oil fields in the Niger Delta. Geologic en Mijnbouw. 1971;50:559–576.
10. Weber KJ, Dankoru EM. Petroleum gelogical aspects of the Niger Delta. Nigeria Journal of Mining and Geology. 1975;12(½):9.
11. Ejedawe JE. Patterns of incidence of oil reserves in Niger Delta Basin. American Association of Petroleum Geologist Bulletin. 1981;65:1574-1585.
12. Ejedawe JE. Occurrence of giant oil field in the Niger Delta Basin. Journal of Mining and Geology. 1982;18(2):7-15.
13. Stacher P. Niger delta hydrocarbon habitat. Nigerian Association of Petroleum Explorationist Bulletin. 1994;9(1):67-75.
14. Emudianughe JE, Ogagarue DO. Investigating the subsurface pressure regime of Ada-field in onshore Niger Delta Basin Nigeria. J Geol Geophys. 2018;7: 452.
15. Stoneley R. The Niger Delta region in the light of the theory of continental drift. Geological Magazine. 1966;105:385-397.
16. Burke KC. Long shore Drift, submarine canyons and submarine Fans in Development of Niger Delta. American Association of Petroleum Geologist Bulletin. 1972;56:1975-1983.
17. Bertram Maduka Ozumba. Stratigraphic Framework of the Western Central Swamp of the Niger Delta, Nigeria. Sci Environm. 2018;1:105.
18. Oresajo BS, Adekeye AO, Haruna KA. Sequence stratigraphy and structural analysis of the Emi field, offshore depobe lt, eastern Niger Delta Basin, Nigeria. Ife Journal of Science. 2015;17(2):395-408.
19. Selley RC. Ancient Sedimentary Environments. 2nd (Ed.) Cornell University Press, Ithaca, New York. 1978;287.
20. Pictet A, Delanoy G, Adatte T, Spangenberg JE, Baudouin C, Boselli P, Föllmi KB. Three successive phases of platform demise during the early Aptian and their association with the oceanic anoxic Selli episode (Ardèche, France). Palaeogeography, Palaeoclimatology, Palaeoecology. 2015;418:101-125.
21. Fru EC, Kilias S, Ivarsson M, Rattray JE, Gkika K, McDonald I, Broman C. Sedimentary mechanisms of a modern banded iron formation on Milos Island, Greece. Solid Earth. 2018; 9(3):573.

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