IJAAR PUBLISHING®

Open Access Journal of Science Research | ISSN: 3027-1185
Vol. 2, Issue 1 (January-March, 2024) | www.ijaar.org

LITHOSTRATIGRAPHIC DESCRIPTION OF SEDIMENTARY STRATA PENETRATED BY WELLS "AMAMA-1 WELL" AND "BARA-1 WELL" OF THE CAMPANIAN – MAASTRITCHIAN STRATAS OF THE ANAMBRA BASIN

[1]Njoku, J.O., [2]Soronnadi-Ononiwu, G.C., [2]Acra, E.J

[1] Department of Geology Federal University of Technology, Owerri
[2] Department of Geology, University of Portharcourt

ABSTRACT

The study aims at a lithostratigraphic description of sedientary strata penetrated by wells "Amama-1 Well" and "Bara-1 well" of the Campanian – Maastritchian ages of the Anambra Basin. The two study wells are located in the Anambra Basin with geographic co-ordinates of latitudes 6°10' to 6°22'N and longitude 7°02' to 7°16' E. Ditch cutting samples and composite wire-line logs were provided for this study. The ditch cutting samples were examined under binocular microscope and analyzed to gather data on the stratigraphic succession, lithologic and textural variations. The data obtained helped to identify the lithofacies associations. Lithologic description show that the stratigraphic units composed of sequences of shale, sandstone and shale/sandstone intervals. The shales are dark grey, moderately hard, fissile and occasionally ferruginised. The sandstones are smoky, predominantly coarse to medium-grained, angular to sub-rounded, mostly consolidated, moderately sorted and occasionally ferruginised plus carbonaceous materials. Paleoenvironmental interpretation of the sections penetrated by the study wells indicated that the sediments were deposited in Non-Marine to Outer Neritic paleo-water depths as flood plain, distributary channel, interdistibutary bay as well as Distal bay facies. This information will enhance the exploration and exploitation of the hydrocarbon resources of the Basin.

Keywords: Lithostratigraphy, Sedimentary strata, Wells, Campanian, Maastrichtian, Anambra Basin

Njoku, J.O., Soronnadi-Ononiwu, G.C. & Acra, E.J (2024). Lithostratigraphic Description of Sedimentary Strata Penetrated by Wells "Amama-1 Well" and "Bara-1 Well" of the Campanian – Maastritchian Stratas of the Anambra Basin. *Open Access Journal of Science Research*. 2(1), 34-44.

Introduction

The Anambra Basin was formed during the second phase of the evolution of the Southern sedimentary Basins of Nigeria (Reyment, 1965; Murat, 1972 and Nwachukwu, 1972). This second phase; the Santonian compressional phase, resulted in the folding, faulting and uplifting the Abakaliki Basin to form an anticlinorium; displacing depocentres westward and eastward to form the Anambra and Afikpo basins. Sedimentary units of the Anambra Basin form a regressive offlap sequence, located on the continental crust and consist of the Nkporo Group and the Coal Measures, with the Nsukka Formation terminating sedimentation in the Anambra Basin (Nwajide, 2005, 2013).

The stratigraphy of the Campano-Maastrichtian Anambra Basin consists of the Nkporo Group (Nkporo/Enugu/Owelli Formation), Mamu Formation, Ajali Sandstones and the Nsukka Formation which is believed to have terminated sedimentation of the Anambra Basin (Nwajide, 2005).

The Enugu and the Nkporo Shales represent the brackish marsh and fossiliferous pro-delta facies of the Late Campanian-Early Maastrichtian depositional cycle (Reijers and Nwajide, 1998). Deposition of the sediments of the Nkporo/Enugu Formations reflects a funnel-shaped shallow marine setting that graded into channeled low energy marshes and accumulated during the regression of the Nkporo cycle (Obaje, 2009). However, the Mamu Formation occurs as a narrow strip trending north–south from the Calabar Flank, swinging west around the Ankpa plateau and terminating at Idah near the River Niger. It is made up of different lithologic units which include shales, siltstones, sandstones and coal. The shales of the Mamu Formation are generally interbedded with chamositic carbonates and overlain by bioturbated siltstones, sandstones and coal units in coarsening upward cycles towards the north (Akande *et al*, 1992). However, the coal deposits of the Mamu Formation are of fluvio-deltaic to fluvio-estuarine environments. Overlying this is the Ajali Formation and the Nsukka Formation of Middle – Late Maastrichtian age. The Ajali Formation is characterized by unconsolidated to poorly consolidated sandstones with thin siltstone interbeds that exhibit profuse cross-bedding; and marks the height of the overall regression in this epoch. The Nsukka Formation on the other hand, consists of dark shale, sandstones, with thin coal seams (Nwajide and Reijers, 1996), marking the beginning of the transgression that led into the formation of the Niger delta basin in the Early Paleogene. The post-Santonian sea level movement was transgressive, and lasted well into the Maastrichtian while the succeeding regression ended in the Danian.

The study aims at a lithostratigraphic description of sedimentary strata penetrated by wells of the Campanian – Maastritchian ages of the Anambra Basin.

Location of the study area

The two study wells are located in the Anambra Basin with geographic co-ordinates of latitudes 6°10′ to 6°22′N and longitude 7°02′ to 7°16′ E as shown on the map below (Figure 1).

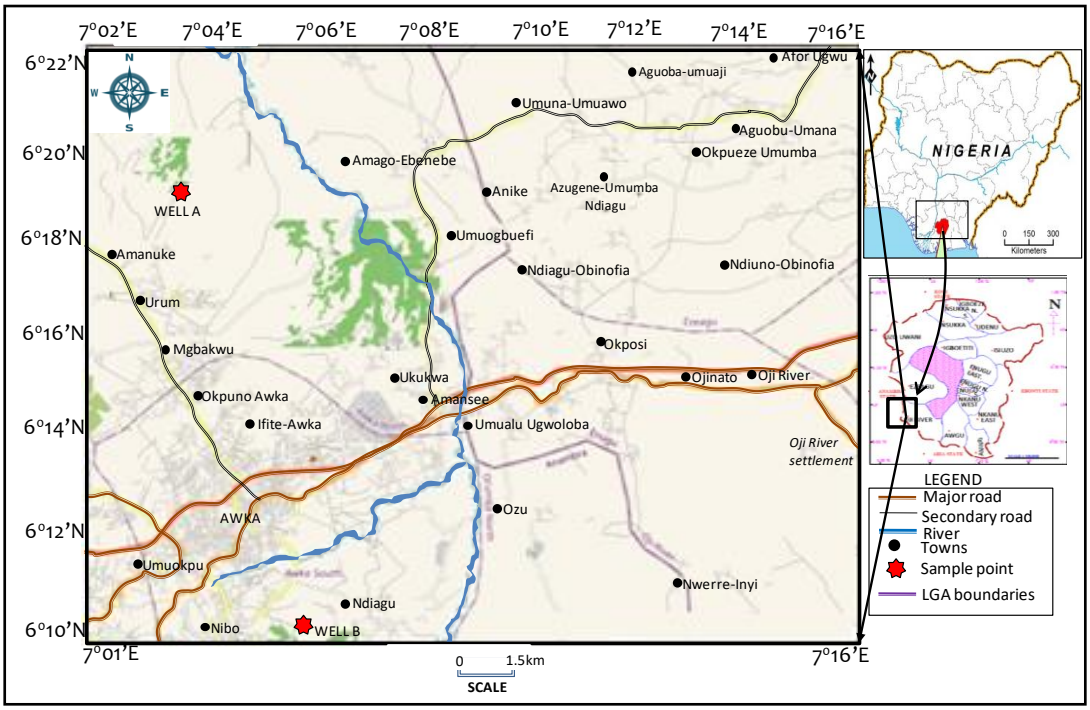


Figure 1. Map of the study area showing Location of the wells used in this study (Modified NGSA, 2004)

METHODOLOGY

Sample Administration

Ditch cutting samples and composite wire-line logs were provided for this study. The sample boxes were checked to confirm if the number of samples and sample depths agreed with the record on the sample manifest. The sample bags were checked for leakages and were repackaged where necessary.

Lithological description

The ditch cutting samples were examined under binocular microscope and analyzed to gather data on the stratigraphic succession, lithologic and textural variations. The data obtained helped to identify the lithofacies associations. The well logs also aided in constructing the lithologic log while detailing their textural properties the presence or otherwise of environmental indicator elements such as fecal pellets, glauconite, gypsum, anhydrite, various grades of coal (lignite), etc wells.

RESULTS

Lithostratigraphy of Wells

Lithostratigraphic unit is defined as a body of rock which is distinguished and delimited on the basis of the lithic characteristics and stratigraphic position. A lithostratigraphic unit generally conforms to the law of superposition and is commonly stratified and tabular in form. It can serve as the foundation of delineating strata, local and regional structure, economic resources, and geologic history in regions of stratified rocks. The lithostratigraphic interpretation of the analyzed section of the well was based on the description of ditch cutting samples and well log information. The various lithostratigraphic units penetrated by the wells in the Anambra basins are described in Table 1-2 and Figure 2-3.

Table 4.1: Lithologic Descriptions of Amama-1 Well

S/N	DEPTH(m)	LITHOFACIES	LITHOLOGIC DESCRIPTION
1.	165-667	Shale (100%)	Dark grey, moderately hard to hard, moderately fissile to fissile, micromicaceous and carbonaceous; with intercalations of sandstone and siltstone.
2.	667-1048	Sandstone (100%)	Smoky, predominantly coarse to medium-grained, angular to sub-rounded, mostly consolidated, moderately sorted and occasionally ferruginised.
3.	1048-1152	Shale (30%) Sandstone (70%)	Shale is dark grey, moderately hard to hard, moderately fissile to fissile, micromicaceous and carbonaceous; with intercalations of sandstone and siltstone. Sandstone is smoky, predominantly coarse to medium-grained, angular to sub-rounded, mostly consolidated, moderately sorted and occasionally ferruginised.
4.	1152-1256	Shale (100%)	Shale is dark grey, moderately hard to hard, moderately fissile to fissile, micromicaceous and carbonaceous; with intercalations of sandstone and siltstone.
5.	1256-1333	Sandstone (100%)	Sandstone is smoky, predominantly coarse to medium-grained, angular to sub-rounded, mostly consolidated, moderately sorted and occasionally ferruginised
6.	1333-1375	Shale (95%) Sandstone (5%)	Shale is dark grey, moderately hard to hard, moderately fissile to fissile, micromicaceous and carbonaceous; with intercalations of sandstone and siltstone Sandstone is smoky, predominantly coarse to medium-grained, angular to sub-rounded, mostly consolidated, moderately sorted and occasionally ferruginised
7.	1375- 1410	Sandstone (100%)	Smoky, predominantly coarse to medium-grained, angular to sub-rounded, mostly consolidated, moderately sorted and occasionally ferruginised.
8.	1410-1448	Shale (100%)	Shale is dark grey, moderately hard to hard, moderately fissile to fissile, micromicaceous and carbonaceous; with intercalations of sandstone and siltstone plus traces of Sandstone.
9.	1448-1467	Sandstone (100%)	Smoky, predominantly medium to fine-grained but occasionally coarse grained, sub-angular to rounded and moderately sorted.
10.	1467-1477	Shale (100%)	Shale is dark grey, moderately hard to hard, moderately fissile to fissile, micromicaceous and carbonaceous; with

			intercalations of sandstone and siltstone
11.	1477-1505	Sandstone (100%)	Smoky, predominantly coarse to medium-grained, angular to sub-rounded, mostly consolidated, moderately sorted and occasionally ferruginised plus carbonaceous materials.
12.	1505-1514	Shale (100%)	Shale is dark grey, moderately hard to hard, moderately fissile to fissile, micromicaceous and carbonaceous; with intercalations of sandstone and siltstone
13.	1514--1581	Sandstone (95%) Shale (5%)	Smoky, predominantly coarse to medium-grained, angular to sub-rounded, mostly consolidated, moderately sorted and occasionally ferruginised plus carbonaceous materials. Dark grey, moderately hard to hard, subfissile to fissile, carbonaceous and micromicaceous
14.	1581--1676	Shale (100%)	Dark grey, moderately hard to hard, subfissile to fissile, carbonaceous and micromicaceous
15	1676-1714	Sandstone (100%)	Smoky, predominantly medium to fine-grained but occasionally coarse- grained, sub-angular to rounded, moderately sorted and consolidated.
16.	1714 -1742	Shale (100%)	Dark grey, moderately hard to hard, subfissile to fissile, carbonaceous and micromicaceous
17.	1742-1753	Sandstone (100%)	Smoky, predominantly medium to fine-grained but occasionally coarse- grained, sub-angular to rounded, moderately sorted and consolidated.
18.	1753 - 1829(TD)	Shale (100%)	Dark grey, moderately hard to hard, subfissile to fissile, carbonaceous and micromicaceous

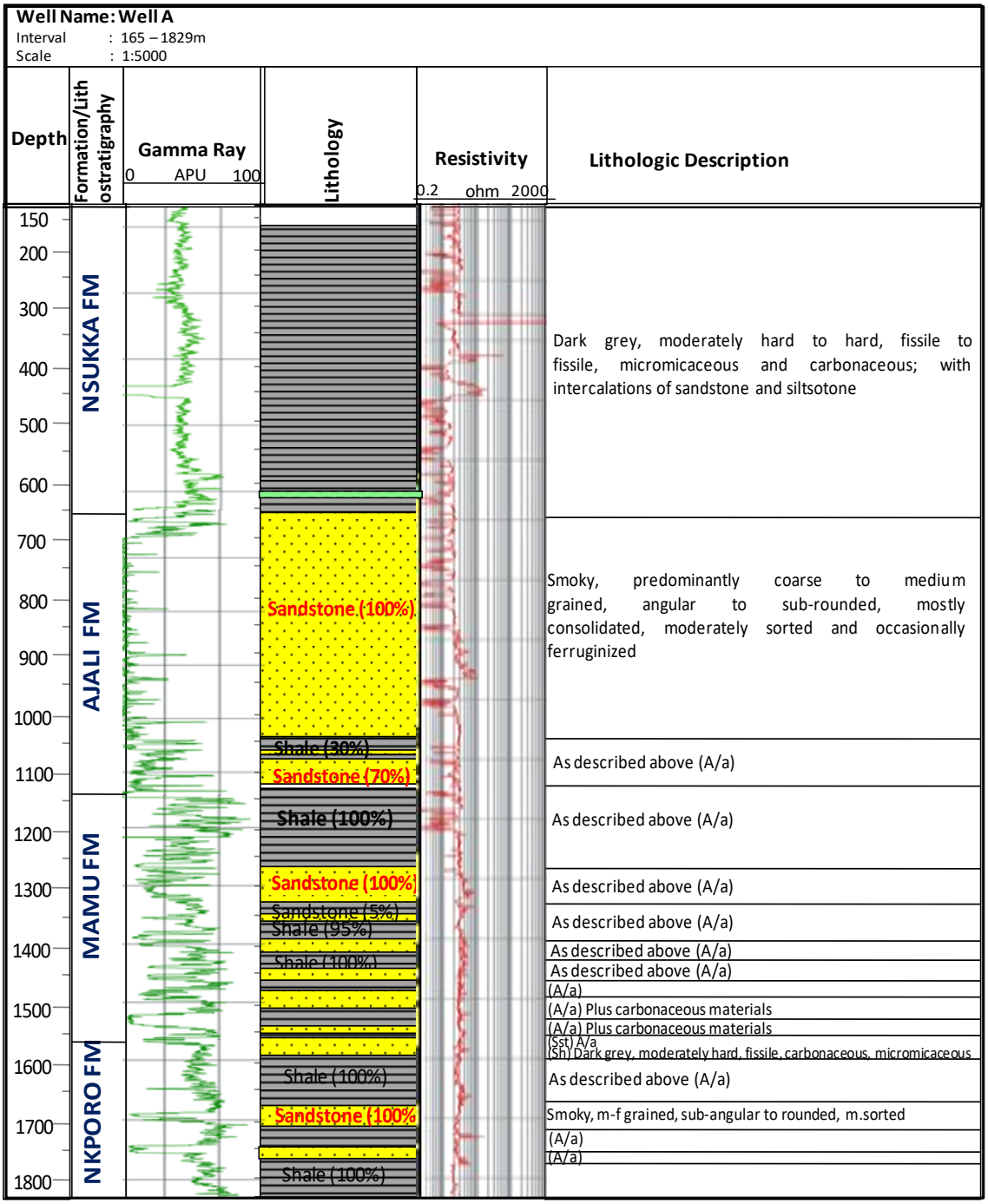


Fig. 2. Lithologic description of Amama-1 Well

Lithologic description of samples from Amama-1 Well

Nkporo Formation (1573-1829m)

This formation was found occurring from 1573 m – 1829m it consists of an extensive dark-grey coloured, subfissile shale, moderately to hard carbonaceous and micromicaceous. It has its lateral equivalent as the Enugu Shales and the Owelli Sandstone which occurred towards the central parts of the Anambra Basin. This Formation is highly fossileferous.

Mamu Formation (1152m to 1573m)

This occurred between depth interval 1152m to 1573m. The formation is made up of dark grey shale which is moderately hard to hard, moderately fissile to fissile, micromicaceous and

carbonaceous; with intercalations of sandstone and siltstone. The formation is known to be composed of coal seam but it was not found in the samples used for this study. The formation is transitional between the marine campanian Enugu shale and the marginal marine Ajali sands.

Ajali Sandstion (622 – 1152)

The Ajali Sandstone occurred at intervals 622m to 1152m. It is made up of sandstones and some shale intercalations. The sandstone is smoky, predominantly coarse to medium-grained, angular to sub-rounded, mostly consolidated, moderately sorted and occasionally ferruginised. Shale is dark grey, moderately hard to hard, moderately fissile to fissile, micromicaceous and carbonaceous; with intercalations of sandstone and siltstone. This formation represents deposition in continental environment.

Nsukka Formation (165 – 622m)

This Formation is encountered between the 165m to 622m. This Formation consists of shales and sandstone intercalation. The shale is dark grey, moderately hard to hard, moderately fissile to fissile, micromicaceous and carbonaceous; with intercalations of sandstone and siltstone. Sandstone is smoky, predominantly coarse to medium-grained, angular to sub-rounded, mostly consolidated, moderately sorted and occasionally ferruginised. The shales also contained finely dispersed coal fragments with some plant debris and microfauna.

Lithologic Description of Samples from Bara-1 Well

The well penetrated three major formations of Nkporo, Mamu, Ajali, and Nsukka Formations (Table 2; Fig 3).

Table 2. Lithologic descriptions of the Bara-1 Well

S/N	DEPTH(m)	LITHOFACIES	LITHOLOGIC DESCRIPTION
1.	305-384	Shale (100%)	Dark grey, moderately hard, fissile and occasionally ferruginised; with traces of smoky, coarse-grained, angular to sub-rounded and well sorted sandstone.
2.	384-429	Sandstone (100%)	Smoky, predominantly coarse to medium-grained, angular to rounded and moderately sorted.
3.	429-457	Shale (100%)	Dark grey, moderately hard and fissile.
4.	457 -485	Sandstone (100%)	Smoky, predominantly medium to fine- grained, sub-angular to rounded and poorly sorted.
5.	485 -495	Shale (100%)	Dark grey, moderately hard and fissile; with ferruginised materials.
6.	495 -530	Sandstone (100%)	Smoky, predominantly medium to fine- grained; occasionally coarse-grained, sub-angular to rounded and poorly sorted.

7.	530 - 563	Shale (100%)	Dark grey, moderately hard and fissile; with ferruginised materials.
8.	563 – 585	Sandstone (100%)	Smoky, predominantly medium to fine- grained; occasionally coarse-grained, sub-angular to rounded and poorly sorted
9.	585 - 634	Shale (100%)	Dark grey, moderately hard and fissile; with ferruginised materials.
10.	634 - 671	Sandstone (100%)	Smoky, predominantly medium to fine- grained; occasionally coarse-grained, sub-angular to rounded and poorly sorted
11.	671 - 683	Shale (100%)	Dark grey, moderately hard and fissile; with ferruginised materials
12.	683 - 701	Sandstone (100%)	Smoky, predominantly medium to fine- grained; occasionally coarse-grained, sub-angular to rounded and poorly sorted
13.	701 - 756	Shale (100%)	Dark grey, moderately hard and fissile; with ferruginised materials
14.	756 - 791	Sandstone (100%)	Smoky, predominantly medium to fine- grained; occasionally coarse-grained, sub-angular to rounded and poorly sorted
15.	791 - 860	Shale (100%)	Dark grey, moderately hard and fissile; with ferruginised materials
16.	860 - 867	Sandstone (100%)	Smoky, predominantly medium to fine- grained; occasionally coarse-grained, sub-angular to rounded and poorly sorted
17.	867 - 1600	Shale (100%)	Dark grey, moderately hard and fissile; with ferruginised materials

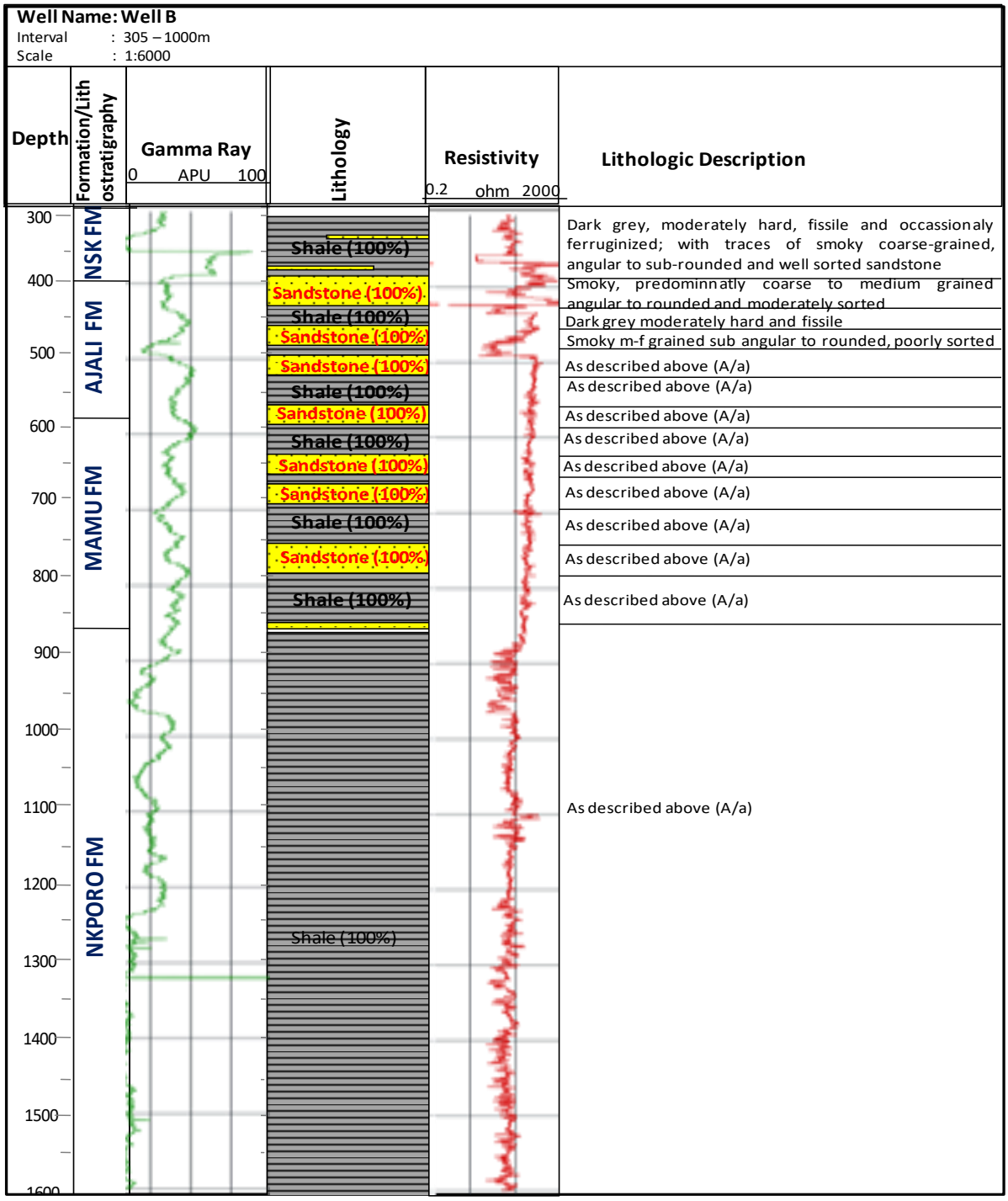


Figure. 3. Lithologic description of Bara-1 Well

Nkporo Formation (879-1600m)

This Formation is found between intervals 879m to 1600m of Bara-1 Well. This formation is composed of Dark grey, moderately hard and fissile; with ferruginised materials shale (Table 4.2). It is composed of central layers of sand and sandy mudstone and represents the lateral equivalents of the Enugu shales and the Owelli sandstones in the Eastern Nigeria.

Ajali Sandstones (384-591m)

It occurred between intervals 384m to 591m. It is made up of sandstones and shale intercalations. The sandstone is dark grey, moderately hard, fissile and occasionally

ferruginised; with traces of smoky, coarse-grained, angular to sub-rounded and well sorted sandstone, while the shale is Smoky, predominantly coarse to medium-grained, angular to rounded and moderately sorted.

Nsukka Formation (305-384m)

The Formation occurred between 305m to 384m. It is composed of shales and shaly sandstones and sandstones intercalations. The Shales are dark grey, moderately hard, fissile and occasionally ferruginised; with traces of smoky, coarse-grained, angular to sub-rounded and well sorted sandstone. The sandstones are smoky, predominantly coarse to medium-grained, angular to rounded and moderately sorted.

Mamu Formation (591-878m)

This formation occurs at depth of between 591 m to 878m. It is composed of shales which are dark grey, moderately hard and fissile; with ferruginised materials, sandstones which are Smoky, predominantly medium to fine- grained; occasionally coarse-grained, sub-angular to rounded and poorly sorted and heterolithic lithologies. The coal seams were not recovered from the samples.

DISCUSSION

Paleoenvironmental characterization of Amama-1 Well was based on the lithological, properties. The basal interval of the well is composed of shale, and shale and sandstone intercalations with a shale predominant upper interval. This suggested deposition in low energy environment such as intertidal zones and swampy environment (Petters 1983, Okwara et al, 2020; Onyekuru and Iwuagwu, 2010).

Paleoenvironmental characterization of Bara-1 Well was based on the lithological/sedimentological properties. The basal interval of the well is composed of shale, while the upper units are made of an alternation of shales and sandstones and sandstones interval. The shales are dark grey, moderately hard, fissile and occasionally ferruginised; with traces of smoky, coarse-grained, angular to sub-rounded and well sorted sandstone.

The sandstones are smoky, predominantly coarse to medium-grained, angular to sub-rounded, mostly consolidated, moderately sorted and occasionally ferruginised plus carbonaceous materials.

This suggested deposition in a non marine environment for the upper units and a low energy environment such as intertidal zones and swampy environment for the lower units (Petters 1983; Onyekuru and Iwuagwu, 2010).

CONCLUSION

Sedimentologic data from have been used to describe the lithostratigraphic intervals of Campanian – Danian of the Anambra Basin penetrated by Wells Amama-1 and Bara-1. Paleoenvironmental interpretation of the sections of the Anambra Basin penetrated by the study wells indicated that the sediments were deposited in Non-Marine to Outer Neritic paleo-water depths as flood plain, distributary channel, interdistributary bay as well as Distal bay facies. This information will enhance the exploration and exploitation of the hydrocarbon resources of the Basin.

REFERENCES

Akande, S.O. and Erdtmann, B.D. (1998): Burial metamorphism (thermal maturation) in cretaceous sediments of the southern Benue Trough and Anambra Basin, Nigeria, AAPG Bull. 82, vol. 6, p1191-1206.

Murat, R. C. (1972): Stratigraphy and Paleogeography of the Cretaceous and lower Tertiary in Southern Nigeria. In: African Geology, Univ. of Ibadan press, p252 – 266.

Nwajide, C.S. (2005): Anambra Basin of Nigeria: synoptic basin analysis as a basis for evaluating its hydrocarbon prospectivity. In: Okogbue, C.O. (ed): Hydrocarbon potentials of the Anambra Basin: geology, geochemistry and geohistory perspectives. Proceedings of the first seminar organized by the petroleum technology development fund (PTDF) chair in geology. University of Nigeria, p 1–46

Nwajide, C.S. (2013): Geology of Nigeria's sedimentary basins. CSS Bookshops Limited, Lagos, p 565.

Nwajide, C.S. and Reijers,T. J. A. (1996): Geology of the Southern Anambra Basin, In: T.J.A. Reijers (ed.), Selected Chapters on Geology. Shell Petroleum Development Company: Warri, Nigeria, p133–148.

Obaje, N.G. (2009): Geology and Mineral Resources of Nigeria, Springer Dordrecht Heidelberg London New York, p158-162.

Okwara, I. C., Dim, C. I. P. and Anyiam, O. A. (2020): Reservoir evaluation within the sequence stratigraphic framework of the Upper Cretaceous Anambra Basin, Nigeria, Journal of African Earth Sciences, vol.162, p1-18.

Onyekuru, S.O, &Iwuagwu, C.J. (2010). Depositional Environments and sequence stratigraphic interpretation of the Campano-Maastrichtian Nkporo Shale Group and Mamu Formation exposed at Leru-Okigwe axis, Anambra Basin, Southeastern Nigeria. *Australian Journal of Basic and Applied Sciences*, 4(12): 6623-6640.

Petters, S. W.(1983): Gulf of Guinea Planktonic Foraminiferal Biochronology and Geological History of the South Atlantic. Jour. Foram. Res., vol.13, no. 1, p32 – 59.