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# CAMPANO- MAASTRICHTIAN AJALI SANDSTONE: A DEEP MARINE DEPOSIT IN ALO AREA OF ANAMBRA STATE.

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**Abstract:**

The subsurface investigation of the facies in Alo and Igbariam wells, Anambra State was carried out to reconstruct the paleoenvironmental setting of the area. Using well logs analysis, sandstone, siltstone and shales were discovered as the major lithologic units prevalent in the area. Further integration of the analysis of well logs with biofacies data revealed basin floor fan, distributary mouth bar, offshore bar, channel sand, deltaic distributaries or turbidite channels, alluvial sands, braided streams, tidal sands, fluvial channels or point bars as the depositional environments of the sand bodies encountered. A basin floor fan which was believed to be Ajali Sandstone was identified in Alo area. It is therefore concluded that Ajali Sandstone which wass documented as continental to marginal marine deposits in the surface may be a deep marine deposit possibly a basin floor fan in the subsurface.

**Keyword:** Depositional Environment, Facies, Sandstone, Log motif, Biofacies data.

## 1.0 INTRODUCTION

Ajali Formation formally known as False Bedded Sandstone is a widespread stratigraphic unit in Anambra/Afikpo Basins of southeastern Nigeria. Regionally, the formation comprises of thick friable, poorly sorted sandstones, usually white in colour but occasionally iron-stained. Mudstones and shales are also common in this formation. Ajali Formation is the only Cretaceous sediments in Anambra basin that is laterally extensive. The sediments extend from the east to the west like the Benin Formation in Niger Delta. The Ajali Formation is superimposed by Nsukka Formation while it is underlain by Mamu Formation.

The depositional environments of the Ajali Formation have been interpreted by several workers. They include Reyment (1965) who inferred continental environment. Hoque and Ezepue (1977) suggested Fluvio-deltaic environment, Banerjee (1979) interpreted Intertidal bar-and-channel, while Amajor (1985) deduced Intertidal bar. These interpretations were based on outcrop studies. This present study therefore concentrates on subsurface investigation of Ajali Sandstone.

## 2.0 GEOLOGIC SETTING AND STRATIGRAPHY.

The study area is located in the southern part of Anambra Basin of Southeastern Nigeria as shown in figure 1 below. The sediments of Anambra Basin include the Albian sediments which comprises of Asu River Group. These sediments contain alternating shales and siltstones with occurrences of sandstone. Asu River Group is the oldest stratigraphic unit in Anambra Basin. It is overlain by the Ezeaku Formation, which constitutes the Turonian deposits. Ezeaku Formation contains hard

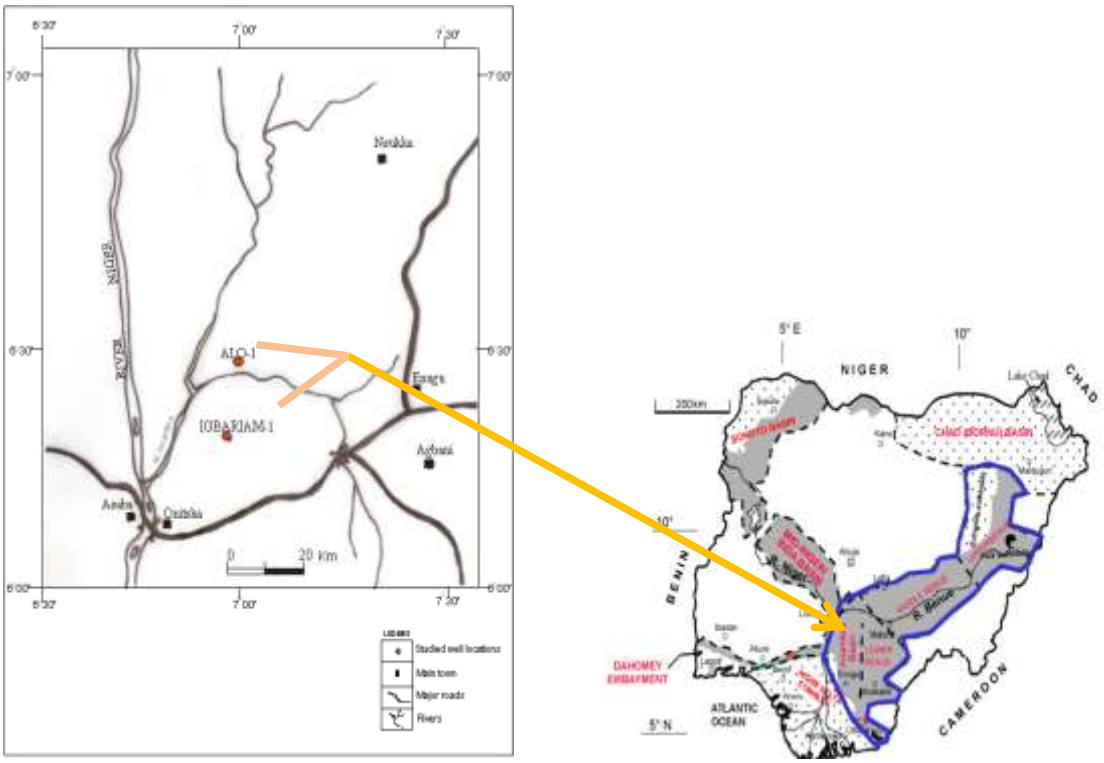



Figure 1: Location map of Anambra Basin showing the study area and the inset of map of Nigeria (After Nwajide, 2006).

grey and black calcareous shale, limestone and siltstone. This formation is covered by Awgu Shale which is predominantly shale. Awgu Shale was substituted by Agbani sandstones. The basal unit of Awgu Shale contains Turonian ammonites while the top is early Coniacian. Awgu Shale is superimposed by the paralic Nkporo/Enugu shale which has Owelli Sandstone as the lateral equivalent in the basin. Enugu Shale is pre-dominantly shales at the base with little limestone and sandstone occurrences. This formation is Coniacian-Santonian in age. The Mamu Formation covers the Nkporo shale. This formation is the basal unit of the coal measure sequence. It is a Campanian deposit. Mamu Formation consists of sandstones, carbonaceous shales, sandy shales and some coal seams.

The Ajali Sandstone which is also known as false-bedded sandstone overlies the Mamu Formation. This formation is predominantly coarse grained sandstone. Ajali Sandstones are deposited during the Maastrichtian. The formation is superimposed by the last Cretaceous sediments in the basin which is the Nsukka Formation. This formation is also known as the Upper Coal Measures. It comprises of carbonaceous shales, sandstones and some thin coal seam. Overlying the Nsukka formation is the Imo Shale. The sediments of this formation consist of shales, shally-limestones and limestones. These sediments were deposited during the Paleocene (Kogbe, 1989). The Eocene Bende-Ameki Formation and its lateral equivalent (Nanka Sandstone) overlie the Imo Shale.

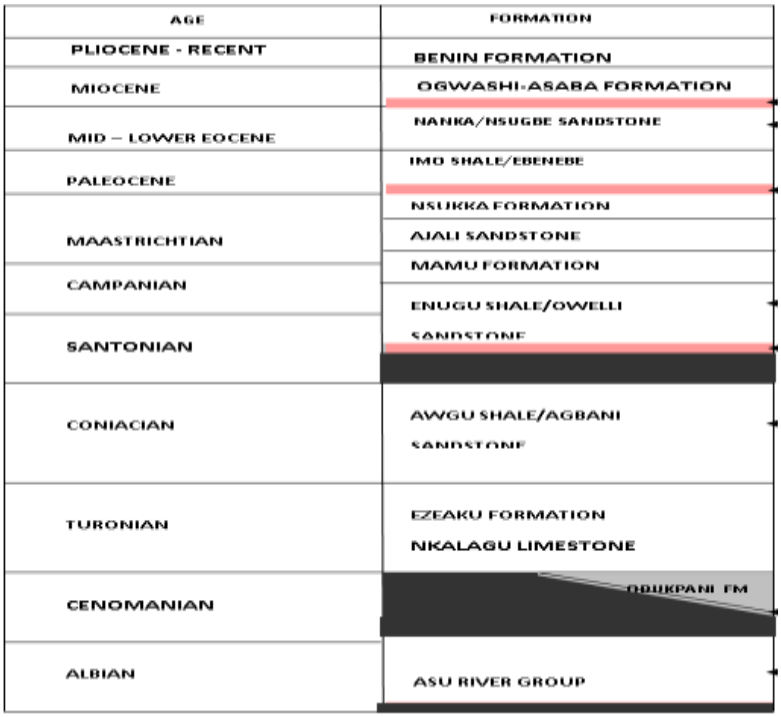
On top of the Ameki formation is the Ogwashi-Asaba Formation which was deposited during the Oligo-Miocene Epoch. The Benin formation which is the last sediment in Anambra Basin was deposited above the Ogwashi-Asaba Formation. The formation is Pliocene-Recent in age. These formations are represented in their stratigraphic order as shown in Table 1.

## 3.0 MATERIALS AND METHOD

The data used in this study include wireline logs (gamma ray & resistivity) and biostratigraphic data. The methodology involved delineation of lithology, identification of electrofacies and paleoenvironmental reconstruction. Sand was recognised with low gamma ray and high resistivity readings while shale displayed high gamma ray and low resistivity readings. Siltstone on the other hand was identified with intermediate readings of both gamma ray and resistivity. Elecrofacies were identified based upon the characteristic shapes and changes on the gamma ray

log. Funnel shaped motif represents coarsening or cleaning upwards trend which shows decrease in clay contents (Figure 2). Bell shaped gamma ray log signature denotes finning or dirtying upwards sequence which represents increase in clay content.

Table1: Stratigraphic Succession in Anambra (Modified from Reyment, 1965)




Cylindrical shaped motif is a suggestive of more uniform bedding and consistent depositional energy within the bed. The gamma ray logs used in the study have a shale reference line of

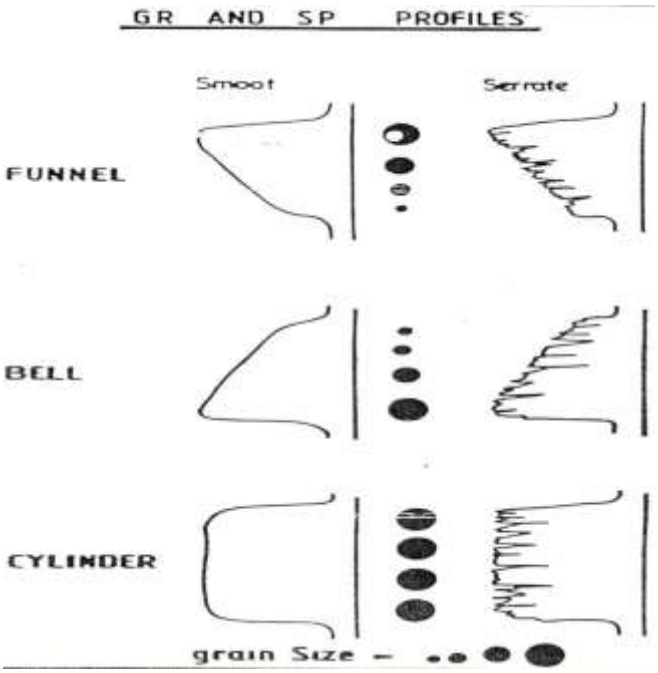



Figure 2: Gamma ray and SP log profiles showing the basic shapes of facies (After Shell, 1982).

$75^0$ API chosen from the usual potential range of 0 - $150^0$ API. The deflection of the log signature to the left of the reference line indicates sand whereas deflection to the right depicts shale. Paleoenvironmental reconstruction was made by integrating the facies analysis with biofacies data.

## 4.0 RESULTS AND DISCUSSION

### 4.1 Lithologic Interpretation

Sandstone, siltstone and shales are the major lithologic units dominant in the study area. Intermediate terminology such as sandy shale or shaly sand was mainly used to explain variations that have significant impact on interpretation. The interval coloured yellow depicts sand while the interval coloured black represents shale. Siltstone is coloured green (Figure 3).

### 4.2 Facies Analysis and Depositional Environment

The first precedence in reservoir description is the determination of the depositional setting and the series of facies that occur within the reservoir. The knowledge of depositional setting is essential for reconstructing the earth history, understanding earth processes and helping humans

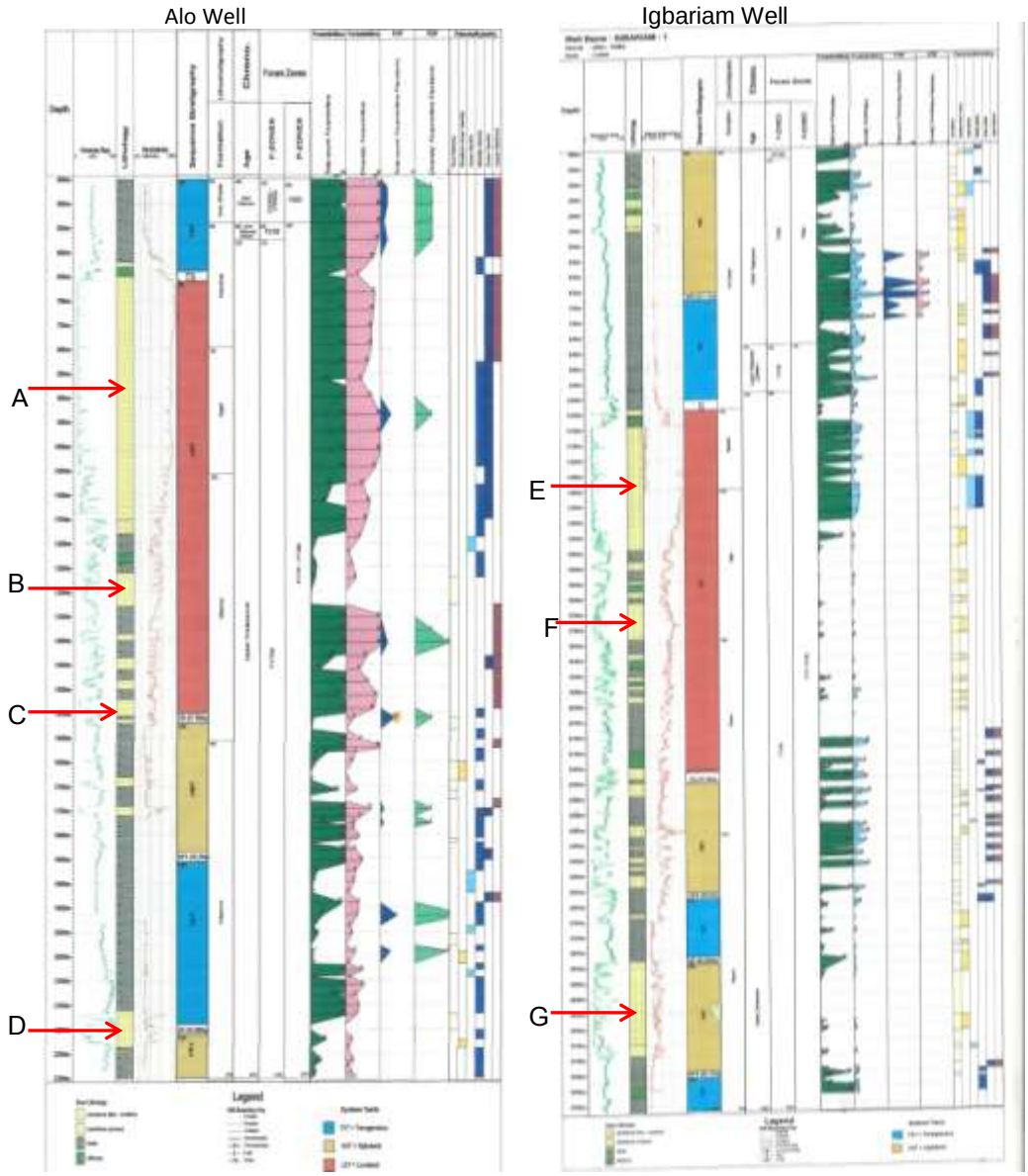



Figure 3: A plot of wireline logs and biostratigraphic data for both Alo and Igbariam wells

manage their environment. Three log facies were documented in two studied wells. They are funnel shaped log motif, bell shaped log motif and finally, cylindrical shaped log signature. A total of seven facies labelled A to G were recognised in both Alo and Igbariam wells (Figure 3).

### 4.2.1 Alo Well

Four facies were identified in Alo area. The facies are labeled A to D. **Sand unit A** which ranges in depth between 660 – 1150m has a cylindrical gamma ray motif. The thickness of this sand body is about 490m. This massive cylindrical shaped facies has sharp boundaries. Facies A is within marine paleobathymetry (Inner Neritic to Upper Bathyal). Based on the log signature and paleobathymetric setting, the environment of deposition may be said to be that of Basin Floor Fan.

**Sand unit B**

The gamma ray log of this sand body shows a funnel shape which is serrated. This facies ranges in depth between 1260 – 1330m (70m thick). The basal contact is sharp. The sand unit falls within non- marine paleobathymetry. The paleoenvironment may be interpreted as distributary mouth bar.

**Sand unit C**

This sand unit in Alo area shows a blocky log signature which is coarsening upward. It occurs between depths 1520 – 1550m with thickness measuring about 30m. The basal contact is gradational. Facies C is within Neritic paleobathymetry. The depositional environment may be inferred as offshore bar based on the above interpretation.

**Sand unit D**

Sand unit D with a depth range of 2170 – 2220m displays blocky but fining upward sequence. The facies is 50m thick. It also has a sharp basal contact and is within non-marine setting. Based on the gamma ray log characteristics and paleobathymetry, this facies may be interpreted as channel sand.

### 4.2.2 Igbariam Well

Three facies labelled E to G were encountered in Igbariam well. These include;

**Sand unit E:** This facies falls within a depth range of 1100 – 1500m (400m thick). The basal and upper contact of this sand unit is sharp with serrated blocky log signature which is cylindrical in shape. This facies may represent turbidite channels or deltaic distributaries since the upper unit of the facies falls within Middle Neritic and the lower section, non-marine.

**Sand unit F:** Log facies of sand unit F has sharp upper contact while the basal contact is gradational. It ranges in depth between 1660–1790m, measuring about 130m in thickness. It has a bell shaped log motif which is fining upward. This facies is within non-marine paleobathymetry. By integrating the long motif with the
paleobathymetry, the environment of deposition may be construed as alluvial sands, braided streams, fluvial channels or point bars.

**Sand unit G:** This facies contains a blocky unit with a cylindrical shaped motif. Sand G ranges in depth between 2850 – 3140m. The thickness is measured as 290m. It also has a sharp basal contact and is within non- marine paleobathymetry. Based on well logs analysis and paleobathymetric setting, the environment of deposition may be interpreted as tidal sands or fluvial channels.

### 4.3 Depositional Model for Ajali Sandstone

Depositional model provides the summary of a precise environment based on the characteristic sedimentary features. The descriptive characters of the depositional model of Ajali Sandstone were obtained by integrating results from facies description and biostratigraphic data. Basin floor fan identified shows that Ajali Sandstone is a deep marine deposit. Basin floor fans are associated with the time of rapid eustatic fall. When sea level falls below the shelf break, sediments are transported across the shelf in incised valleys and rapidly deposited into the basin. Figure 4 represents the depositional model of Ajali Sandstone.

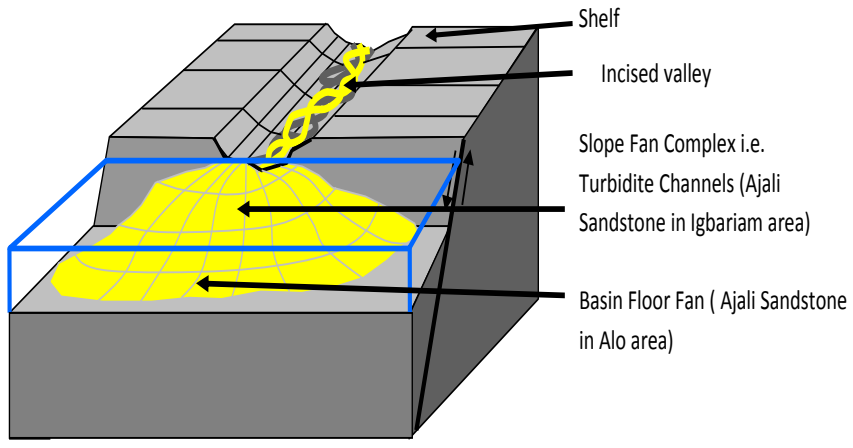



Figure.4: Depositional model of Ajali Sandstone

## SUMMARY AND CONCLUSIONS

Sandstone, siltstone and shale are the major lithologies present in the study area. Three log facies which include funnel, bell and cylindrical shaped motifs were recognized from well logs. These facies represent environment of basin floor fan,

distributary mouth bar, offshore bar and channel sand in Alo area while the depositional environment as observed in Igbariam area include; deltaic distributaries or turbidite channels, alluvial sands, braided streams, tidal sands, fluvial channels or

point bars. Basin floor fan believed to be Ajali Formation were found in Alo well.

These are capped with shales (Nsukka Formation) which serve as seal. The same Ajali Formation was observed at Igbariam area as deltaic distributaries or turbidite channels.

This study therefore, has revealed that the Ajali Sandstone, which was regarded as continental in origin by Reyment (1965) or intertidal by Amajor (1985) was likely deposited in an environmental spectrum ranging from deep marine through transitional to continental.

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