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PALEOENVIRONMENTAL INTERPRETATION OF SUCCESSION PENETRATED BY THE DRILL IN NASARA-1 WELL, GONGOLA BASIN, NORTHERN BENUE TROUGH

F.A. Lucas and D.O. Obozekhai

Department of Geology, University of Benin, Benin City, Nigeria

Abstract

Nine (9) ditch cutting samples taken at several shaly intervals between 1500ft and 5190ft from Nasara-1 well, Gongola Basin, Northern Benue Trough were subjected to standard methods and techniques employed in the research institute and oil industry for foraminiferal contents. The aim of the research was to interpret the environments in which the analyzed intervals penetrated by the drill in the well were deposited, and this had to be done by first knowing the foraminiferal species present within the intervals, because forams, particularly the benthic forms give idea of past depositional environments. The analyzed interval was deposited in a Transitional to Inner Neritic setting, slightly low salinity, dysoxic environment, based on the recovered agglutinated benthic foraminiferal species.

Keywords: Paleoenvironments, Gongola Basin, Agglutinated benthics, Foraminifera species.

1. INTRODUCTION

The Benue Trough of Nigeria is part of the West and Central African Rift System; a tectonic structure formed by tension generated due to the separation of the African and South American plates during the Early Cretaceous [1]. The trough is filled with up to 6000m of Cretaceous-Paleogene sediments [1, 2].

With increasing advancement of biostratigraphy as a means of petroleum exploration, it therefore means the environment of deposition of sediments within a given well sequence should be known and correlation with other wells within the region is necessary. Understanding of the depositional environments and processes which brought about the deposition of sediments within a given well sequence, give the petroleum geologist a first look knowledge of certain characteristics such as source rock maturity, some reservoir properties, etc., when exploration is being carried out.

Location of well: Ditch cutting samples were collected from Nasara-1 well which lies between latitude 9^{o} $50'$N and longitude 10^{o} $54'$E (fig. 1), Gongola Basin, Northern Benue Trough.

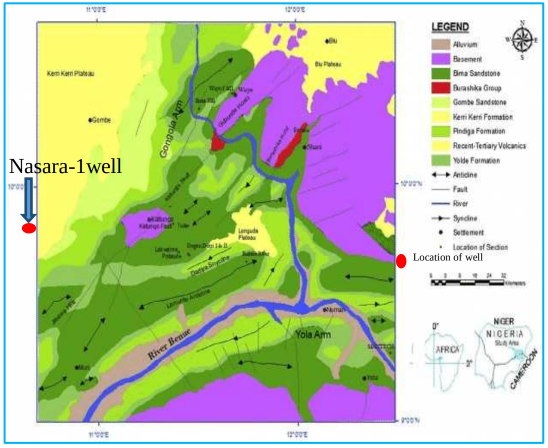

Fig. 1: Geological map of Northern Benue Trough showing location of Nasara-1 well arrowed. (Adapted from [3]).

Corresponding Author**:** Lucas F.A., Email: drfalucas@gmail.com, Tel: +2348181656805, +2347063413312 (DOO)

Stratigraphy of Gongola Basin

The Gongola arm of the Northern Benue Trough is N-S trending arm of the 1000km long Benue Trough. Its lithostratigraphical sequence begins with the Bima Group, which the continental to marine Yolde Formation lies on, the Gongila Formation conformably overlies the Yolde Formation, the Pindiga Cretaceous series follows, and then the Gombe Formation and the Tertiary Kerri-Kerri Formation follow in the stratigraphic sequence respectively (fig. 2).

Bima Formation: It is the oldest lithologic unit occupying the base of the cretaceous successions. The Bima Formation has been differentiated into three members by [4] and [5]; the Lower Bima (B_1), the Middle Bima (B_2) and the Upper Bima (B_3) which were also identified in the seismic section of the Nigerian sector of the Chad Basin [6]. The Lower Bima (B_1) is the oldest member (Late Jurassic-Berremian-Aptian) and has been described as consisting of fault controlled conglomerates, sands and gravels with poorly defined internal structures and characterized by well-defined fining-upward succession [5].

The Late Aptian-Albian Middle Bima (B_2) unconformably overlies the Lower Bima Member. It is composed of medium to very coarse grain feldspathic sandstones with trough and tabular cross bedding interbedded with clays [7, 8]. The Upper Bima (B_3) conformably overlies the Middle Bima (B_2); it has a relatively homogenous appearance consisting of planar cross bedded, medium to coarse grained sandstone that shows soft sediment deformation [9].

Yolde Formation: This is a Continental to Marine (transitional) Formation that lies above the Bima Formation. It has a thickness of about 200 meters. In [4] the formation was defined as a variable sequence of sandstones and shales which marked the transition from continental to marine sedimentation and that the base of the formation is defined by the first appearance of marine shales and the top by the disappearance of sandstone and commencement of limestone-shale deposition.

Gongila Formation: The Gongila formation lies conformably on the Yolde Formation. The limestone of the Gongila Formation which occur near the base is rich in fossils that indicates an Early Turonian age.

Pindiga Formation: Mostly termed the Pindiga Cretaceous Series Formation believed to have a thickness of about 240 meters. It is divisible into three units: the Kanawa member, Upper Cenomanian to Lower Turonian shales and limestones, the Gulani, Deba Fulani and Dumbulwe members, sands deposited during a middle Turonian regression, and the Fika member, marine and mainly argillaceous at the top.

The Gombe Formation: It is a Maastrichtian coarsening-upward deltaic unit. Consists mainly of grits and clay and is restricted to the western part of the Basin. It completes the Cretaceous sequence.

The Kerri-Kerri Formation: The Tertiary Kerri-Kerri Formation is composed of flat-lying to gently dipping basal conglomerate, grits, sandstone, siltstone and clay which unconformably overstep the Maastrichtian Fika shale and Gombe sandstone.

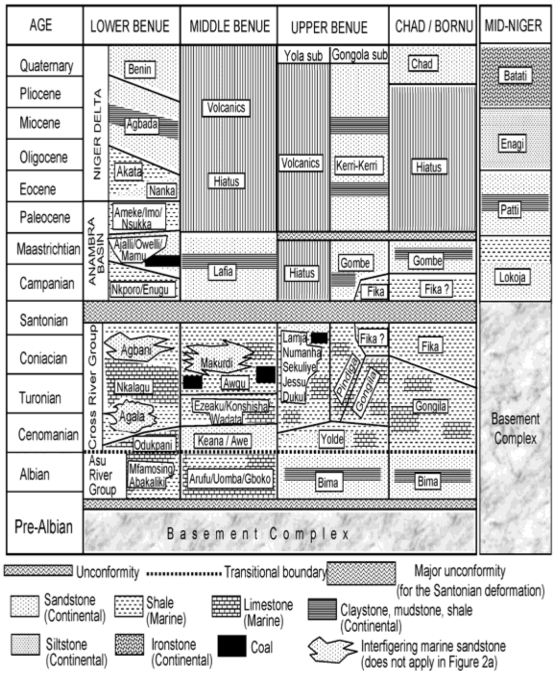

Fig. 2: Stratigraphic Successions of the Gongola Basin in Relation to the Benue Trough. (Adapted from [10]).

2. MATERIALS AND METHODS

Nine (9) ditch cutting samples were taken at certain intervals within depth 1500ft-5190ft basically because of their shale facies content for foraminiferal analysis.

Foraminiferal sample preparation: The sample preparation was carried out by the standard methods given below.

Materials: sieves, distilled water, water jet, kerosene, aluminium bowls, liquid soap, hot plate, micropaleontological microscope.
Procedures: 20gm of each sample is weighed into each sample bowl. Hot plate is switched on and regulated to temperature of about 80^0c. Samples are removed and allowed to cool to an extent. Depths on samples are correctly transferred into aluminium bowls. 30ml of kerosene is then poured into the sample and allowed to soak for two (2) hours. Decant kerosene and cover sample with water and leave for five (5) hours. Sieves are passed in blues methyle in order to easily identify any intruding contaminants. Each sample is washed over a 63microns sieve with water from the water jet. The residue collected from the sieve is replaced in the bowl and dried on a hot plate. The residue is sieved over 20 and 80 mesh sieves for the coarse and medium fractions, while the finest residue in the receiver is treated as fine fraction. All fractions are stored in a properly labeled sample phials and then transferred for picking and analyzing.

3. RESULTS AND DISCUSSIONS

Results obtained from foraminiferal analysis are given and discussed below.
Foraminiferal analysis results: The results from foraminiferal analysis carried out on nine (9) ditch cutting samples from interval 1500ft and 5190ft show that foraminiferal assemblage is generally poor. The few species recorded include; *Ammobaculitescoprolithiformis, Ammobaculitessp, Ammoscalarispseudospiralis, Haplophragmoidesbauchensis, Haplophragmoideshausa, Haplophragmoidespindigaensis, Reophaxsp, Haplophragmoidessp, Trochammina sp.*

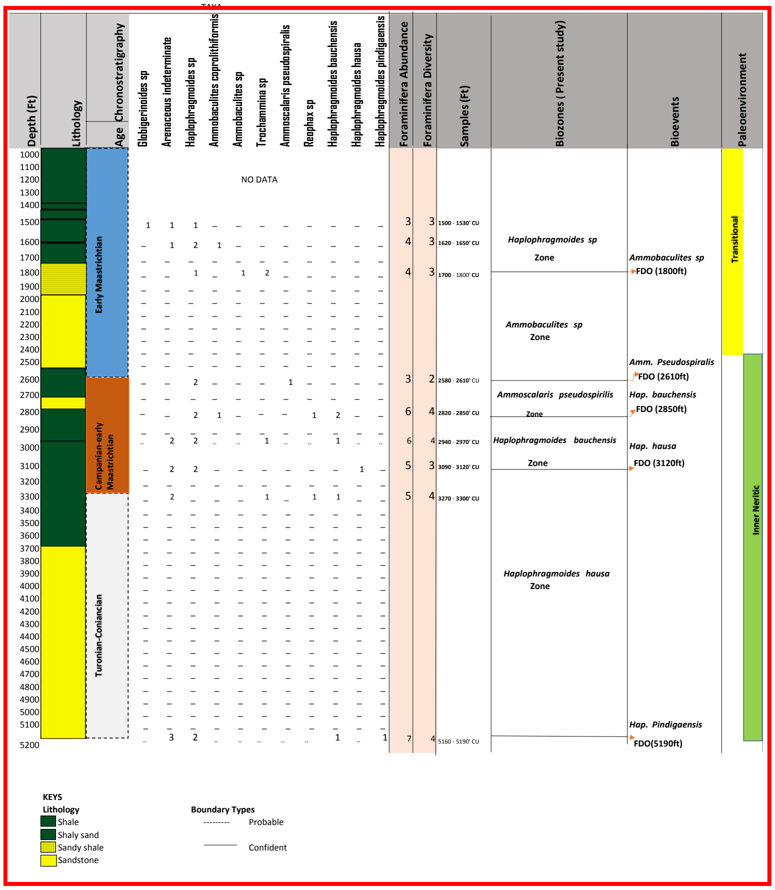

Fig. 3: Geological framework (model) of succession penetrated by the drill in Nasara-1 well, showing paleoenvironment.

Total foraminifera count within the succession penetrated by the drill in Nasara-1 well
This given by;
Total foraminifera count (T) = total number of agglutinated benthics + total number of planktic
Number of agglutinated benthics observed = 42 foraminifera species
Number of planktic observed = 1 foraminifera species
T = 42 + 1
T = 43 foraminifera species

PALAEOENVIRONMENTAL INTERPRETATION OF NASARA-1 WELL

The foraminiferal assemblages from Nasara-1 Well are almost entirely of agglutinated benthic forms, with just one planktic taxa (*Globigerinoidessp)* encountered. The *Arenaceous indeterminate, Haplophragmoides, Ammobaculites*and *Trochammina*dominate the Foraminiferal assemblages within the analyzed interval. Palaeoenvironment entails Palaeobathymetry, Palaeosalinity and Palaeo-oxygenation and these parameters are discussed below based on the Foraminiferal assemblages within the analyzed section in Nasara-1 Well.

From [11] and [12] an idea of the ecological characteristics of agglutinated benthic foraminiferal is given, which has helped in explaining the Palaeobathymetry, Palaeosalinity and Palaeo-oxygenation of Nasara-1 Well.

Ammobaculites

According to [11, 12] the genus covers almost all ecological niches in modern seas. As described by [12] it as an infaunal deposit feeder that lives in muddy sediments of brackish to normal marine salinity in marsh to upper bathyal environments. Its occurrence in certain Cretaceous sediments shows its tolerance to low oxygen levels [11]. *Ammobaculitessp*and *Ammobaculitescoprolithiformis*are the only two species that occurred within the analyzed section of the Nasara-1 Well.

Haplophragmoides

The genus is a probable infaunal, detritivore that is commonly found in muddy to sandy substrates in environments ranging from marsh hyposaline lagoons and estuaries to bathyal [12, 13]. *Haplophragmoidessp, Haplophragmoidesbauchensis, Haplophragmoidespindigaensis*and *Haplophragmoideshausa*are found occurring within the analyzed section in Nasara-1 Well.

Trochammina

The genus has been described by [12] as an infaunal or epifaunal deposit and plant feeder which tolerates very wide ranges of salinity (0-60‰) and water depth (0-> 6000m).Trochamminids was described by [11] as being also tolerant of low oxygen values.

Reophax

The genus is an infaunal deposit feeder, living today in muds and sands of lagoons, shelves and bathyal regions [12]. It was also reported by [12] as mainly a marine genus, but has also been reported from brackish lagoon and estuaries.

Palaeobathymetry

In the light of the above ecological description of the foraminiferal assemblages, two bathymetry of Nasara-1 Well is suggested to be from Transitional to Inner Neritic setting

1. **1,000ft – 2,610ft Transitional setting:** The rare recovery of foraminiferal species within this interval in Nasara-1 Well suggests that the environment is unsuitable for the colonization of foraminiferal species probably as a result of high energy of the environment. The interval recorded rare *Haplophragmoiidessp, Trochamminasp, Ammobaculitescoprolithiformis, Arenaceous indeterminate* and *Ammoscalarispseudospiralis.*
2. **2,610ft – 5,190ft Inner Neritic setting:** The foraminiferal assemblage within this studied interval is characterized by few foraminiferal species, but a bit of increased diversity. The interval recorded common *Haplophragmoidesbauchensis,Haplophragmoideshausa,Haplophragmoidespindigaensis, Ammobaculitescoprolithiformis* and *Trochammina sp.* The above foraminiferal association suggest an Inner Neritic setting.

Palaeosalinity

Benthonic foraminiferal genera are divided into two groups according to their ecology; brackish and unrestricted. Brackish genera are restricted to distinctly reduced salinity, while unrestricted genera inhabit a wide spectrum of salinities; they live under slightly reduced salinity, say slightly below 32‰ and live between marine and brackish environment.

*Ammobaculites, Reophax, Haplophragmoides*and *Trochammina*belong to the group of unrestricted genera. The above foraminiferal assemblage are the predominant forms in the analyzed section in Nasara-1 Well. It therefore means the analyzed section within the well was deposited in a slightly low salinity environment.

Palaeo-oxygenation

Agglutinated benthonic foraminifera can survive under dysoxic to anoxic condition [14, 15]. In light of the above idea, it therefore means the analyzed section within Nasara-1 Well was deposited in an oxygen depleted or dysoxic environment, being that 99% of foraminiferal within the well section are agglutinated benthics.

4. CONCLUSION

Agglutinated benthic foraminiferal constitute the greater percentage of the foraminiferal assemblage within the studied well section.Based on the diversity and distribution of the foraminifera species within the Well, the studied interval was deposited in a Transitional to Inner Neritic setting, slightly low salinity, dysoxic environment.

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REFERENCES

[1] SarkiYandoka, B.M., Abubakar, M.B., Abdullahi, W.H., Amir Hassan, M.H., Adamu, B.U., Jitong, J.S., Aliyu, A.H., and Adegoke, K.A. (2014). FaciesAnalysis, palaeoenvironmental reconstruction and stratigraphic development of the Early Cretaceous sediments (Lower Bima Member) in the Yola sub-basin, Upper Benue Trough, NE Nigeria. African Journal of Earth Science vol. 96: 168-179.

[2] Abubakar, M.B. (2014). Petroleum potential of the Nigerian Benue Trough andAnambra Basin; a regional synthesis. Natural Resources 5(1), 25-58.

[3] Hamidu, H., Abubakar, U., Abdulganiyu, Y., Usman, M.B., and Farida, G.I. (2015). Groundwater Resources Evaluation of the Upper Bima Sandstone Aquifer in Kaltungo Area and environs, Northeastern Nigeria. p. 5.

[4] Carter, J.D., Barber, W., Tait, E.A., and Jones, G.P. (1963). The geology of parts of the Adamawa, Bauchi and Bornu provinces in Northeastern Nigeria. Geological Survey of Nigeria Bulletin. Vol. 30 pp. 53-61.

[5] Guiraud, M. (1990). Tectono-sedimentary framework of the Early Cretaceous Continental Bima Formation (Upper Benue Trough, NE Nigeria). Journal of African Earth Sciences vol. (10): pp. 341-353.

[6] Avbovbo, A.A., Ayoola, E.O., and Osahon, G.A. (1986). Depositional and structuralstyles in Chad Basin of Northeastern Nigeria. American Association of Petroleum Geologists Bulletin v. 70: pp. 1787-1798

[7] Offodile, M.E. (1976). The Geology of the Middle Benue, Nigeria. Paleontological Institution of the University of Uppsala, Sweden, pp. 1-116. Special vol. 4.

[8] Zarboski, P.F., Ugodulunwa, A., Idornigie, P., Nnabo, K., and Ibe, (1997). Stratigraphy of the Cretaceous Gongola Basin, Northeast Nigeria. Bulletin du Centre de recherches Elf Exploration Production. Vol. 21(1): pp. 154-185.

[9] Samiala, N.K., Abubakar, M.B., Dike, E.F.C., and Obaje, N.G. (2006). Description of soft sediment deformation structures in the Cretaceous Bima Sandstone from the Yola Arm, Upper Benue Trough, Northeastern Nigeria. AfricanJournal of Earth Science. Vol. 44: pp.66-74.

[10] Obaje, N.G., Attah, D.O., Opeloye, S.A., and Moumount, A. (2005). Geochemical evaluation of hydrocarbon prospects of sedimentary basins in Northern Nigeria. Geochem. J. 40, 227-243.

[11] Koutsoukos, E.A.M, Leary, P.N., and Hart, M.B. (1990). Latest Cenomanian to Earliest Turonian low-oxygen tolerant benthic foraminifera: a case study from Sergipe Basin (N.E. Brazil) and Western Anglo-Paris Basin (Southern England). Palaeogeography, Palaeoclimatology, Palaeoecology. Vol. (77):pp. 145-177.

[12] Murray, J.W. (1991). Ecology and palaeoecology of benthic foraminifera. Longman; New York; 397pp.

[13] Bronnimann, P., Whittaker, J.E., and Zaninetti, L. (1992). Brackish water Foraminifera from mangrove sediments of southwestern Vitilevu, Fiji Island, Southwest Pacific. Revue de paleobiologie. Vol. (11): pp. 13-65.

[14] Vercoutere, T.L., Mullins, H.T., Mcdougall, K., and Thompson, J.B. (1987). Sedimentation across the Central California oxygen minimum zone: an alternative coastal upwelling sequence. Journal of sedimentary petrology. Vol. 57: pp. 709-722.

[15] Kaiho, K. (1994). Benthic foraminiferal dissolved-oxygen index and dissolved-oxygen levels in the modern ocean. Geology. Vol. (22): pp. 719-722.