



Upper-Cretaceous and Paleocene Biostratigraphy of Nkporo Shales, Calabar Flank, Southern Benue Trough

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Keywords

Foraminiferal,
 Palynological,
 Paleocene age,
 Non-marine.

Abstract

The present study Biostratigraphic (foraminiferal and palynological), paleoenvironment and paleoecological evaluations are aimed at interpreting the lithology, age, paleoenvironmental as well as the paleoecological condition of the deposited sediments newly exposed along Ikot Okpara Otopy, Southeastern Nigeria. Lithological descriptions of the samples reveal that this section is predominantly shale. This shale is dark grey to light brown, fossiliferous with minor occurrence of silts and sandstones. Foraminiferal analysis reveals a Paleocene interval within the Nkporo Formation for the first time. The sediments have low to moderate number of taxa with 96% benthic and 4% planktics, while a total of 196 microflora were recovered and identified. The microfloral species contain 60% of continental plants with 40% of marine counterparts. Key foraminiferal taxa used in this study include *Bolivina afra*, *Bolivina explicata*, *Globigerina frange* and *Haplophragmoides talokaense*, while their microfloral counterparts encountered within the section include *Cingulatisporites ornatus*, *Auriculidites reticulatus*, *Ephedripites ambonoides*, *Retidiporites magdalenensis*, *Synolocporites marginatus*, *Constructipollenites ineffectus*, *Foveotrilites margaritae*, *Buttinia andreevi*, *Proxapertites operculatus*, *Zlivisporis blanensis* and *Paleocystodinium* sp. These assemblages (Foraminiferal and Palynological) depict the deposition of these sediments during the Maastrichtian Paleocene age. The combination of lithologic and biostratigraphic data reveal paleoenvironment interpretation of the study section to range from marginal - shallow to Middle neritic paleo-water depths, while the paleoecological studies depicts a fluctuation in the salinity from brackish to marine settings deposited within a tropical to subtropical warm and humid climate.

1. Introduction

The origin of the Calabar Flank is intimately associated with the development of the Benue rift system, an event which is related to the opening of the South Atlantic and the existence of an RRR triple junction which was active in the Early Cretaceous times under the Niger delta miogeocline. However, the Calabar Flank represents that part of the foundered southern Nigeria continental Margin dominated by NW-SE Trending step fault system that resulted in the formation of horst and graben structure within the area. Subsequent development of the flank was controlled by the vertical tectonics of those fault blocks and eustatic sea-level changes within the adjacent south Atlantic Ocean.

The Ikang Trough and the Ituk High which represent the graben and horst structures respectively constitute the major tectonic elements. For most of the depositional history of the area, the Ikang Trough was an intracratonic mobile depression which accumulated mostly shales while the Ituk High, a relatively stable submarine platform received predominantly limestones [1, 2]. According to Nyong and Ramanathan [3], the Calabar Flank contains about 3500m of Cretaceous sediments in outcropping sections [2].

Sediment thickness is over 3500m with the on lap (or feathered edge) of the outcropping units, along the fringes of the Oban Massif Basement Complex. The Formations are best exposed along Calabar -Ikom road and a succession consists of five (5) Cretaceous and a Tertiary lithostratigraphic units. Awi Formation is the oldest basal unit and sits non-conformably on the Basement Complex of Oban Massif. The

formation is designated as Aptian in age [4]. This is overlain by Mfamosing Limestone of Middle- Upper- Albian age [2] deposited during the first marine transgression into the basin. The aforementioned formation in turn was succeeded by Late Albian-Cenomanian to Turonian, Ekenkpon Shale. Subsidence on the faulted blocks of horst and graben allowed wide spread deposition of shales with minor marl and mudstone intercalation. The New Netim Marl of Coniacian [5] age succeeded the shale. The Santonian period was marked by a major unconformity in the study area. Nkporo Shale of Late Campanian to Early Maastrichtian [6] capped marine transgression and Mesozoic sedimentation in the Calabar Flank. The Tertiary continental sands and gravel of the Benin Formation complete the sedimentation in the Calabar Flank.

2. Location of the study area

The area of study is located at Ikot Okpara village, off Calabar-Itu road in Odukpani Local Government Area of Cross River State, Southeastern Nigeria (Figure 1). Three sampling locations (LOC.1-3) were investigated. Their geographic coordinates were N05° 10' 13.8" and E08° 15' 44.4" for location 1 sample; N05° 10' 02.9" and E08° 15' 43.2" for location 2 and N05° 09' 37.3" and E08° 15' 35.8" for location 3 respectively.

The relief of the area can generally be described as very gentle and sometimes undulating. The elevation is approximately 100m to 200m above mean sea level.

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Received 21 November 2021; Revised 23 January 2022; Accepted 27 January 2022

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<https://doi.org/10.36937/janset.2022.6572>

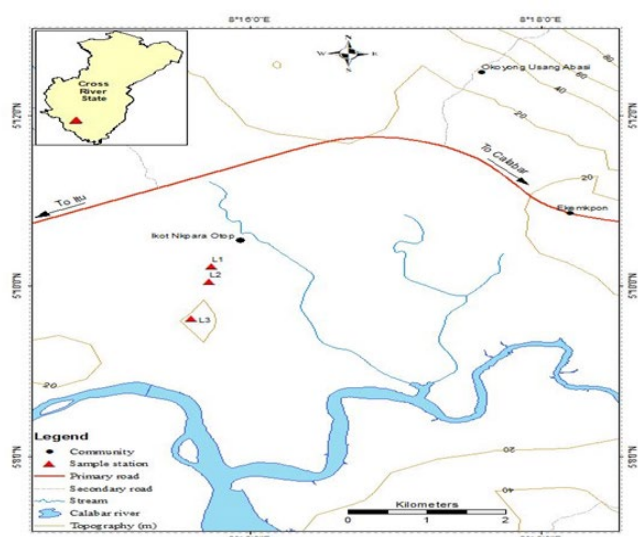


Figure 1. An outlined map of part of the study area

2.1. Vegetation and Relief of the Area

Vegetation is used in describing the environment with respect to the described trees, shrubs and grasses which grow on the earth surface. The vegetation in the study area, Ikot Okpara Otopy shows a varied combination of different types of plant groups of trees, shrubs and grasses. The vegetation cover is influenced by man's activities such as bush burning, farming, hunting, and timbering which reduces it to a mere secondary forest with moderate trees and shrubs (Figure 2).



Figure 2. Vegetation in the study area

The sedimentary terrain of study area falls within the Calabar Flank which is part of the coastal sedimentary basin of the southeastern Nigeria.

The term Calabar Flank was first proposed by Murat [1] for that part of the southern Nigeria sedimentary basin characterized by crustal block fault trending in a NW-SE direction and located at the eastern-most part of the Gulf of Guinea. The basin according to Nyong [5] is bounded by the Oban Massif in the north, Calabar hinge line separates the basin from Niger Delta basin in the south, while Ikpe platform and Cameroon volcanic trend delineate it in the west and east respectively (Figure 3).

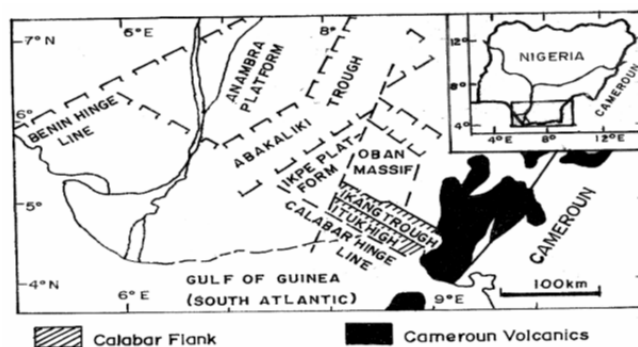


Figure 3. Geologic sketch map of south – eastern Nigeria showing Calabar Flank [7]

3. Materials and Methods

A detailed field map was created using the accessibility (topographic) map, GPS to locate the research sections on the map, and a compass clinometer to determine the trend of the geologic boundaries. The laboratory materials used include a transmitted light binocular microscope, SedLog version 3.0, an excel spread sheet, and other relevant publications for researching prior studies in the topic field. The limits were deduced from the gradual changes in lithology, flora, and terrain. The boundaries between formations, however, were inferred based on gradational changes in lithofacies. The foraminifera and palynomorph content of the shale samples was determined. Due to extensive weathering and poor matrix composition, available sandstone materials were unsuitable for foraminifera and palynological examination. Outcrop logging was done in a variety of areas where they were exposed due to road cuts, erosion, and stream channels. The observation and recording of the features began at the beginning of the exposures. The geological features documented are: lithotypes, bed thickness, grain size, color, mineral composition, nature of contact between beds, sedimentary structures (physical, biogenic, and chemical), bed attitude, and cross bed azimuth.

The degree of bioturbations at various beds was recorded, and drawings of their structures were prepared in the field notebook. To confirm the presence of carbonates, dilute HCl was administered to probable carbonate-containing strata. The conventional foraminiferal and palynological procedures were used to process all samples. The zeiss stereo microscope was used for foraminiferal and lithologic investigations, while the trinocular Acuscope biological microscope was used for palynological identification. Foraminifera and palynomorphs were counted in the samples. The foraminifera were prepared by washing and treating small quantities (approximately 20 g-30 g) of outcrop material with one teaspoonful of anhydrous sodium carbonate for full disintegration. Following that, the samples were sieved into coarse, medium, and fine fractions, which were then stored in well-labeled sample bags. The samples were finally subjected to mounting procedures.

4. Results and Discussion

4.1. Lithostratigraphy

The detailed lithologic examination and description of all the samples retrieved from the study area reveal that this section is made predominantly of shales. This shale is dark grey to light brown, subfissile to fissile, moderately hard, micaceous and calcareous. Abundant microfauna occur. Light to dark grey, very fine grained and smooth silt with minor sandstones were recorded in some locations. The general characteristic of the sediment as exposed in Ikot Okpara Otopy showed that the samples possessed some similar features belonging to late Cretaceous sediments of Nkporo Formation as they exhibit lithological similarities to the lithostratigraphy of Nkporo Shale of the Calabar Flank.

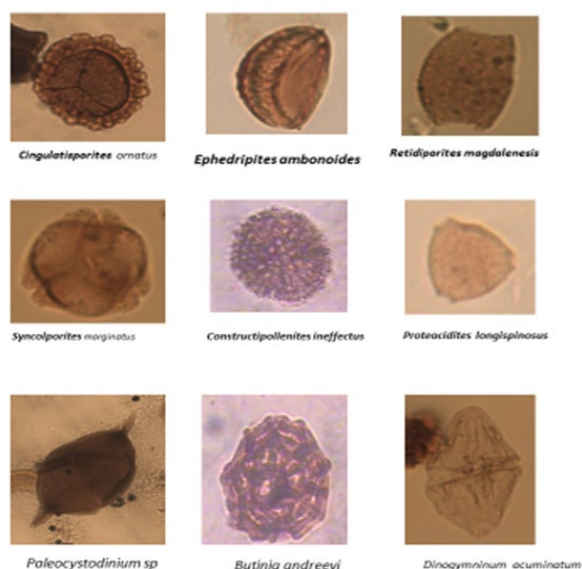


Plate 2. Key Palynomorphs

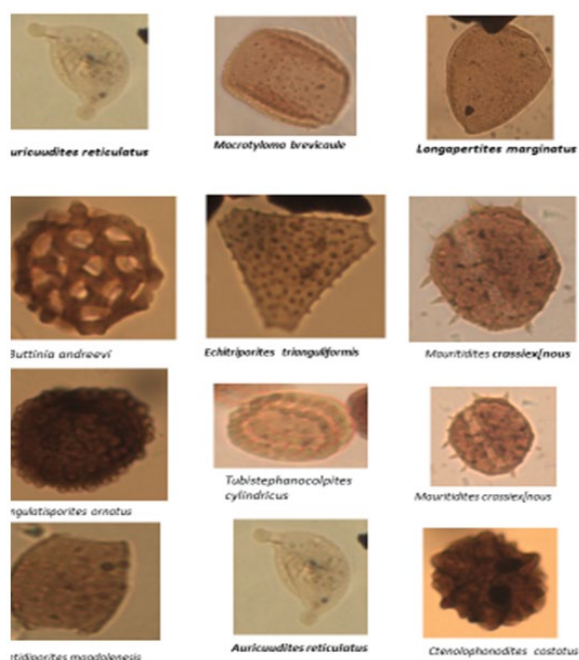


Plate 3. Key Palynological

5. Conclusion

The studied area belongs to the Late Cretaceous sediment of Calabar Flank known as the Nkporo shale. The lithological analysis shows that sediments were made predominantly of dark grey to light brown, fossiliferous shale with minor occurrences of silts and sandstone. The biostratigraphic analyses (foraminiferal and Palynological) depict the Maastrichtian, Paleocene age for the study area.

The paleoenvironmental and paleoecological analysis carried out from the study section revealed that the sediments were deposited in a shallow to open marine settings within Non-marine through Inner to Middle neritic paleo-water depths. The palynological interpretation on the paleoenvironmental and paleoecological studies from the investigated section suggests deposition in the environment not too far from the source of the depositions. The occurrence of both continental and marine palynomorphs infers transitional environment between marine and continental settings. The

occurrence of some palm taxa confirms the Late Cretaceous Palmae Province of Africa, South America and India. The palm province supports a tropical to subtropical climate and the assemblages are interpreted as indicative of a warm and humid climate.

Declaration of Conflict of Interests

The authors declare that there is no conflict of interest. They have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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How to Cite This Article

Harry, T.A., Uwemedimoh, I., Udofia, M., and Itam, A., Upper-Cretaceous and Paleocene Biostratigraphy of Nkporo Shales, Calabar Flank, Southern Benue Trough, *Journal of Nature, Science & Technology*, 1(2022), 6572.
<https://doi.org/10.36937/janset.2022.6572>