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Research Paper

Calcareous Nannofossils as Cenozoic Biozonal Markers: Offshore Western Niger Delta, Nigeria Example

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ABSTRACT: *The study involved the identification of calcareous nannofossils and their use as Cenozoic biozonal markers. Ditch cuttings from five wells at the industry standard of 9.14 m depth intervals were used in the study. The area of study is located in the offshore western Niger Delta area of Nigeria. Niger Delta lies between latitudes 4° and 6° N and longitudes 3° and 9° E in the south-south geo-political region of Nigeria. The pipette and smear laboratory technique was used for the calcareous nannofossils recovery for identification. The Cenozoic biozones identified are Calcidiscus premacintyrei (Zone NN6-NN7), Catinaster coalitus (Zone NN8) and Discoaster hamatus (Zone NN9) and they were calibrated to be of Miocene geological age. The identified calcareous nannofossil biozones are very useful for mapping subsurface horizons in the offshore western Niger Delta area of Nigeria. It is recommended that other methods such as seismic sections and wireline logs should be integrated in future study of the area.*

KEYWORDS: *Calcidiscus premacintyrei , Catinaster coalitus, Discoaster hamatus, offshore western Niger Delta, Nigeria*

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I. INTRODUCTION

The study area is located in the offshore western Niger Delta area, Nigeria (Figure 1). The Niger Delta is situated in the Gulf of Guinea on the west coast of Central Africa. It lies between latitudes 4° and 6° N and longitudes 3° and 9° E in southern Nigeria [1] and [2]. The Delta is situated at the intersection of the Benue Trough and the South Atlantic Ocean where a triple junction developed during the separation of South America and Africa in the Late Jurassic [3].

The aim of the research was to identify and analyze the abundance of calcareous nannofossils in the strata penetrated by the studied wells and to use the data to zone, date, and correlate the wells.

II. GEOLOGICAL SETTING

Three formations, namely: Akata, Agbada and Benin Formations, are in the subsurface onshore and offshore of Niger Delta basin [5], [6], [7], [8], [9] and [10]. Akata and Agbada Formations are marine and transitional, while Benin Formation is continental [11]. The Akata Formation is the basal unit and it is consists of marine shale, which is the petroleum source rock. The Agbada Formation overlies the Akata Formation. It consists of alternating sandstone, siltstone and shale sequences that constitute the petroleum reservoirs of the basin and it is Eocene to Pliocene in age [2].

The topmost unit called the Benin Formation largely consists of non-marine sands with shaly intercalations [11].

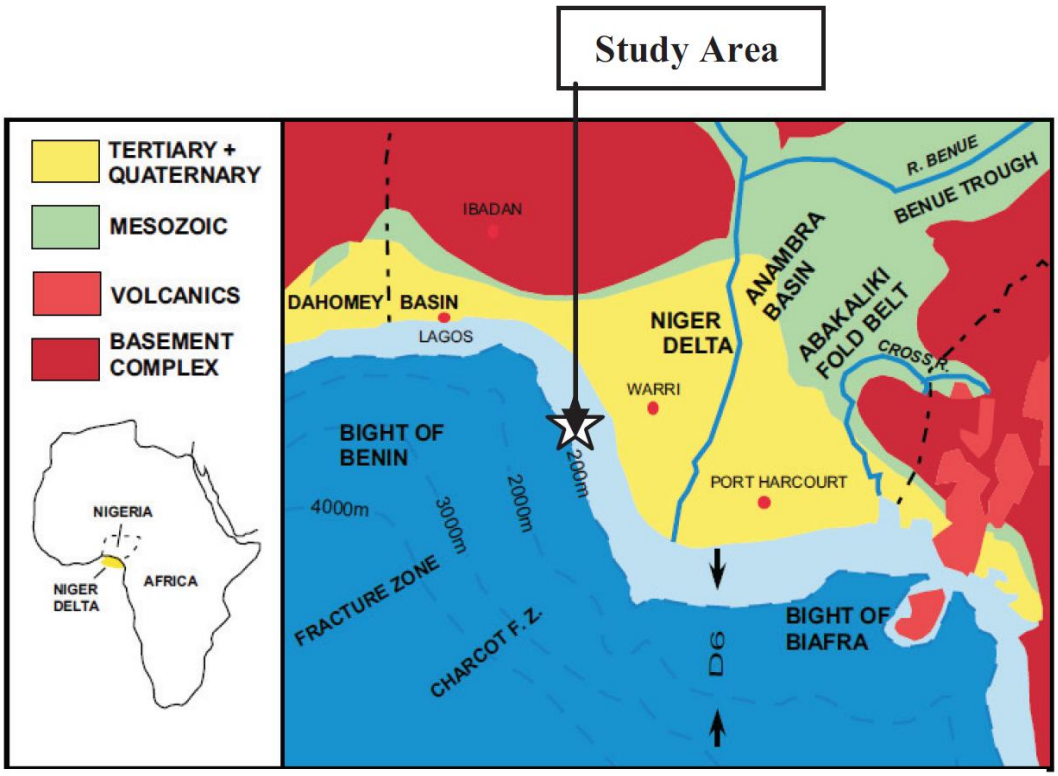


Figure 1: Index map of Niger Delta and location of study area [4]

III. METHODS OF STUDY

The five wells are denoted by TMB- 1, 2, 4, 5 and 6 and they have 226, 212, 222, 216 and 224 ditch cutting samples, respectively, totalling 1,100 samples that were collected at the industry standard of 9.14 m sampling intervals for analysis for calcareous nannofossils. The pipette and smear technique was used for calcareous nannofossils preparation. The unwashed ditch cuttings were slightly rinsed to remove drilling mud. Absolute care was taken at all stages of the sample preparation to avoid contamination. About 25 grams of each sample were required but 10 grams were utilized. They were broken down by soaking and swirling in distilled water. Addition of a small quantity of sodium hexametaphoshate (calgon) helped in the dispersion of the clays and ensured even distribution of the particles in the final mount. Drops of the suspensions taken from the beakers using pipette were carefully placed on glass cover slips (22 mm x 22 mm). Few drops of distilled water were added to dilute the suspensions, which were then dried on a hot plate. Two blobs of Norland optical adhesive (Refractive Index = 1.56) were placed on glass slips with the samples inverted over the glass slides until the adhesive was completely spread evenly, resulting in clean mounts. The mounts were cured over ultraviolet light for 30-45 minutes. The glass slides were then made ready for inspection under the microscope. The statistical data were recorded using the StrataBugs software. The complete nannopaleontological data were plotted in colour using the StrataBugs software at 1:5,000 scale with depth in Y-axis and the identified taxa in X-axis for each well. The StrataBugs software plotted charts were interpreted using the first and last downhole occurrences of diagnostic taxa, the assemblages, ratio of taxa occurrence, and taxon quantitative distribution within the stratigraphic interval.

IV. RESULT AND DISCUSSION

4.1 Calcareous Nannofossil Biozones

Twenty-six species of calcareous nannofossil assemblages were found at different depths in the five wells studied. The first occurrences (referred to as the last downhole occurrences) and the last occurrences (referred to as the first downhole occurrences) of selected marker species were used to delineate the biozones. In this study, the standard nannoplankton zonation scheme [12] was utilized. Martini [12] used Nannoplankton Neogene (NN) and numbers to identify zones. In the five wells studied, three biozones were recognized and they are equivalent to NN6-NN7, NN8 and NN9 Zones of Martini [12]. The calcareous nannofossil biozones recognized indicated Middle to Late Miocene age (Figure 2). Photomicrographs of marker species used for the biozones are shown in Figure 3.

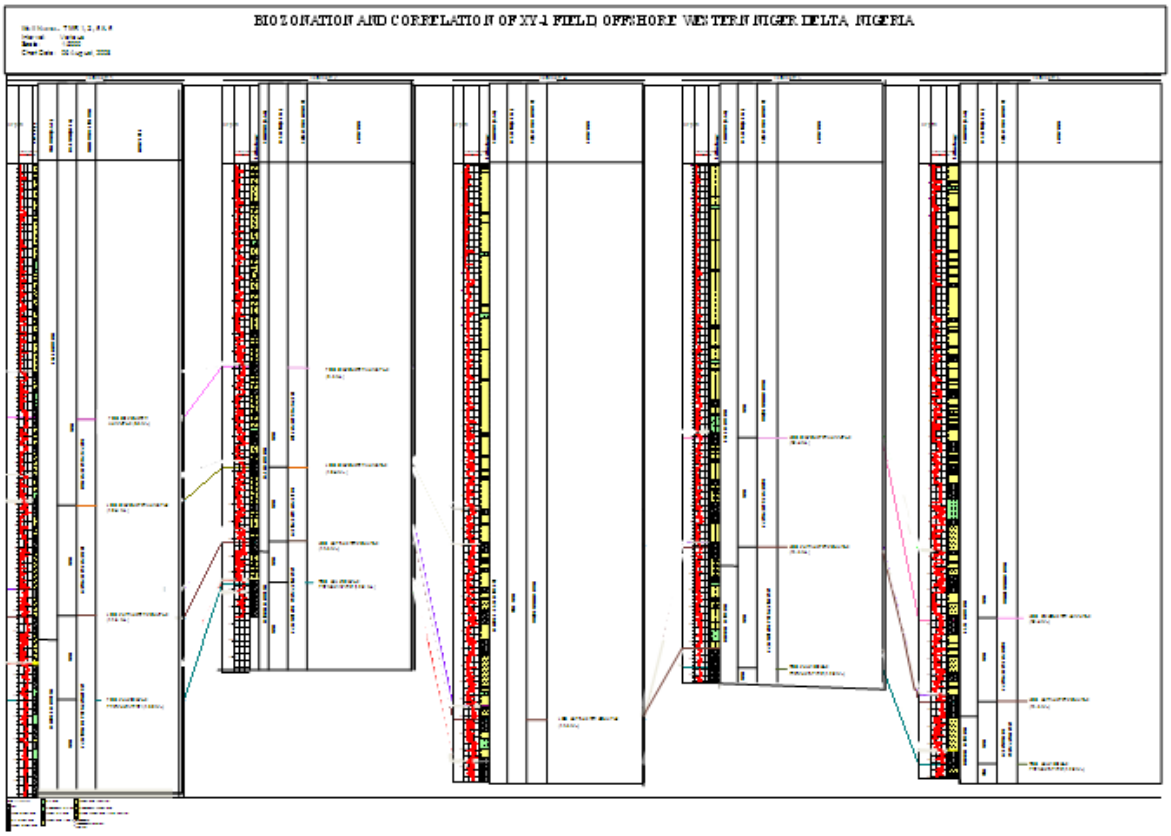
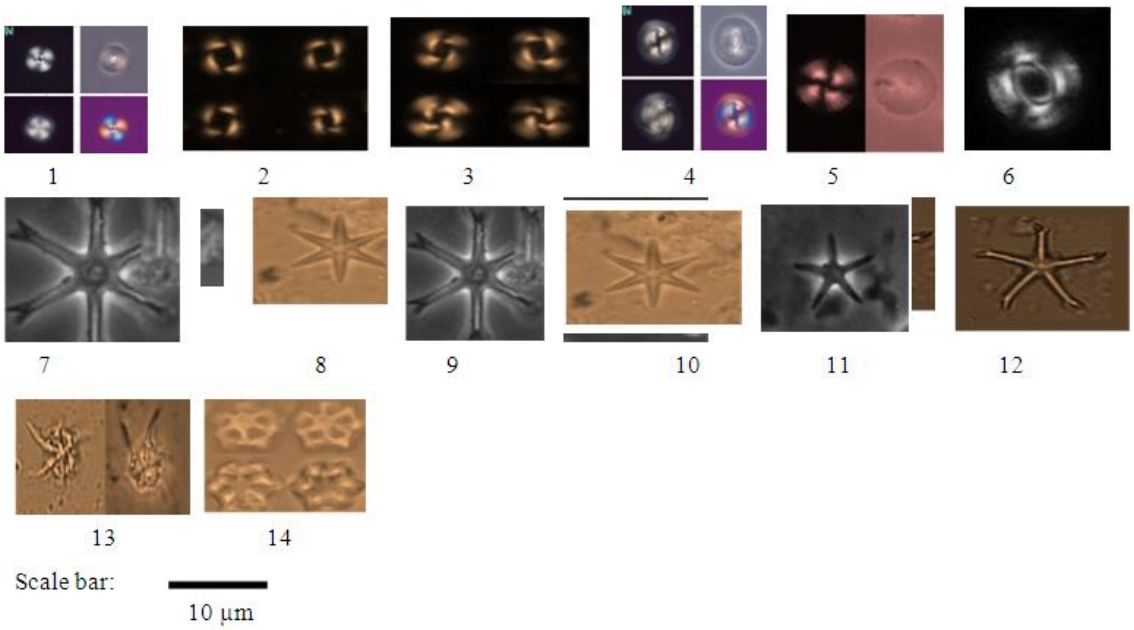


Figure 2: Calcareous Nannofossils Correlation Chart of XY-1 Field [2]



1. *Cyclicargolithus floridanus* (ROTH & HAY)
2. *Reticulofenestra pseudoumbilicus* (GARTNER)
3. *Reticulofenestra haqii* BACKMAN
4. *Coccolithus pelagicus* (WALLICH)
5. *Calcidiscus leptoporus* (MURRAY AND BLACKMAN)
6. *Calcidiscus premacintyrei* THEODORIDIS
7. *Sphenolithus heteromorphus* DEFLANDRE
8. *Discoaster bollii* MARTINI & BRAMLETTE
9. *Discoaster exilis* MARTINI & BRAMLETTE
10. *Discoaster braarudii* BUKRY
11. *Discoaster bellus* BUKRY & PERCIVAL
12. *Discoaster hamatus* MAR
13. *Catinaster calyculus* MARTINI & BRAMLETTE
14. *Catinaster coalitus* MARTINI & BRAMLETTE

Figure 8: Photomicrographs of Marker Species

4.1.1 *Calcidiscus premacintyrei* Zone

Stratigraphic interval:

TMB-1 Well: 3,150.41-3,446.37 m
TMB-2 Well: 3,218.08-3,404.92 m
TMB-4 Well: -
TMB-5 Well: 2,933.10-3,466.80 m
TMB -6 Well: 3,622.55-3,907.23 m

Base: The base of this zone is defined by the first downhole occurrence of *Calcidiscus premacintyrei* (THEODORIDIS) at the depths of 3,446.37 m, 3,404.92 m, 3,466.80 m and 3,907.23 m in TMB- 1, 2, 5 and 6 wells, respectively. The base of this zone is dated to 12.8 Ma [13].

Top: The top of this zone is defined by the last downhole occurrence of *Catinaster coalitus* (MARTINI & BRAMLETTE) at depths of 3,150.41 m, 3,218.08 m, 2,933.10 m and 3,622.55 m in TMB- 1, 2, 5 and 6 wells, respectively. The associated fossil species are *Cyclocargolithus floridanus* (ROTH & HAY), *D. bolli* (MARTINI & BRAMLETTE), *D. braarudii* (BUKRY), *S. heteromorphus* (DEFLANDRE) and *D. exilis* (MARTINI & BRAMLETTE).

Age: Middle - Late Miocene equivalent to NN6-NN7 Zones [12]

4.1.2 *Catinaster coalitus* Zone

Stratigraphic interval:

TMB-1 Well: 2,731.31-3,150.41 m
TMB-2 Well: 2,882.80-3,218.08 m
TMB-4 Well: -
TMB-5 Well: 2,443.89-2,933.10 m
TMB-6 Well: 3,258.01-3,622.55 m

Base: The base of this zone is defined by the last downhole occurrence of *Catinaster coalitus* (MARTINI & BRAMLETTE) at depths of 3,150.41 m, 3,218.08 m, 2,933.10 m and 3,622.55 m in TMB - 1, 2, 5 and 6 wells, respectively.

Top: The top of this zone is defined by the last downhole occurrence of *Discoaster hamatus* (MARTINI & BRAMLETTE) at depths of 2,731.31 m, 2,882.80 m, 2,443.89 m and 3,258.01 m in TMB- 1, 2, 5 and 6, respectively. The top of this zone is dated to 10.4 Ma [13]. The associated species within this zone are *D. bellus* (BUKRY & PERCIVAL), *D. exilis* (MARTINI & BRAMLETTE), *Catinaster calyculus* (MARTINI & BRAMLETTE), *D. bolli* (MARTINI & BRAMLETTE), *D. braarudii* (BUKRY) and *R. haqii* (BACKMAN), etc.

Age: Late Miocene equivalent to NN8 Zone [12].

4.1.3 *Discoaster hamatus* Zone

Stratigraphic interval:

TMB-1 Well: 2,431.39-2,731.31 m
TMB-2 Well: 2,431.39-2,882.80 m
TMB-4 Well: -
TMB-5 Well: -
TMB-6 Well: -

Base: The base of this zone is defined by the last downhole occurrence of *Discoaster hamatus* (MARTINI & BRAMLETTE) at depths of 2,731.31 m and 2,882.80 m in TMB-1 and 2 wells. Though the entire zone is absent in TMB- 4, 5 and 6 wells, however, the base of this zone was identified at depths of 2,443.89 m and 3,258.01 m in TMB- 5 and 6 wells. The base of this zone marked the end of NN8 Zone of Martini [12] and it is dated to 10.4 Ma [13].

Top: The top of this zone is defined by the first downhole occurrence of *Discoaster hamatus* (MARTINI & BRAMLETTE) at depths of 2,431.39 m in TMB- 1 and 2 wells. However, the top of this zone was not recognized in TMB- 5 and 6 wells. The associated species are *Reticulofenestra pseudoumbilicus* (> 7 µm) (GARTNER), *Coccolithus pelagicus* (WALLICH), *Calcidiscus leptoporous* (MURRAY & BLACKMAN), *D. bolli* (MARTINI & BRAMLETTE), *D. braarudii* (BUKRY) and *D. bellus* (BUKRY & PERCIVAL) [14] and [15].

Age: Late Miocene and equivalent to the *Discoaster hamatus* (NN9) Zone [12].

Remarks: The diagnostic species for this zone is *Discoaster hamatus* (MARTINI & BRAMLETTE).

4.3 Correlation of Offshore Western Niger Delta

4.3.1 Calcareous Nannofossil Biozones Correlation

Three biozones, namely: *Calcidiscus premacintyrei* (Zone NN6-NN7), *Catinaster coalitus* (Zone NN8) and *Discoaster hamatus* (Zone NN9) were identified and correlated in TMB-1 and TMB-2 wells, respectively. *Calcidiscus premacintyrei* (Zone NN6-NN7) was found between intervals of 3,150.42 m to 3,446.37 m in TMB-1 well and 3,218.08 m to 3,404.92 m in TMB-2 well, 2,933.10 m to 3,466.80 m in TMB-5 well and 3,622.55 m to 3,907.23 m in TMB-6 well. But it was completely absent in TMB-4, probably because it was eroded away thereby erasing the record from the well. Also, *Catinaster coalitus* (Zone NN8) was found between intervals of 2,731.31 m to 3,150 m in TMB-1 well, 2,443.89 m to 2,933.10 m in TMB-5 well, 3,258.01 m to 3,622.55 m in TMB-6 well. Alternatively, *Discoaster hamatus* (Zone NN9) was found between intervals of 2,431.39 m to 2,731.31 m in TMB-1 well, 2,431.39 m to 2,882.80 m in TMB-2 well and 3,258.01 m to 3,622.55 m in TMB-6 well. However, it was absent in TMB-4 and TMB-5 wells (Figure 7). It may be inferred from the biozone correlation of the wells that TMB-1 and TMB-2 wells have complete set of the biozones because they were preserved from erosion and denudational forces.

On the other hand, between TMB-2 and TMB-4 wells, strong evidence of eroded horizons probably due to uplifting, faulting and erosion was inferred as possible source of the observed unconformity. Similar scenario was noticed between TMB-4 well and TMB-5 well. From the correlation, there are faults between TMB-4, 5 and 6 wells, respectively. Between TMB-4 and TMB-5, the downthrown side of the fault was inferred in the TMB-4 well area, alternatively between TMB-5 and 6 wells, respectively, the downthrown side was deduced in the TMB-6 well area (Figure 7). The significance of the biozones cannot be overemphasized because of their usefulness in subsurface mapping and reservoir characterization study, especially in tectonically complex areas.

V. CONCLUSION

The biozones and correlation give better understanding of the geology of the area useful for regional subsurface geological mapping and the development of the offshore western Niger Delta serving as good input into the reservoir characterization model. The calcareous nannofossil biozones defined indicated various stratigraphic variations in some taxa in the studied wells in comparison to standard biozonation scheme [12, [13] and [16]. The identified three calcareous nannofossil biozones are *Calcidiscus premacintyrei* (Zone NN6-NN7), *Catinaster coalitus* (Zone NN8) and *Discoaster hamatus* (Zone NN9). These biozones are indicative of Middle to Late Miocene age for the well depth intervals.

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