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CALCAREOUS NANNOFOSSIL BIOSTRATIGRAPHY OF WELL AMKP 2-13, SHALLOW OFFSHORE NIGER DELTA BASIN, NIGERIA

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ABSTRACT

Calcareous nannofossil studies were carried out on 155 ditch-cutting samples from Well AMKP 2 - 13 (interval 2840m to 4360m), offshore Niger Delta basin using the short centrfuging technique. The aim was to identify key bioevents, determine the nannozones and age of the study section. Samples were generally dark to light grey, non-calcareous to mildly calcareous shale and penetrated the shale unit of the Agbada Formation. Biostratigraphic result yielded 400 calcareous nannofossil count, 12 calcareous nannofossil taxa:Helicosphaera cateri, Discoaster pentaradiatus, Ceratolithus spp, Calcidiscus laptoporus, Sphenolithus abies, Reticulofenestra pseudoumbilicus, Discoaster brouweri, Braarudosphaera biggelowii, Coccolithus pelagicus and discoaster spp, including 2 index fossils-Discoaster quinqueramus and Discoaster beggrenni. Two nannozones were identified: an indeterminate zone characterised by the absence of calcareous nannofossils at 2840m -3530m and an NN11 zone of Martini (1971) at 3530m - 4360m determined by an influx of calcareous nannofossils (ACME) at 3550m dated late Miocene (Messinian) due to the co-occurrence of Discoaster quinqueramus and Discoaster berggreni at 3560m. The base of the zone was not encountered at total depth (TD) due to non-recovery of fossils from intervals 4135m – 4360m (TD) and probably terminated within the Late Miocene NN11 Zone and? older ages of Martini (1971) at TD.

Keywords: Biostatigraphy; Calcareous nannofossil; Biozonation; Bioevents; Formation

INTRODUCTION

The Niger Delta basin is the youngest of the three large sediment bodies that filled the aulacogen formed after the separation of the African and South American plates. It is bounded onshore by the Benin Flank to the north; the Abakiliki High to the northeast and the Calabar Flank to the east/south-east. The offshore part is bounded onshore by the Cameroon volcanic line to the east; the Dahomey basin to the west and the Atlantic Ocean to the South (Tuttle *et al.*,1999). The

Niger Delta depobelts developed as portions for sediment accumulation leading to the deposition of three major units. These units correspond easily to the marine Akata Shales as source rock, the paralic Agbada Formation as the reservoir rock and the continental Benin Sand as the aquiferous zone in the Niger Delta Petroleum system. Structural and tectonic activities affected the depositional sequence of the Niger Delta basin leading to gross lateral variations in facies. Therefore, the accurate sequence of events would require fossil taxa identification and association applying biostratigraphic studies (Ukpabi *et al*., 2018).

Calcareous nannofossils biostratigraphy has the potential to provide the stratigraphic frameworks that are essential for hydrocarbon exploration and production. Calcareous nannofossils, the microscopic remains of coccolithophores, are a critical component of marine phytoplankton. Composed primarily of calcium carbonate, these microfossils are abundant in marine sediments and exhibit rapid evolutionary changes. The relevance of nannofossils is becoming increasingly important because of the advantage of its size, the limited stratigraphic range of many of its species with resolution to some thousands of years, its cheap and speedy processing technique that yields rapid outcome where age determination is required. In the shallow offshore Niger Delta, nannofossil assemblages can be used to establish age models and identify key bioevents, which are essential for constructing accurate stratigraphic frame works (Bown & Young, 1998). They are particularly valuable for dating and correlating marine sedimentary rocks and also useful in interpreting paleoceanographic conditions, such as sea-level changes and paleo temperature variations (Adegoke *et al*., 2018).

This study is focused on well AMKP 2 -13 situated on latitude 04°08' 01.687"N and longitude 07°30' 53.070"E, within the Nigeria maritime boundary, in the Gulf of Guinea, shallow offshore region of the Niger Delta basin (Figure 1). The calcareous nannofossil biostratigraphic research would identify calcareous nannofossil assemblages, present data generated in tables and biostratigraphy charts, and correlate the fossil assemblages to standard zonation schemes (Martini, 1971), establishing biozones and age calibration.

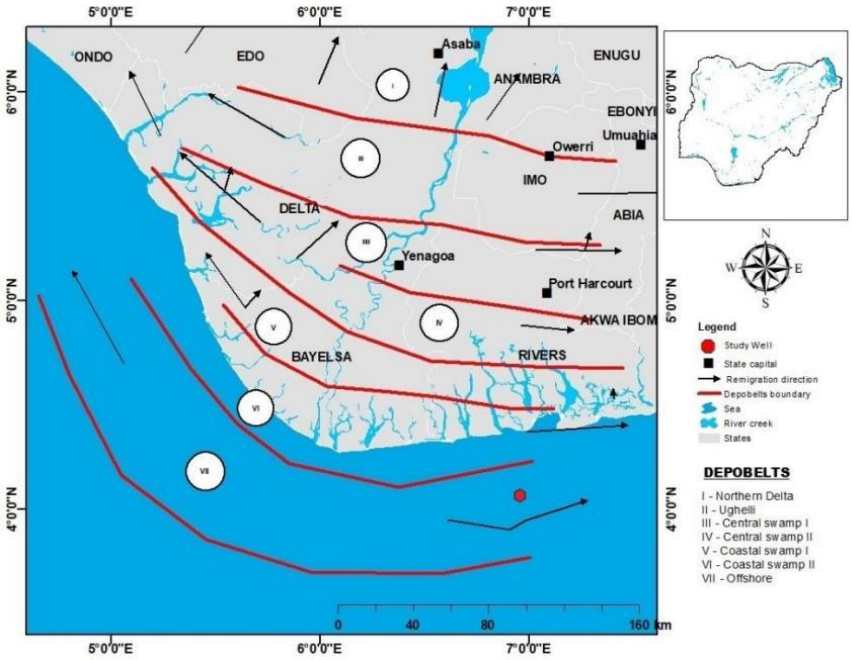

Figure 1: Location Map of Study Area showing the study well

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MATERIALS AND METHODS

155 ditch-cutting samples recovered at10m from well AMKP 2 -13 covering 2820m to 4360m, mud logs of the well section and the study location map were available for this research. All analyses were carried out at the Paleontology Laboratory of the Department of Geology, University of Port Harcourt following few steps.

Sample Description

Depth-to-depth sample lithologic description was carried out on the study samples. A hand lens was used to identify physical parameters like the grain sizes, sorting, colour, presence of plant remains, mica flakes, pyrites and shell fragments. 0.2M of hydrochloric acid (HCl) was also applied to determine the presence of calcareous material within the samples. All the identified physical parameters were recorded in a logging sheet. Data generated from the sample description was compared with the well-mud log.

S*ample Analyses*

The ditch-cutting samples were composited at 30m yielding fifty-one (51) samples which were processed and analysed for nannopaleontology evidence. The standard short centrifuging technique was used because it has been found to yield more recoveries for samples that have been stored over a long period and also to reduce cases of debris obscuring the fossils. Recovered nannofossils were identified using standard manuals such as the Calcareous Nannofossils Biostratigraphy (Bown,1998), Calcareous Nannofossil Zonation Scheme (Martini,1971), Cenozoic Geochronology and Chronostratigraphy (Berggren *et al*.,1995), Cenozoic Calcareous Nannofossils (Perch-Nielsen, 1985; incorporated in Bolli and Saunders, 1985). All the nannofossils encountered were counted and documented and taxa count was computed and called up into the biostratigraphy analytical software (StrataBugs 10.1) from where the identification of biostratigraphic events such as First Downhole Occurrence/Last Appearance Datum (FDO/LAD), Last Downhole Occurrence/First Appearance Datum (LDO/FAD), explosive events (ACME), and fossil influx were made.

RESULTS AND DISCUSSION

Lithology

Samples showed a predominance of dark grey to smokywhite/light grey, non-calcareous to calcareous shale especially towards the base of the sampled section which is typical of the shale unit of the Agbada Formation.

Biostratigraphy

Out of the fifty-one (51) processed and analysed samples, 40 sampled points were barren of nannofossils while 11 sampled points recorded the occurrence of calcareous nannofossils. The top samples within 2840m to 3320m and the base, 4105m to 4360m, were barren of nannofossils. Interval 3320m recorded the first occurrence of *Reticulofenestra pseudoumbilicus* while 3360m recorded the first occurrence of *Discoaster spp*. 3530m to 3675m recorded abundant and diverse occurrences of calcareous nannofossils with a condensed section at 3550m. A total of 400 calcareous nannofossils including 12 nannofossil taxa and 2 index fossils - *Discoaster quinqueramus* and *Discoaster beggrenni* - were encountered. Identified taxa included *Helicosphaera cateri, Discoaster pentaradiatus, Ceratolithus spp, Calcidiscus laptoporus, Sphenolithus abies, Reticulofenestra pseudoumbilicus, Discoaster brouweri, Braarudosphaera biggelowii, Coccolithus pelagicus and Discoaster spp.*

The nannofossil stratigraphic distribution chart (figure 2) show details of the calcareous nannofossils species recovered from well amkp 2 -13, with the fossil counts, the significant datums, biozones, age determinations and maximum flooding surfaces (mfs) in the study well. a photomicrograph of identified nannofossils is presented in plate 1.

PALEONTOLOGY (NANNOFOSSIL) CHECKLIST
WELL: AMPK 2 -13 2640 - 4360m DATE: MAY, 2024
IBEXON SERVICES
PALEONTOLOGIST: OTTAH IBEABUCHI

S/N	sample depth (m)	BARREN	Degree of dissolution; x=medium, xx=high	RETICULOFENESTRA PSUEDOUMBILICUS	DISCOASTER PENTARADIATUS	CERATOLITHUS SPP	CALCIDISCUS LEPTOPOROUS	DISOASTER SPP	SPHENOLITHUS ABIES	HELICOSPHAERA CARTERI	DISCOASTER QUINQUERAMUS	COCCOLITHUS PELAGICUS	DISCOASTER BROUWERI	DISCOASTER BEGGRENII	BRAABDOSPHAERA BEGELOWII	TOTAL ABUNDANCE	TOTAL DIVERSITY	Nanno Zone / Age	COMMENT/AGE(Ma)
1	2840	B														0	0	undiagnostic	
2	2870	B														0	0		
3	2910	B														0	0		
4	2930	B														0	0		
5	2960	B														0	0		
6	2990	B														0	0		
7	3020	B														0	0		
8	3050	B														0	0		
9	3080	B														0	0		
10	3110	B														0	0		
11	3140	B														0	0		Interval completely barren of Calcarous nannofossils
12	3170	B														0	0		
13	3200	B														0	0		
14	3230	B														0	0		
15	3260	**B**														0	0		
16	3290	B														0	0		
17	3320			1												1	1		
18	3330	B														0	0		
19	3360							1								1	1		
20	3410	B														0	0		
21	3440	B														0	0		
22	3470	B														0	0		**?Fault or Unconformity at 3500n**
23	3500															0	0		
24	3530					1										1	1		
25	3560			1	10				55		4	1	5	5		76	7		Co-occurrence of *Discoaster quinqueramus and Discoaster berggrenii* at depth 3560m indicates the penetration of lower NN 11 zone of Martini, 1971. The slight floral increase, over interval 3530 -3675m. is thought to be associated with a Maximum Flooding Surface(Undated)section
26	3580			6	10		2		180	7	24		5	4		240	8		
27	3610			1	4		1		30	1	5		4	1		46	8		
26	3630								1							1	1		
29	3675				1				1	1						3	3		
30	3705															0	0		
31	3745	B														0	0		
32	3775	B														0	0		

Figure 2: Nannofossil Stratigraphic Distribution Chart of well AMKP 2 -13, showing the encountered nannofossil taxa and bioevents

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Plate 1. Photomicrographs of Nannofossils

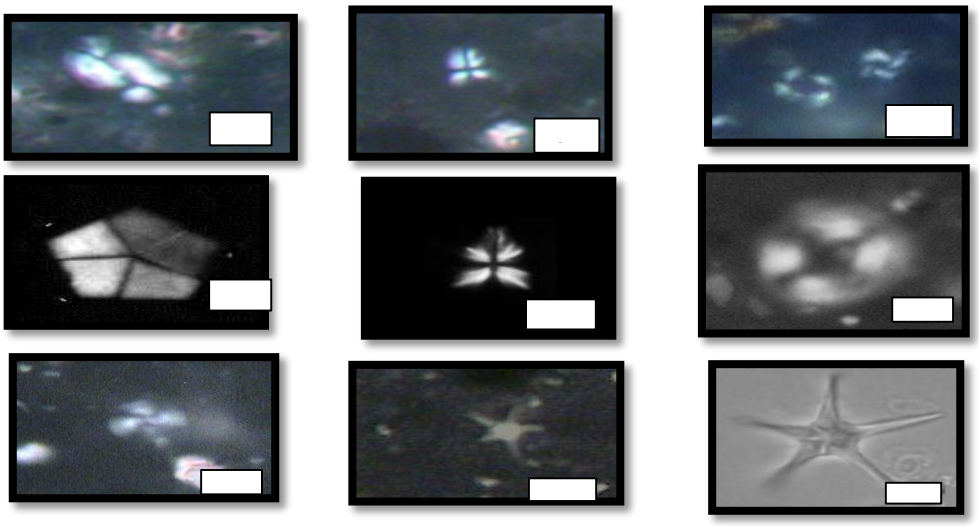


Table 1: Explanation of Plate1 Photomicrographs

S/N	Plate Number	Species	Depth of occurrence(m)
1	a	*Helicosphaera cateri*	3580
2	b	*Sphenolithus abies*	3530
3	c	*Reticulofenestra pseudoumbilicus*	3320
4	d	*Braarudosphaera biggelowii*	4070
5	e	*Sphenolithus abies*	3530
6	f	*Coccolithus pelagicus*	3560
7	g	*Calcidiscus laptoporus*	3580
8	h	*Discoaster berggrenii*	3560
9	i	*Discoaster quinqueramus*	3560

Biozonation and Age Determination

Age interpretation and the definition of the associated nannozones were achieved by using the occurrence of age-diagnostic nannofossil taxa including *Discoaster pentaradiatus, Sphenolithus abies, Reticulofenestra pseudoumbilicus*(>7u), *Ceratolithus spp, Discoaster quinqueramus* and *Discoaster beggreni*. Based on these, an undiagnostic interval and an NN11and?Older nanno-zones have been delineated in this study using the approach of Martini (1971). The interpretation of biozonation of the penetrated section of well AMKP 2-13 was enabled by the stratigraphic distribution of recovered marker fossils as follows:

Interval: 3530m – 4360m (TD).

Top (LDO/FAD): *(Ceratolithus spp***)**

Base: (Not penetrated)
Nanno Zone: NN11 and? Older
Age: Late Miocene

Interval characterized by: Co-occurrence of *Discoaster quinqueramus* and *Discoaster beggrenii* at 3560m with a major condensed section (CD) at 3550m.

This interval is characterizedby high recovery of nannofossils between 3530m – 3675m.The nannofossils recorded include *Helicosphaera cateri, Reticulofenestra pseudoumbilicus* (>7micron), *Sphenolithus abies, Discoaster quiqueramus, Discoaster beggrenii, Discoaster pentaradiatus, Discoaster brouweri* and *Calcidiscus leptoporus.*The top of this zone lies unconformably below a nannofossils barren interval, suggesting a possible truncation/hiatus or erosion/faulting

at 3500m. This surface is defined by truncation of possible flooding events of calcareous nannofossil-rich intervals to an overlaying completely barren horizon. The recorded stratigraphically significant datums, nanno-zones and age determinations together with the delineated Maximum Flooding Surfaces (MFS) are contained in the Calcareous Nannofossil Biostratigraphic Summary of well AMKP 2–13 (Table2). The co-occurrence of *D.quinqueramus* and *D.beggrenii* at 3560m suggests the penetration of the NN11nannozone of Martini (1971) at this horizon. A major flooding event (undated) encountered at 3500m was characterized by the occurrences of divers and abundant nannofossils with a dominance of *D.quinqueramus* over *D.beggrenii.*

This interval is the deepest interval penetrated in the studied section of the well. The base of the zone was not encountered in this study at TD due to the non-recovery of fossils from 4135m – 4360m. This interval lies directly below a nannofossil-laden zone that penetrated the NN11 Zone of Martini (1971). Therefore, well AMPK 2-13 probably terminated within the Late Miocene NN11 Zone and? older ages of Martini (1971) at TD.

Interval: 2840m – 3530m

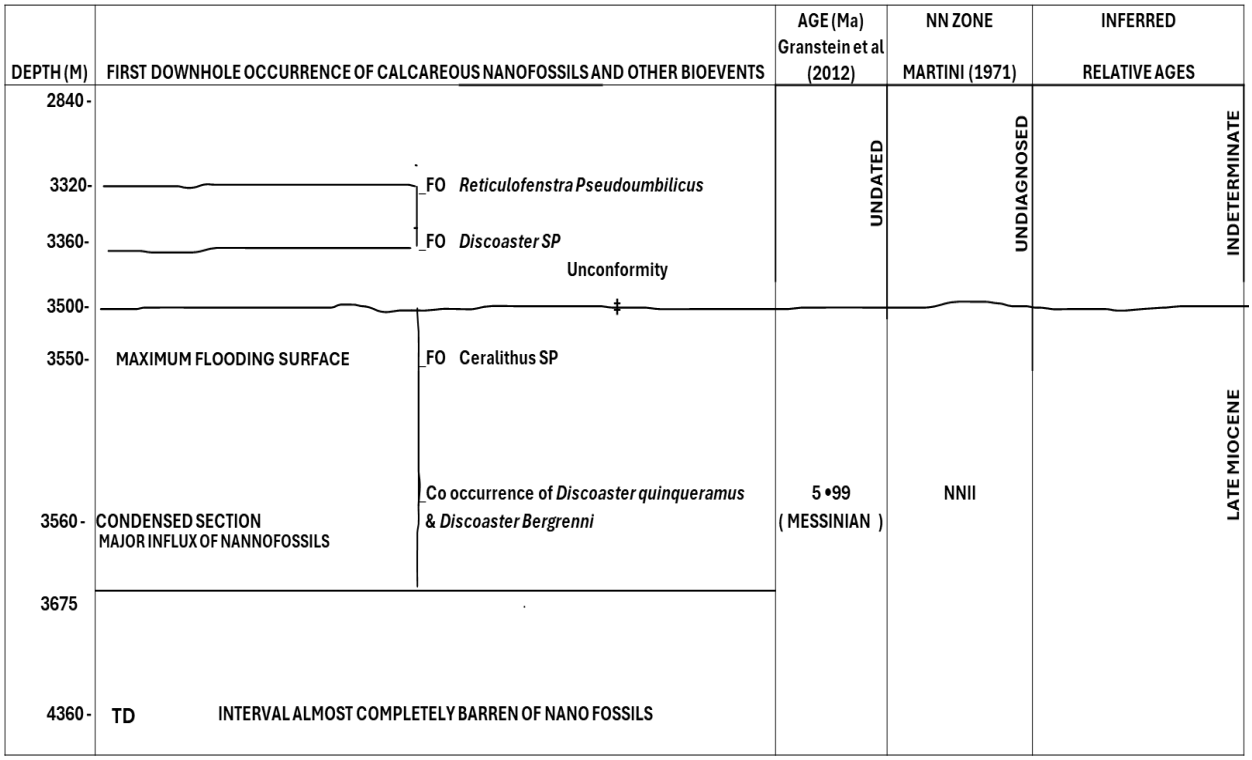
Top; (LDO/FAD): Indeterminate
Base: (LDO/FAD):*Ceratolithus spp*
Nanno Zone: INDETERMINATE
Age: UNDIAGNOSTIC

Interval is completely barren of calcareous nannofossils.

The non-recovery of nannotaxa in the samples within this well section is presumed to be a result of the predominantly clastic sediments which suggests a possible paleo bathymetric depositional setting. Hence, this section of the well has been designated as undiagnostic.

The result of the analysis indicates that the sediments from Well AMPK 2 - 13, interval 3530m-4360m were deposited during late Miocene times, while the upper section (2840m – 3530m) was undiagnostic due to the non-recovery of nannofossil.

Table 2: Calcareous Nannofossil Biostratigraphic Summary of Well AMKP 2 - 13



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CONCLUSION

The penetrated section of Well AMKP 2-13 (2840m- 4360m) lies within the shale unit of the Agbada Formation of the Niger Delta as indicated by the dominant lithology consisting of light to dark grey, calcareous to non-calcareous shale deposits. Key bioevents recorded were a maximum flooding surface (MFS) recorded at 3550m which preceeded an influx of diverse calcareous nannofossils, (ACME) at 3530m-4360m. A condensed section (CS) was recorded at 3560m. Two nannozones were identified based on diagonistic markers present - an indeterminate zone characterized by the absence of calcareous nannofossils at 2840m -3530m and an NN11 zone determined by the diversity of calcareous nannofossilsand dated late Miocene (Messinian) due to the co-occurrence of *Discoaster quinqueramus* and *Discoaster berggreni* at 3560m in the well. The base of the zone was not encountered in the study at TD due to the non-recovery of fossils from intervals 4135m – 4360m (TD).

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