Global Scientific JOURNALS

GSJ: Volume 9, Issue 8, August 2021, Online: ISSN 2320-9186
www.globalscientificjournal.com

Calcareous Nannofossil study of Wells X1 and X2, Coastal Swamp depobelt, Niger Delta, Nigeria

[1]Omokhodion O.M, [1]Lucas F.A

[1]Department of Geology, Faculty of Physical Science, University of Benin

Abstract

The present study is aimed at subdividing and dating the sediments in two Wells in the Niger Delta using calcareous nannofossils. Fifty ditch cuttings from two Wells labelled X1 and X2 were used for this study. The samples were prepared using standard nannofossil preparation technique and viewed in a microscope to determine the nannofossil species. Nannofossil records such as the First Downhole occurrence(FDO), Last Downhole occurrence(LDO), Last common occurrence and repetitive bioevents of regional field scale importance such as changes in abundances of nannofossils, diversity of the nannofossils within various sections of the wells were recorded. The recovered species included *Braarudosphaera bigelowii, Calcidiscus leptoporus, Coccolithus pelagicus, Cyclicargolithus floridanus, Discoaster deflandrei, Discoaster petaliformis, Helicosphaera ampliaperta, Helicosphaera carteri, Pontosphaera multipora, Reticulofenestra pseudoumbilicus, Sphenolithus heteromorphus, Sphenolithus moriformis.* The sediments were subdivided into NN5, NN4 and NN3 zones and dated Early to late Miocene on the basis of identified index fossils. Species abundance and diversity and presence of marker species was used to divide the wells into four Assemblages labelled 1 to 4 corresponding to the 14.8MA, 15.6MA, 16.8MA and 18.0MA maximum flooding surfaces respectively.

Introduction

Biostratigraphy is the scientific technique of subdividing rock units based on the fossils found in each of the units. Hydrocarbon exploration has employed the use of Biostratigraphy since the 1890s, being applied first in Poland for well correlation(Kaminski *et al*. 1993). Since then,

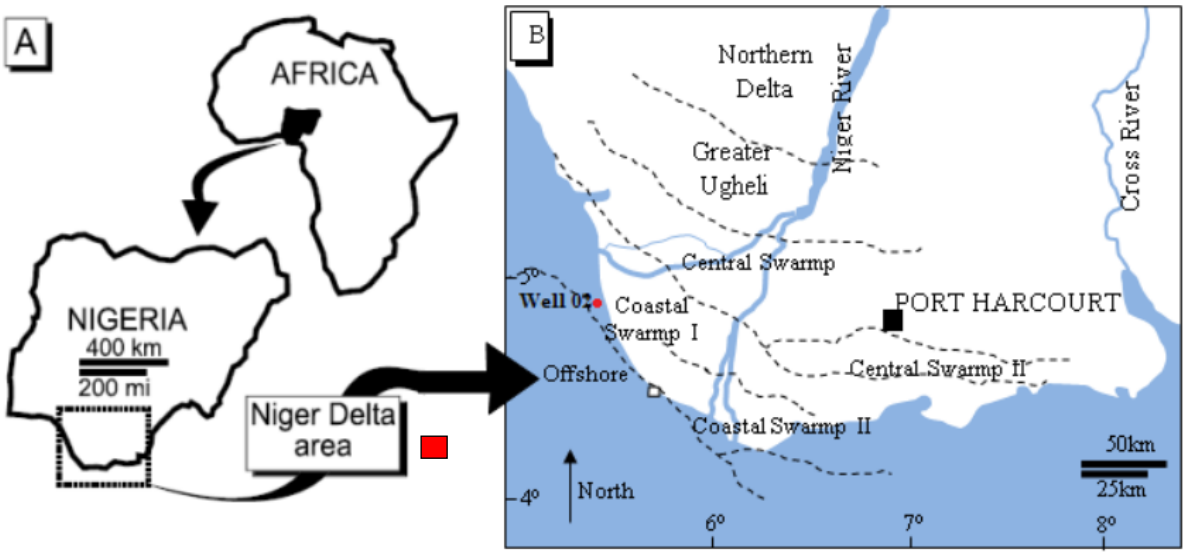
Biostratigraphy has being acknowledged as a vital tool for dating and correlating sediments for exploration purposes. In recent times, an area of Biostratigraphy that has become very useful for correlation and reservoir studies is nannostratigraphy which is the technique that requires the use of calcareous nannofossil (Bown, 2012). Calcareous nannofossils is a term which comprises all calcareous fossils smaller than 30 microns(μm) and also all nannoplankton which can pass through the smallest sieve size of 63 μm(Lohmann, 1909). Nannofossils are very useful biostratigraphic tools because of their good preservation and their minute size which prevents mechanical damage. Also their widespread distribution, as part of the phytoplankton coccolithophores allows them to be distributed throughout the photic zone especially the upper 50m of the water column spanning almost all marine habitats. A very large number of individual coccoliths may be preserved in small amount of sediment thus very small quantities of sample are needed for analysis. There has been the wide use of Foraminifera and Palynomorphs in stratigraphic and correlation studies in the Niger Delta. There is the need for a shift in the wide use of Foraminifera and palynomorphs to a less expensive and more reliable tool in interpreting sedimentary sequences. The use of nannofossils represents this shift as nannofossils are global biological markers and because of their short period of existence, they are reliable tools in marking sediments deposited within short geological time periods.

Aim and objectives of the study

The aim of this study is to apply nannofossil studies in characterization of sediments in two Wells in the Niger Delta. The specific objectives are To:

1. Determine the nannofossils present in both Wells
2. Determine repetitive nannofossils bioevents
3. Determine the Neogene Nannofosssils (NN) zones in the wells with the aid of recovered nanofossils
4. Determine the age of the sediments using recovered nannofossils.
5. Correlate the age related sediments across both Wells.

Location of the Study



Map of the Niger Delta showing the location of the study (After STRATCOMM)

■ Study Location

Literature Review

Previous studies have been carried out in the Niger Delta where Nannofossils have been used for geologic interpretation.

Boboye *et al*., (2007) in their work tittled " Biostratigraphic study of the Calcareous Nannofossil of Well XH-1, Deep Offshore, Niger Delta, Nigeria" carried out a calcareous nannofossil biostratigraphic study on sediments of well XH-1 located in the deep offshore of Niger Delta, Nigeria. Forty-one (41) calcareous nannofossil species were identified and were used for biostratigraphic zonation, dating and erecting a sequence stratigraphic framework for the Well. Two major nannofossil zones (NN11 and NN10 / CN9 and CN8) belonging to the Late Miocene age were identified using standard biozonation schemes.

Three major zones of *Discoaster quinqueramus* zone, *Discoaster berggrenii* zone, and *Discoaster boli* zone, were erected for this well based on the index taxa and fossil assemblage recorded. *Discoaster berggrenii* zone was further subdivided into two subzones. On the strength

of the lithostratigraphic studies, the sediments were hemipelagic shale with minor amounts of sand at the lower section of the well. Nannofossil abundance/diversity patterns calibrated with chronostratigraphically vital bioevents reveals three (3) Condensed Sections when correlated to the Global Cycle Chart. This was associated with the 5.8 Ma, 7.0 Ma and 9.2 Ma Maximum Flooding Surfaces.

Fadiya and Salami (2015) in their work titled "A Neogene Calcareous Nannofossil Biozonation Scheme for the Deep offshore, Niger Delta" carried out detailed calcareous nannofossil study on Deep offshore sediments penetrated by eight Wells with the aim of achieving a basin wide nannofossil biozonation for the Niger Delta Neogene sediments.

Ditch-cuttings were used from eight selected offshore deepwater Niger Delta Wells code-named DPW1-8 for proprietary reasons. The cuttings were prepared into Smear slides using the Pipette and strew method and were mounted using the Norland Optical Adhesive mounting medium, the slides were then examined with an Olympus trinocular polarizing photomicroscope (CX31P) at 1000X and 1500X magnifications under cross-polarized and transmitted light. The nannofossils forms in each of the eight Wells were identified to the species level. The relative abundance and diversity and other relevant information such as taxa appearance under light microscope, preservation state, and dissolution degree, were recorded and logged on a logging sheet for each sample.

From the analysis, 93 coccolith and nannolith species were recognized. The Helicosphaeraceae, Sphenolithaceae, Discoasteraceae, and Prinsiaceae were the predominant nannofossil families. Other important families were the Ceratolithaceae, Coccolithaceae and Triquetrorhabdulaceae. Coccolithus pelagicus (Wallich, 1877) was abundant in the Early to Middle Miocene strata of most of the Wells.

The study revealed that despite the abundant Niger Delta deepwater nannofossil occurrences, Martini (1971) and Okada and Bukry (1980) schemes and zonal markers were for numerous reasons, inadequate for refined biozonation in the Niger Delta as many taxa used by Worldwide zonal schemes and subdivisions were not present or showed inconsistent occurrences while some other species used in the study that had very consistent occurrences were not featured in the earlier biozonation schemes. Therefore, the study incorporated the schemes' events and datums recognized into the local zonation scheme (of zones and subzones) and constructed a zonation scheme for the Niger Delta deep offshore region.

Obaje S.O *et al,* in their work titled "calcareous nannofossils Biostratigraphy of XY-1 Field, offshore, Western Niger Delta carried out calcareous nannofossils studies to determine the calcareous nannofossils abundance and also nannofossil biozonation of the studied wells.

Five wells were used for the study with a total of 1,100 ditch cuttings retrieved from the wells taken at an interval of 9.14m. The laboratory method used for the preparation of the nannofossils was the pipette and smear method. The study recognized three calcareous nannofossils zones; *Calcidiscus premacintyrei* (NN6-NN7 zone), *Catinaster coalitus* (NN8 zone) and *Discoaster hamatus* (NN9 zone).

These biozones were correlated across the five wells. The sediments in the wells were assigned the age middle to late Miocene on the basis of the recovered nannofossils.

Methodology

Sample Preparation and Analyses

Ditch cuttings from two Wells in the Niger Delta were used for the study. The cuttings were processed and analysed for their fossils content and to provide bio-data for stratigraphic age, and sequence stratigraphy. Samples were prepared for microscopic examination following the standard standard nannofossil preparation methods. The smear slides were studied in a light microscope under crossed and parallel polarisation filters at a magnification of 100X. The assemblages were qualitatively and semi-quantitatively characterized in terms of abundance and diversity. Calcareous nannofossil total abundance was estimated as number of specimens for field of view. References were made to Martini (1971), and Bown (1998) Cenozoic Geochronology and the Chronostratigraphic ages of nannofossil datums In addition, the STRATCOMM Cenozoic Calcareous Nannofossils of Niger Delta, (2017), the nannofossil range chart of Perch Nielsen (1985) as well as Cenozoic and Modern Coccolithophores album (in www.mikrotax.org) aided in the description and identification of the nannofossils recorded and zonation of the succession. The results of the analysis was presented in tables and charts of relative species abundance, relative species diversity, First Downhole occurrence(FDO), Last Downhole occurrence(LDO), Last common occurrence. More significantly, repetitive bioevents of regional field scale importance was recorded. These repetitive bioevents includes changes in abundances of nannofossils, diversity of the nannofossils within various sections of the wells, this was be correlated across the wells thereby subdividing the wells into smaller distinct packages on the basis of repetitive bioevents.

Result and Discussions

Table 1: Nannostratigraphic summary for Well 1

Depth (ft)	Nanno- events	Age(Ma)	Nann-zone		**Stratcomm Zone**	Relative Age
6520	First sample analyzed		**Undiagnostic**		**Undiagnostic**	**Indeterminate**
6520 – 6720	Interval completely barren of Nannofossils					
6720	FO: of *Sphenolithus heteromorphus*					**MIDDLE MIOCENE**
6720 – 6760	Interval with fairly high occurrence of nannofossils. Major condensed section	14.2				
6720	Acme of *Helicosphaera cateri and Sphenolithus heteromorphus*	14.2	**NN5**		**NND4**	
6840 – 7000	Interval completely barren of nannofossils					
7040	FDO of Helicosphaera ampliaperta	15.6				
7040 – 7260	Interval with high occurrence of nannofossils (Condensed Section)			**NN4B**		
8810	Condensed Section (MFS) Acme of *Helicosphaera ampliaperta,*	16.8	**NN4**		**NND3**	**EARLY MIOCENE**

	Sphenolithus heteromorphus and *Cyclicargolithus floridanus*			**NN4A**		
7320 – 7760	Interval barren and /or with Sporadic occurrances of nannofossils					
9980	LDO of *Sphenolithus heteromorphus*	18.2	**NN3 & Older**		**NND2 & Older**	
10010 – 11960	Interval completely barren of nannofossil					
11960	TD					

Nanno-Zone: NN5

Interval: 6720 – 7080ft.

Age: Middle Miocene

Interval characterized by:

- Top Occurrence (HO) of *Sphenolithus heteromorphus* @ 6720ft
- First Downhole Occurrence (FDO) of *Helicosphaera ampliaperta* @7080ft

The FDO of *Sphenolithus heteromorphus* was used to define the top of NN5 zone of Martini, 1971 (NND4 of the Stratcomm Zone). The occurrence of this taxa at 6720ft is the basis for the assignment of the NN5 zone from this interval of the well.

The upper part (6720ft. – 6760ft) yielded fairly high abundance and diversity of calcareous nannofossils. The interval is characterized by the occurrences of nannofossil such as; *Sphenolithus heteromorphus, Discoaster deflandrei, Cyclicargolithus floridanus, Helicosphaera carteri, Reticulofenestra pseudoumbilicus (5-7microns), Reticulofenestra pseudoumbilicus (>7microns), Helicosphaera carteri and Sphenolithus moriformis.*

The high abundance of nannofossils withnessed at the top of this section, with its diversity peak at 6750ft represents the 14.8Ma Maximum Flooding Surface of Haedenbol et al., 1998 in this study.

The lower section of the interval (6800ft – 7000ft), were completely barren of nannofossils. The FDO of *Helicosphaeara ampliaperta* recorded at 7080ft was used to delineate the base of the zone. This bio-event marks the boundary of the NN5/NN4 nannozones of Martini,1971 (NND3 of Stratcomm Zone).

Nanno-Zone: NN4

Interval: 7040ft. – 7760ft.

Age: Early Miocene

Interval characterized by:

- FDO of *Helicosphaera ampliaperta* @7080ft.
- Interval 7080 – 7290ft TD with very high occurrence of nannofossils.
- Acme of *Helicosphaera ampliaperta* and *Discoaster deflandrei* at 7120ft

The top of this interval is defined by the FDO of *Helicosphaera ampliaperta* at 7080ft dated 15.6Ma by Bergreen et al., 1985). This bio- event marks the top of NN4 zone of martini, (1971) (NND3 Stratcomm Zone).

The upper part of this interval (7080 – 7280ft.), witnessed high abundance and diversity of calcareous nannofossils. The nannofossils recorded include*: Helicosphaera carteri, Reticulofenestra pseudoumbilicus (5-7microns), Reticulofenestra pseudoumbilicus (3-5 microns), Reticulofenestra pseudoumbilicus (>7microns), Discoaster sp, Helicosphaera carteri, Reticulofenestra pseudoumbilicus, Coccolithus pelagicus, Sphenolithus moriformis, Calcidiscus leptoporus, Helicosphaera ampliaperta, Discoaster deflandrei, Sphenolithus heteromorphus, Cyclicargolithus floridanus, Pontosphaera multipora and Discoaster petaliformis*.

Three Condensed section were observed within the interval. First at 7080 – 7280ft with its diversity peak at 7120ft, is considered to represent the 15.6Ma Maximum Flooding Surface (Hardenbol et al., 1998) in this study (Assemblage 2). The Acme of *Sphenolithus heteromorphus, Helicosphaera ampliaperta* and *Cyclicargolithus floridanus* associated with this peak lends credence to the dating of the surface.

The second minor increase in calcareous nannofossils abundance and diversity was observed at 7720 – 7880ft with its diversity peak at 7520ft and is considered to represent the 16.8Ma MFS of Haq et al., (1985) (Assemblage 3) . The continued down-hole increase of *Discoaster deflandrei* associated with this peak, lend credence to the dating of this surface. This bio-data was also used to refine the NN4 zone into Upper NN4B and lower NN4A following the approach of Fadiya et al., 2005.

The third nannofossil increase observed towards the base of the interval with its diversity peak at 9360-9460ft with its abundance and diversity peak at 9360ft represents the 18.0Ma MFS of Hardenbol et al., 1998 in this study (Assemblage 4).

The base of this zone was delineated at 9460ft using the LDO of *Sphenolithus herteromorphus*. This event marks the boundary of NN4/NN3 zone of Martini, 1971 and is dated dated 18.2Ma by Berggern et al., 1985. Hence, this sediments within the interval was deposited within the NN4 zone (NND3 Zone of Stratcomm 2002) of Middle Miocene age.

Nanno-Zone: NN3 & ?Older

Interval: 9460ft – 12,000ft

Age: Early Miocene & ?Older

Interval characterized by:

- LDO of *Sphenolithus heteromorphus* @7760ft
- Paucity of nannofossils nannofossils.

The LDO of *Sphenolithus heteromorphus* at 9460ft was used to define the top of this interval (martini, 1971). This event markes the top of the NN3 Early Miocene zone of Martini, 1971 (NND2 of Stratcomm Zone).

This interval is generally characterized by paucity of nannofossils. The predominance of barren depths and the non-recovery of any nannofossil marker specie within the lower section of the well made the age determination of the interval cumbersome. Hence, the sediments within this interval 9460 – 12000ft) is considered to have probably deposited within the NN3 and Older Zone during the Early Miocene and Older times.

Therefore, the Well – 1 sediments were deposited during the Middle – Early Miocene &?Older Ages within the NN5 – NN3&?Older nannozone (Equivalent of the NND4

Nannostratigaphic Summary of Well 2

Dept (ft)	Nanno- events	Age(Ma)	Nann-zone		Stratcomm Zone	Relative Age
5760	First sample analyzed		**Indeterminate**		**Indeterminate**	**Indeterminate**
5760 - 7170	Interval completely barren of Nannofossils					
7170	FO: of *Sphenolithus heteromorphus*		**NN5**		**NND4**	**MIDDLE MIOCENE**
7200 – 7740	Interval with fairly high occurrence of nannofossils. Major condensed section	14.2				
7200	Acme of *Helicosphaera cateri and Sphenolithus heteromorphus*	14.2				
7200	FDO of Helicosphaera ampliaperta	15.6	**NN4**	**NN4B**	**NND5**	
7200 - 8220	Interval with high occurrence of nannofossils (Condensed Section)					
7200	Condensed Section (MFS) Acme of *Helicosphaera ampliaperta, Sphenolithus heteromorphus* and *Cyclicargolithus floridanus*	15.6				

8220 - 6460	Interval barren and /or with few occurrances of nannofossils					
8490 - 8640	Condensed Section (MFS) Increase occurrence of *Discoaster deflandrei*	16.8		**NN4A**		**EARLY MIOCENE**
9980	LDO of *Sphenolithus heteromorphus*	18.2	**NN3 & ?Older**		**NND2 & ?Older**	
8940 - 9390	Interval barren and /or with sporadic occurrences of nannofossil					
9390	TD					

Nanno-Zone: NN5

Stratcomm Zone: NND4

Interval: 7200 – 7740ft

Age: Middle Miocene

Interval characterized by:

- Top Occurrences (HO) of *Sphenolithus heteromorphus* @ 7200ft
- First Downhole Occurrence of *Helicosphaera ampliaperta* @ 7740ft

The interval is characterized by low abundance and diversity of calcareous nannofossils such as *Helicosphaera carteri, Reticulofenestra pseudoumbilicus (5-7microns), Reticulofenestra pseudoumbilicus, Discoaster deflandei, Helicosphaera carteri, Sphenolithus heteromorphus, Reticulofenestra pseudoumbilicus, Coccolithus pelagicus, Cyclicargolithus floridanus* and *Sphenolithus moriformis.*

A major surface of unconformity or erosion/faulting was mapped at 7200ft. The surface was defined by abrupt truncation of major flooding event as observed from a calcareous nannofossils

rich interval underlying a shallow marine facies. The hiatus probably has removed considerable sediments of NN5 zone.

The Highest Occurrence (HO) of *Sphenolithus heteromorphus* that occurred at 7200ft provided evidence of the penetration of the of NN5 (NND4) zone of Martini, (1971) at this horizon. The moderate increase of nannofossil recorded at 7200ft – 7410ft with its diversity peak at 7200ft represents the 14.8Ma MFS of Hardenbol et al., (1998). The base of the interval was delineated using the FDO of Helicosphaera ampliaperta at 7740ft.

Nanno-Zone: NN4

Stratcomm Zone: NND3

Interval: 7740ft - 8910ft TD.

Age: Early Miocene

Interval characterized by:

- FDO of *Helicosphaera ampliaperta* at 7740ft.
- Interval 7740 – 7900ft and 8490 – 8640ft with fairly high recovery of nannofossils
- LDO of *Sphenolithus heteromorphus* at 8910ft

The top of this interval is defined by the FDO of *Helicosphaera ampliaperta* dated 15.6Ma (Bergreen et al., 1985) at 7740ft. The FDO of *Helicosphaera ampliaperta* marks the top of NN4 (NND3) Zone of martini, 1971.

The upper (7740ft. – 7900ft.) and (8490 – 8640ft) section of this interval witnessed moderately high abundance and moderate diversity of calcareous nannofossils, while the other section were either barren and or with scanty recovery of nannofossils. The taxa recorded include: *Helicosphaera carteri, Reticulofenestra pseudoumbilicus (5-7microns), Reticulofenestra pseudoumbilicus (3 – 5microns), Reticulofenestra pseudoumbilicus (>7microns) , Discoaster deflanderi, Helicosphaera carteri, Sphenolithus heteromorphus, Coccolithus pelagicus, Sphenolithus moriformis, Calcidiscus leptoporus* and *Cyclicargolithus floridanus*. The increase occurrence of nannofossil recorded at interval 7740ft – 7900ft with its diversity peak at 7800ft represents the 15.6Ma MFS of Hardenbol et al., (1998).

The renewed major increase in calcareous nannofossils abundance and diversity is observed at the lower part (interval 8490 – 8640ft TD) with its diversity peak at 8520ft, represents the 16.8Ma Maximum Flooding Surface (Hardenbol, 1998) in this study. The continued down-hole

increase occurance of *Discoaster deflanderi* associated with this event lends credence to the dating of this surface. This bio-event was also used to sun-divide this zone into Upper NN4B and Lower NN4A after Fadiya et. al., 2005. The Last Downhole Occurrence (LDO) of *Sphenolithus heteromorphus* observed at 8910ft was used to delineate the NN4 / NN3 zonal boundary (Martini, 1971). This event is dated 18.0Ma by Berggren et al., 1985 and it occurs with in the 18.0Ma(MFS) condensed section. Accordingly, this interval is assigned NN4 zone (NND3 Stratcomm Zone) of Middle Miocene age.

Nanno-Zone: NN3 & ?Older
Stratcomm Zone: NND2 &Older
Interval: 8910 – 9390ft TD.
Age: Early Miocene
Interval characterized by:

- LDO of *Sphenolithus heteromorphus* at 8910ft
- Paucity of nannofossils.

This interval is generally characterized by the poor recovery of nannofossils. However, the LDO of *Sphenolithus heteromophus* recorded at 8910ft suggest the penetration of the NN3 zone. The age of the lower part of this interval could not be determined due to the non-recovery of nannofossils at this horizon.

Hence, the analyzed intervals of Well – 2 probably terminated with the Early-Middle Miocene NN3 (NND2) zone of Martini, (1971) and Older.

Nanno Statigraphic Correlation of Well - 1 and Well - 2

The correlation of well 1& 2 was based on the Four nannofossil assemblages identified in both wells.

The four nannofossils assemblages identified were based on the presence or absence of species and by patterns of species abundance and diversity and their super-positional relationships. The assemblages are further identified by the presence of primary or secondary marker species where possible. The assemblages have been numerically designated from 1 to 4 in a descending order.

Assemblage 1

The assemblage is characterized by the presence of *Sphenolithus heteromorphus, Cyclicargolithus floridanus* and *Discoaster deflandrei*.

The assemblage is present in Well -1 and Well – 2 and coincides with the 14.8Ma Maximum Flooding Surface (MFS).

Assemblage 2

Assemblage 2 recorded the highest occurrence of nannofossils in this study and is present in Well – 1 and Well -2. It is charaterised by the highest occurrences of *Sphenolithus heteromorphus, Cyclicargolithus floridanus, Discoaster deflandrei and Helicosphaera ampliaperta*. The First Downhole Occurrence (FDO) of *Helicosphaera ampliaperta* occurred at the upper part of this assemblage. This assemblage coincides with the 15.6Ma MFS

Assemblage 3

The assemblage 3 is well developed in Well -2 and weakly developed in Well -1. The assemblage is characterized by the continued downhole increase of *Discoaster deflandrei*. The assemblage represents the 16.8Ma Maximum Flooding Surface.

Assemblage 4

The base of *Sphenolithus heteromorphus* occurs in the assemblage. The assemblage is weakly developed in both Well – 1 and Well – 2. It is probably partially removed by erosion. It contains the 18.0Ma Maximum Flooding Surface.

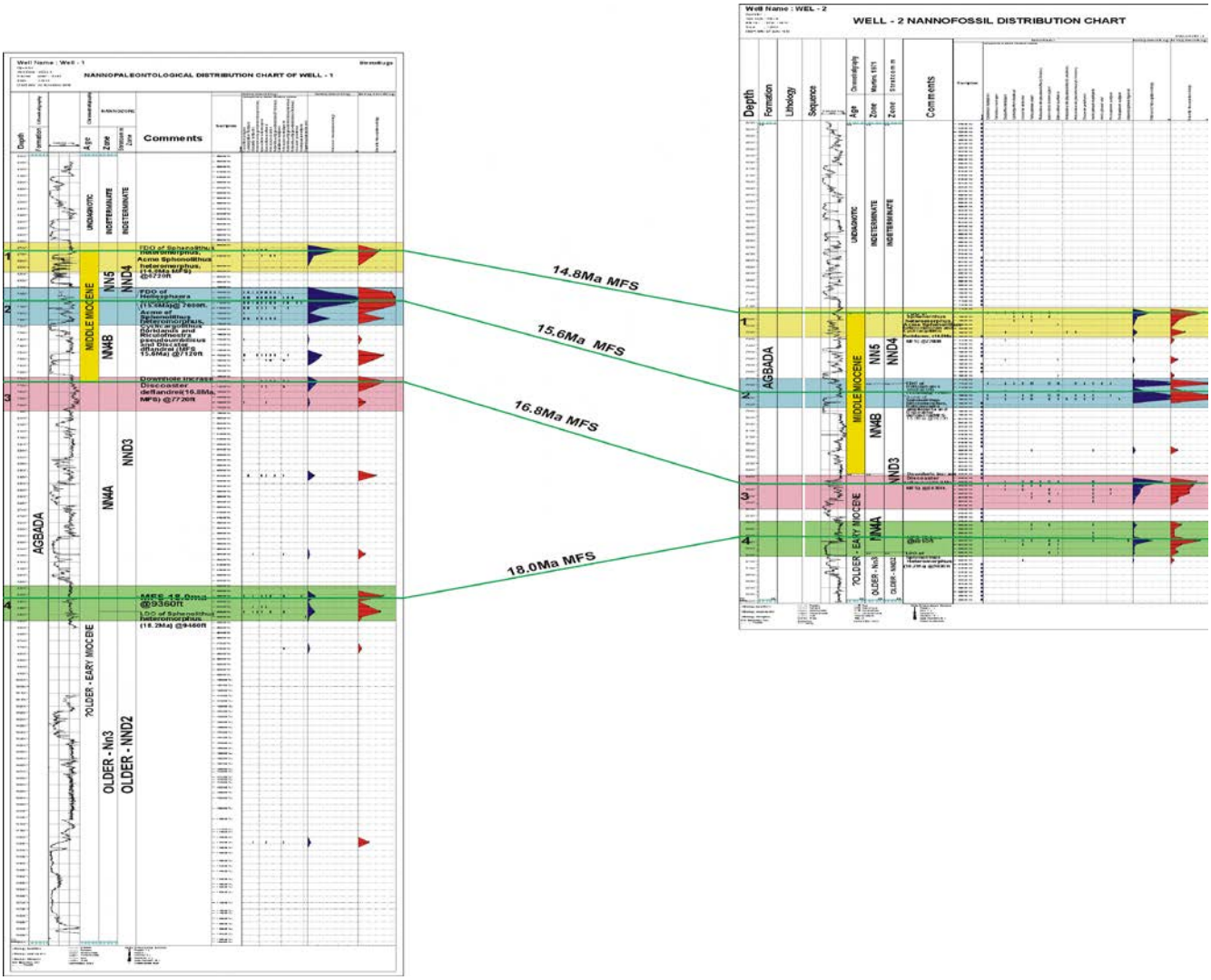


Fig 2: Nannopaleontogical correlation of Well 1 and 2

Conclusion

This study has adequately applied nannofossil events to determine the age and date the sediments encountered in both Wells in the Niger Delta of Nigeria. Events such as the First downhole Occurences, Last Downhole Occurrences, Top occurrences have aided in recognizing and placing the Maximum Flooding surface which is essential in delineating Hydrocarbon reservoir sands, the pattern of species abundance and diversity has also been used to subdivide the Wells into four Nannofossil Assemblages.

References

Bown, P.R. (1998) Taxonomy, biostratigraphy, and evolution of late Triassic-early Jurassic calcareous nannofossils. *Special Papers in Palaeontology*, 38, 1-118.

Bown, P. R. & Dunkley Jones, T. (2012). Calcareous nannofossils from the Paleogene equatorial Pacific (IODP Expedition 320 Sites U1331-1334). *Journal of Nannoplankton Research*. 32(2): 3-51.

Berggren. W.A, Kent, D.V, and Van Couvering. J.A, (1985). The Neogene: Part 2. Neogeochronology and chronostratigraphy, in The Chronology of the Geological Record, (ed. N.J. Soelling), *Geological Society Memoir* 10: 211-260.

Boboye O.A, Fowora O., (2007). Biostratigraphic study of the Calcareous Nannofossil of Well XH-1, Deep Offshore, Niger Delta, *Nigeria Journal of Mining and Geology* 43(2):175-186.

Fadiya, S.L., Jaiyeola-Ganiyu, F.A., and Fajemila, O.T., (2014). Foraminifera Biostratigraphy and Paleoenvironment of sediments from Well AM-2, Niger Delta. *Ife Journal of science* 16(1), 61-63.

Hardenbol, J, Thierry, J, Farley, M, Jacquin, T, Vail, P., (1998). Mesozoic and Cenozoic Sequence Chronostratigraphic Framework for European Basins. *American Association of Petroleum Geologists Bulletin* 56(10): 10-17.

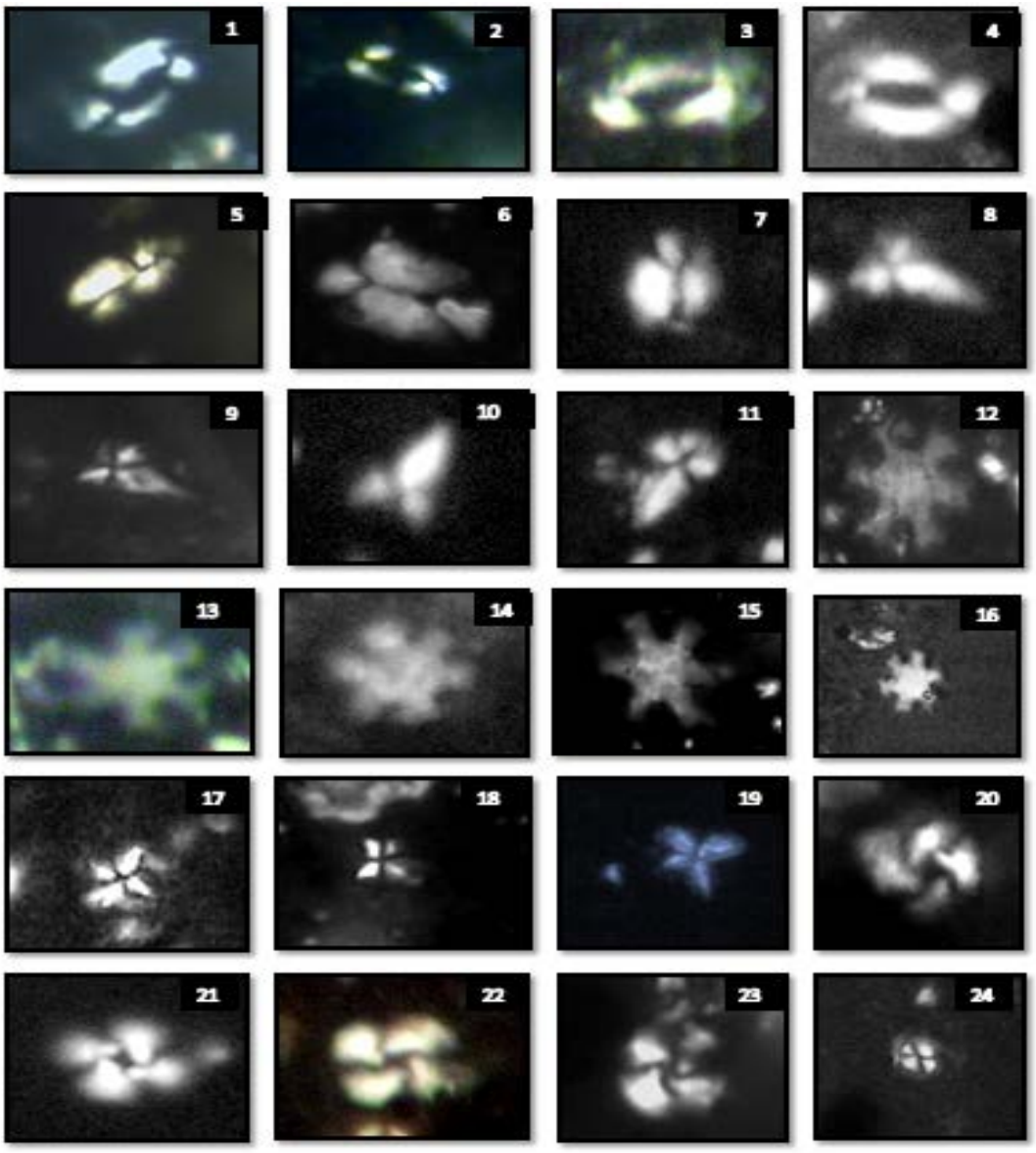
Obaje S.O, Okosun, E.A, Olasehinde P.I, Udensi E.E, (2014). Calcareous Nannofossil Biostratigraphy of XY-1 Field, Offshore Western Niger Delta, Nigeria. *International Journal of Science and Technology*, 3(5): 2-4.

Okada, H, and Bukry, J, (1980). Supplementary modification and introduction of code numbers to low-lattitude coccolith biostratigraphic zonation, Marine Micropaleontology 5, 321-326.

Martini, E., (1971). Standard Tertiary and Quaternary calcareous nannoplankton zonation, in Proceedings of the Second Nannoplanktonic Conference, Roma, 1970, (ed. Farinacci, A.), *Edizioni Technoscienza*, Rome, 2, 739-785.

APPENDIX

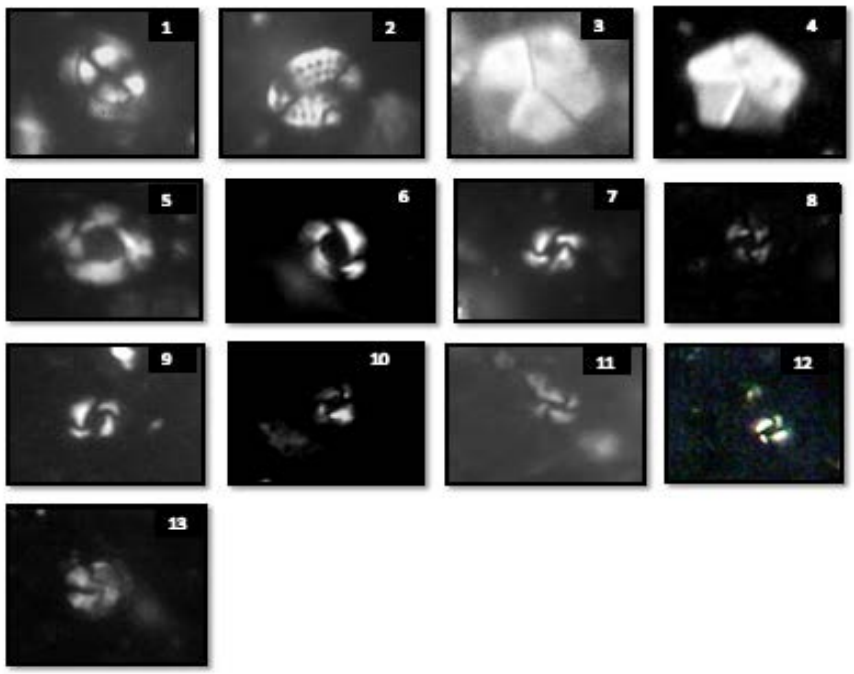
Nannofossil Plates(Well 1)



1. *Helicosphaera ampliaperta* @7720ft (Well -1)
2. *Helicosphaera ampliaperta* @ 7560ft (Well – 1)
3. *Helicosphaera ampliaperta* @ 7830ft (Well – 2)
4. *Helicosphaera ampliaperta* @ 8490ft (Well – 2)
5. *Helicosphaera cateri* @ 7740ft (Well – 2)
6. *Helicosphaera cateri* @ 8520ft (Well – 2)

7. *Helicosphaera cateri* @ 7080ft (Well – 1)
8. *Sphenolithus heteromorphus* @ 6720ft (Well – 1)
9. *Sphenolithus heteromorphus* @ 7080ft (Well – 1)
10. *Sphenolithus heteromorphus* @ 7200ft(Well – 2)
11. *Sphenolithus heteromorphus* @ 8490ft (Well – 2)
12. *Discoaster deflandrei* @ 7040ft (Well – 1)
13. *Discoaster deflandrei* @ 7120ft (Well – 1)
14. *Discoaster deflandrei* @8520ft (Well – 2)
15. *Discoaster deflandrei* @ 8550ft (Well – 2)
16. *Discoaster deflandrei* @7860ft (Well – 2)
17. *Sphenolithus moriformis* @7040ft (Well – 1)
18. *Sphenolithus moriformis* @ 7200ft (Well – 2)
19. *Sphenolithus moriformis* @ 8940ft (Well – 2)
20. *Cyclicargolithus floridanus* @7040ft (Well – 1)
21. *Cyclicargolithus floridanus* @ 7240ft (Well – 1)
22. *Cyclicargolithus floridanus* @ 7740ft (Well – 2)
23. *Cyclicargolithus floridanus* @ 8520ft (Well – 2)
24. *Coccolithus pelagicus* @ 7160ft (Well – 1)

Nannofossil Plates (Well 2)



1. *Coccolithus pelagicus* @7200ft (Well 2)
2. *Pontonsphaera multipora* @7120ft (Well – 1)
3. *Braarudosphaera bigelowii* @8490ft (Well – 2)
4. *Braarudosphaera bigelowii* @9520ft (Well – 1)
5. *Reticulofenestra pseudoumbilicus*(>7microns) @7200ft (Well – 2)
6. *Reticulofenestra pseudoumbilicus*(5 - 7microns) @7080ft (Well – 1)
7. *Reticulofenestra pseudoumbilicus*(5 - 7microns) @7800ft (Well – 2)
8. *Reticulofenestra pseudoumbilicus*(3 - 5microns) @7120ft (Well – 1)
9. *Reticulofenestra pseudoumbilicus*(3 - 5microns) @7350ft (Well – 2)
10. *Reticulofenestra pseudoumbilicus*(<3microns) @7080ft (Well – 1)
11. *Reticulofenestra pseudoumbilicus*(<3microns) @7120ft (Well – 1)
12. *Reticulofenestra pseudoumbilicus*(<3microns) @7120ft (Well – 1)
13. *Calcidiscus macintyrei* @7200ft (Well – 2)