Dinoflagellate Cyst Biozonation Of Upper Cretaceous Succession Of Mbeji-1 Well, Central Chad Basin, North East Nigeria

Yikarebogha Y, Oloto, I. N. Soronnadi-Ononiwu, G. C Omoboriowo, A. O

Abstract: - The dinoflagellate cysts from the Upper Cretaceous succession penetrated by Mbeji-1 well in the Chad Basin, Nigeria were investigated. The investigation yielded biostratigraphically significant dinoflagellate cyst species recovered from interval 1600m – 3720m of the well. Based on the stratigraphic distribution of these bioevents, five informal dinoflagellate cyst assemblage zones from the Cenomanian to Maastrichtian are proposed. The zones in stratigraphically ascending order are as follows*: Subtilisphaera inaffecta* (Zone I), *Odontochitina operculata* (Zone II), *Coronifera oceanic* (Zone III), *Exochosphaeridium muelleri* (Zone IV) and *Hystrichodinium pulchrum* (Zone V). The ages of these zones based on stratigraphic positions and series of first occurrences of key species are: Cenomanian-Turonian (Zone I), Coniacian-Santonian (Zone II), Santonian (Zones III-IV) and Campanian-Maastrichtian (Zone V).

INTRODUCTION

The erection of the dinoflagellate cyst biozones of Mbeji-1 well is based essentially on the diagnostic dinoflagellate cyst assemblages observed within the various sections of the studied interval. Mbeji-1 well is located between longitude 12^0 and 14^0 E and latitude 13^0 and 15^0N in the Chad Basin in North East Nigeria, and it is one of the twenty-three exploration oil wells drilled by the Frontier Exploration Service of the Nigerian National Petroleum Corporation (FES-NNPC) . On the basis of the stratigraphic distribution of the recovered dinoflagellate cysts in the well, a palynological range chart suitable for erection of the five dinoflagellate cyst biozones was generated. Hitherto, there has been no detailed dinoflagellate studies for the Nigerian sector of the Chad Basin when compared to the numerous researches that have been done in the other basins in Nigeria, most especially the Niger Delta and Anambra Basins. These works include the Middle Miocene – Early Pleistocene Western Niger Delta (Durugbo *et al.,* 2011,) Late Cretaceous –Tertiary Succession Of Gbekebo-1 Well,Benin Flank, Anambra Basin (Lucas, F.A and Ishiekwene, E , 2010), Middle Miocene Niger Delta (Oboh, 1992), Maastrichtian section of the Nkporo shale of the Gbekebo-1 Benin Flank of the Niger Delta (Oloto, 1989), the Cretaceous Upper Benue Trough (Lawal and Moullade, 1986), the Nkporo shale on the Calabar Flank of South Eastern Nigeria (Edet and Nyong, 1994),

- Yikarebogha Y, Oloto, I. N. Soronnadi-Ononiwu, G. C Omoboriowo, A. O
- Affliation; 1Nigerian Petroleum Development Company, Benin, Nigeria, 2, 4 Department of Geology, University of Port Harcourt, Nigeria, 3Department of Geology and physics, Niger Delta University, Nigeria
- Corresponding email: adeboriowo@yahoo.com

The Maastrichtian-Lutenian succession of the Benin-1 well from the Western Anambra Basin flank of Southern Nigeria (Asadu and Lucas, 2006), the Paleocene - Lowermost Eocene successions in the Alo-1 well from the Anambra Basin, Southeast Nigeria (Antolinez and Oboh-Ikuenobe, 2007), the Oshosun Formation in the Sagamu quarry, Dahomey Basin, South-Western Nigeria (Bankole *et al.*, 2006), and the Upper Cretaceous Patti Formation, Southeastern Bida Basin Nigeria (Ojo and Akande, 2006).

AIM AND OBJECTIVES OF THIS RESEARCH WORK

The reason for undertaking this study is as a result of the lack of dinoflagellate studies in the Chad Basin as revealed above. The objective of this study therefore, is to add to existing palynological records through the erection of dinoflagellate zonation schemes which would promote better use of palynological events in age dating and correlation of wells, as well as paleoenvironmental inferences in combination with pollen and spore species.

GEOLOGICAL SETTING

The Chad Basin is the largest intracratonic basin in Africa (Reading, 1982) and the largest area of inland drainage in Africa, occupying about 2,330,000km^2 in the Central Sahara and Southern Sudan with a diameter of 1000km Barber (1965). In Nigeria, only 10 percent of South-West corner of the basin is situated in the North-East part of the country (Fig. 3), where the western limit is formed by the water divide between the Niger and the Chad drainage systems and the southern limit by the divide between the Chad and Benue systems (Barber, 1965). The Chad Basin resulted from plate divergence along the West Africa continental margin (Petters, 1979d, 1981c). The basin is believed to be the vestige of the fragmentation and dispersal of Gondwanaland, like other Mesozoic - Cenozoic sedimentary basins of Central West Africa. The various stages leading to plate divergence started with regional thermal doming, volcanism, rifting, formation of oceanic crust, marine incursion and subsequent widening and deepening of young oceans as outlined by Evans (1978). Initial deposition of non-marine clastics in Chad Basin probably resulted from reversal of paleo-drainage due to doming and rifting in the Cretaceous (Petters, 1978). The Cenomanian-Paleocene deposits however were a result of

marine incursion into the basin due to global eustacy, local subsidence and sea floor spreading in the nearby ocean (Petters, 1981c).Post Paleocene continental sedimentation in the Chad Basin had been sustained by renewed uplift of parts of the African continent (Burke, 1976). Sedimentation in the Chad Basin began in the Albian times. The basal sedimentary sequence is the Bima Sandstone, which was deposited unconformably over the Precambrian crystalline basement rock (Barber, 1965). Deposition of the Bima Sandstone continued up to the Cenomanian. The Turonian was characterized by extensive transgression during which the Gongila Formation was deposited as a transitional sea deposit (Avbovbo et al., 1986). The transgression which began in the Turonian continued up to the Senonian during which the Fika shale was deposited (Matheis, 1976). Towards the end of the Cretaceous, during the Maastrichtian time, an estuarine deltaic environment prevailed in the basin and the Gombe Sandstone was deposited with intercalations of siltstone, shale and ironstone (Matheis, 1976). Immediately after the deposition of the Gombe Sandstone, a regime of intense folding began, during which the Cretaceous sediment from the Albian to Maastrichtian age were folded into a series of anticline and syncline that were later eroded, creating an erosional unconformity at the base of the Tertiary deposits (Matheis, 1976). The Kerri-Kerri Formation was deposited unconformably on the eroded surface of the Gombe Sandstone in the Paleocene (Matheis, 1976). Finally, an unconformable Pleistocene deposit of the Chad Formation was deposited on the Kerri-Kerri Formation (Matheis, 1976). The Chad Formation is today covered in some part by recent alluvial (Table 1).

MATERIAL AND METHODS

A total of eighty ditch cuttings samples from 1600m – 3720m depth intervals of Mbeji-1 well were collected and sampled. From each depth-interval, about 5gm was weighed, thoroughly washed/cleaned. The pre-treatment of the samples with various Acid combinations include removal of unwanted carbonate material by washing with 10ml diluted hydrochloric acid as well as further treating the residue with 40% hydrofluoric acid and boiling hydrochloric acid to dissolve all silicates and silicofluoride gel respectively. The ultrasonic centrifuge machine further separated out the dissolved material from the organic matter residue for 2minutes. Subsequently, three drops of safarin'o dye solution dropped into the residue to stain the dinocyst and left for few minutes to allow for proper mixing and then pipette into a cover slip glass slide on top of the hot plate until dryness and was ready for palynological microscopic study. The Slide were properly labelled and observed under research microscope through which snapshot was taken. **See Plate 1, 2 and 3** for the photomicrograph of the palynomorphs.

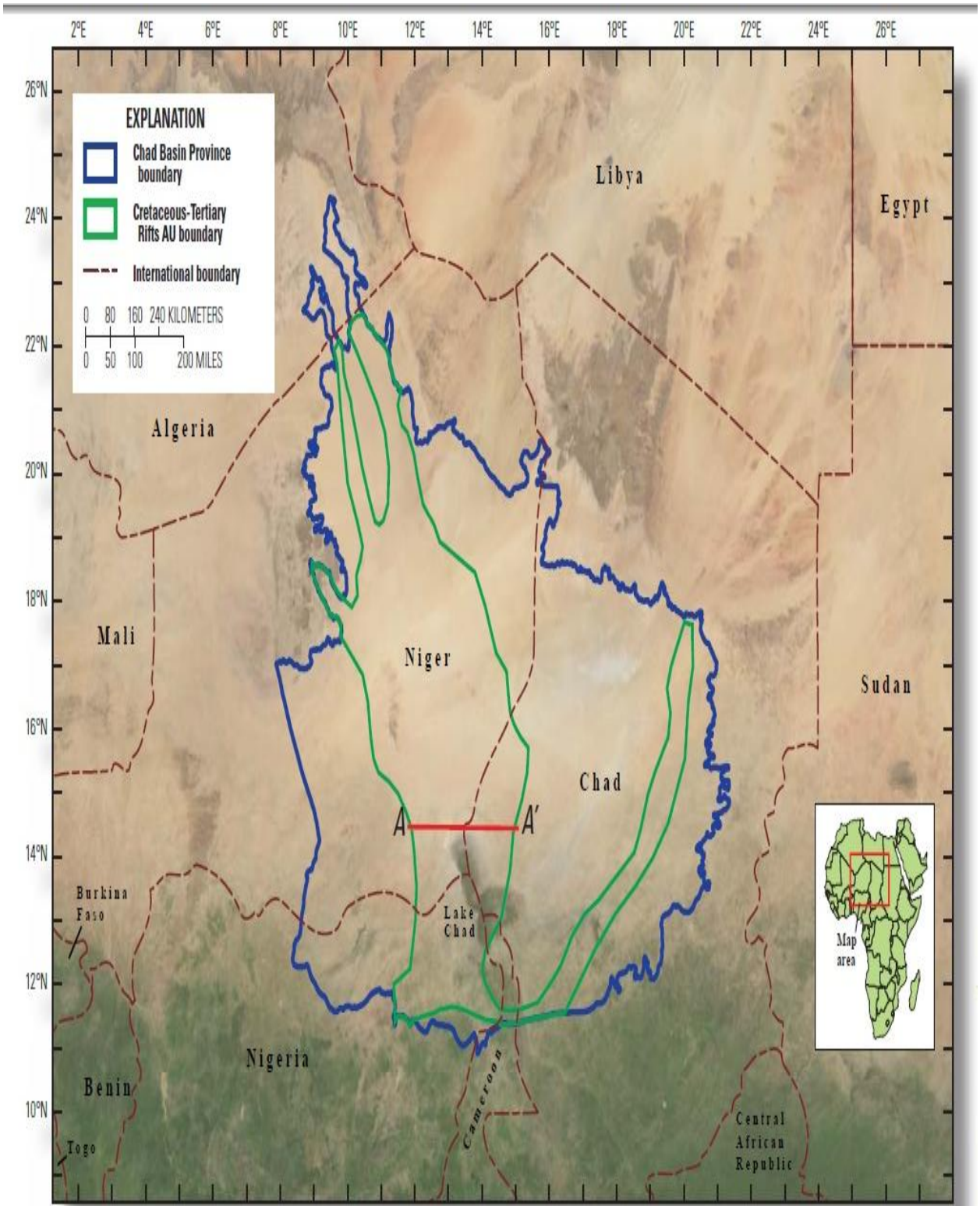

FIG.1 : Map showing the Extent of Chad Basin (adapted from USGS, 2010)

Table: 1. Stratigraphic Succession for the Chad Basin in Nigeria (adapted from Carter *et al*., 1963)

Age	Formation	Lithology	Depositional Environment
Pliocene Pleistocene	Chad Formation	Clay, Sand	Continental
----------Unconformity----------			
Palaeocene (?)	Kerri-Kerri Formation	Coarse Sandstones, Clay stone, sandstones	Continental
----------Unconformity----------			
Maastrictian Campanian	Gombe Formation	Shale, Sandstones, Siltstone	Deltaic Estuarine
Santonian Turonian Coniacian	Fika Shale	Blue-Black Shales	Marine
Turonian	Gongila Formation	Sandstones, Shales	Marine Estuarine
Cenomanian	Bima Formation	Sandstones	Continental
.....Unconformity			
Crystalline Basement			

RESULT AND DISCUSSION

(A) PALYNOSTRATIGRAPHY

Eighty ditch cutting samples from Mbeji-1 well succession have been studied. Dinoflagellate cysts are recovered from several levels of the penetrated intervals. In general, dinocyst recovery is poor to moderate. The preservation is poor to moderate at best. Stratigraphic distribution of significant dinoflagellate cysts were analysed and Interpretation of this distribution from bottom to top has yielded five informal biozones ranging in age from Cenomanian to Maastrichtian (Table 2). The biozones are defined based on the use of the first and last occurrences of at least one species. The biozones are compared with those proposed by Oloto (1994), Williams (1977) and Williams and Bujak (2000).

(B) DINOFLAGELLATE CYST ZONES

(a) Biozone I- *Subtilisphaera inaffecta*

Reference section: 3360m-3720m. The base of this zone is the same as the base of the well (fig. 2). The species encountered in this zone are *Spiniferites ramosus and Subtilisphaera inaffecta.* The top of the zone is defined by the last downhole occurrence of *Odontochitina operculata, Polysphaeridium zoharyi and Xenascus ceratoides.*

(b) Biozone II- *Odontochitina operculata*

Reference section: 3000m-3360m. The base of this zone is the same as the top of zone I. Events at the top are the last downhole occurrence of *Coronifera oceanic, Spiniferites radiculata and Tanyosphaeridium regulare.* Species in this zone include *Odontochitina operculata, Polysphaeridium zoharyi and Xenascus ceratoides.*

(c)* Biozone III- *Coronifera oceanic

Reference section: 2900m-3000m. The base of this zone is the same as the top of zone II. The top of the zone is characterized by the last downhole occurrence of *Exochosphaeridium muelleri, Hystrichodinium dinocysta and Leiosphaeridia sp.* The forms in this zone include *Coronifera oceanic, Spiniferites radiculata, Tanyosphaeridium regulare and Canningia reticulate.*

(d)* Biozone IV- *Exochosphaeridium muelleri

Reference section: 2780m-2900m. The base of this zone is the same asn the top of zone III. The events at the top of the zone are the last downhole occurrence of *Hystrichodinium pulchrum and Cupaniedites reticularis.*

(e) Biozone V- *Hystrichodinium pulchrum*

Reference section: 1600m-2780m. The base of this zone is the same as the top of zone IV. While the top represent the top of the studied interval. The species recovered in this zone include *Hystrichodinium pulchrum, Cupaniedites reticularis, Dinogymnium euclaensis, Florentinia radiculata, Trichodinium magnum and Exochosphaeridium sp.*

Table 2: DINOFLAGELLATE CYST BIOZONATION OF MBEJI-1 WELL

PERIOD	AGE	FORMATION	DEPTH (M)	ZONE CODES	DINOCYST ZONES
CRETACEOUS	MAASTRICHTIAN	GOMBE	1600	V	Hystrichodinium pulchrum
	CAMPANIAN		1780		
	SANTONIAN	FIKA	1920	IV	Exochosphaeridium muelleri
			2780	III	Coronifera oceanic
	CONIACIAN		2900	II	Odontochitina operculata
	TURONIAN	GONGILA	3000		
	CENOMANIA		3360	I	Subtilisphaera inaffecta
			3500		
			3720		

(C) AGE OF BIOZONES

Palynological analyses of ditch cutting samples of Mbeji-1 exploration well has allowed the erection of five dinofllagellate cyst biozones. The erected dinoflagellate assemblage zones are compared with the zonation schemes defined by Williams (1977) and Williams and Bujak (2000). Assemblage zone I of Mbeji-1 well is assigned the age Cenomanian-Coniacian on the basis of recognized diagnostic dinocyst assemblages within the section 3720m-3360m which corresponds to the *Bacchidinium polypes*, *Surculosphaeridium longifurcatum* and *Callaioshaeridium asymmetricum /Oligosphaeridium pulcherimum* zones by Williams (1977) and Williams and Bujak (2000). The dinoflagellate assemblage zones II, III and IV of Mbeji-1 well all fall within the Santonian age. The occurrences of *Dinogymnium acuminatum* and *Coronifera oceanic* have been reported in Santonian sediment by Williams (1977) and this zone corresponds to the *Cordosphaeridium truncigerum* dinoflagellate zone of Williams and Bujak (2000) which is aged Santonian. Dinoflagellate assemblage zone-V of Mbeji-1 well fall within the Campanian-Maastrichtian age. *Exochosphaeridium phragmites, Dinogymnium euclaensis* and *Hystrichodinium pulchrum* have been reported in Campanian-Maastrichtian sediments by Umeji (2006) and Williams (1977) respectively. This zone corresponds to the *Odontochitina operculata* and *Dinogymnium euclaense* dinoflagellate zone defined by Williams (1977) and Williams and Bujak (2000) which is aged Campanian and Maastrichtian respectively.

CONCLUSION

The evaluation of dinoflagellate cyst recovered from Murshe-1well Central Chad Basin, North East Nigeria has allowed for the erection of five informal assemblage biozones ranging in age from Cenomanian to Maastricthian. The dinocyst recovery is poor to moderate and the preservation is poor to moderate at best. On the basis of recognized diagnostic dinoflagellate cyst assemblages within the various sections studied, Cenomanian-Coniacian age was assigned to biozone I, Santonian age to biozones II, III and VI, and Campanian-Maastrichtian for biozone V.

REFERENCES

[1]. Antolinez, H.J. and Oboh-Ikuenobe, F.E. (2007). New Species of Dinoflagellate Cysts from the

[2]. Paleocene of the Anambra Basin, Southeastern Nigeria. *Palynology*, **31**: 53-62.

[3]. Asadu, A.N. and Lucas, F. A. (2006). A Dinoflagellate Cyst Biozonation Framework for Maastrichtian- Lutetian Succession of Benin-1 well, OPL 205, Western Anambra Basin Flank, Southern, Nigeria. *Nigerian Association of Petroluem Explorationists Bulletin,* **19(1):**1-14.

[4]. Avbovbo, A. A.; Ayoola, E. O. and Osahon, G. A. (1986). Depositional and Structure Styles in Chad Basin of Northeastern Nigeria. AAPG Bull. Vol.70, No.12, pp.1787-1798.

[5]. Bankole, S.I., Shrank, E., Erdtmann, B. D., and Akande, S.O.(2006). Palynostratigraphic Age and Paleoenvironments of the newly exposed section of the Oshosun Formation in the Sagamu Quarry, Dahomey Basin, Southwestern, Nigeria. *Nigerian Association of Petroluem Explorationists Bulletin,* 19(1):25-34.

[6]. Barber, W. (1965). Pressure water in the Chad Formation of Bornu and Dikwa Emirates, North - Eastern Nigeria, Geol Surv. Of Nigeria, Bull. 35, (1965), Pub. The Ciswick press, New Southwest, London n-11.

[7]. Burke, K. (1976). The Chad Basin: An inactive intra-continental basin. Tectonophysics, Vol.36, pp. 197-206.

[8]. Carter, J.O., Barber, W., Tait, E. A. and Jones, G. P. (1963). The Geology of Parts of Adamawa, Bauchi and Bornu Provinces in Northeastern Nigeria. Geol. Survey. Nigeria Bull., Vol.30, pp. 1-108.

[9]. Durugbo, E. U., Ogundipe, O. T. and Ulu, O. K.(2011). Preliminary Reports on Middle Miocene – Early Pleistocene Dinoflagellate Cysts from the Western Niger Delta, Nigeria. *Ozean Journal of Applied Sciences* 4(4), 373-394

[10]. Edet, J.J. and Nyong, E.E. (1994). Palynostratigraphy of Nkporo Shale Exposures (Late Campanian-Maastrichtian) on the Calabar Flank, SE Nigeria. *Review of Palaeobotany and Palynology*, 80(1-2): 131-147.

[11]. Evans, R. (1978). Origin and Significance of Evaporite Basins around Atlantic Margin.

[12]. Amer. Assoc. Petrol. Geol. Bull. , Vol. 62, pp. 223-234.

[13]. Lawal, O. and Moullade, M. (1986). Palynological biostratigraphy of Creatceous sediments in the Upper Benue Basin, N.E. Nigeria (1). *Revue Micropaleontologe*, 29:61-83.

[14]. Lucas, F. A and Ishiekwene, E. (2010). Dinoflagellate Cyst Biozonation for Late Cretaceous–Tertiary Succession of Gbekebo-1 Well, Benin Flank, Anambra Basin, Nigeria. *World Journal of Applied Science and Technology Vol.2. No. 2: 289 - 295*

[15]. Matheis, G. (1976). Short review of the Geology of the Chad Basin in Nigeria.In C. A. Kogbe (ed.): Geology of Nigeria. Eliazabeth Publishing Company Lagos, pp.120 – 150.

[16]. Oboh, F.E. (1992). Middle Miocene Palaeoenvironments of the Niger Delta. *Palaeogeography, Palaeoclimatology, Palaeoecology,* 92:55-84.

[17]. Ojo, O. J. and Akande, S. O. (2006). Sedimentological and Palynological Studies of the Patti Formation, Southeastern Bida Basin, Nigeria:Implications for Paleoenvironments and Paleogeography. *Nigerian Association of Petroluem Explorationists Bulletin,* 19(1):61-77.

[18]. Oloto, I.N. (1989). Maastrichtian Dinoflagellate Cyst Assemblage from the Nkporo Shale on the Benin flank of the Niger Delta. *Review of Palaeobotany and Palynology*, 57:173-186.

[19]. Oloto, I. N. (1994). Nigerian Maastrichtian to Miocene Dinoflagellate and Miospore

[20]. Biozonation-A summary. Journal of Mining and Geoscience Society (NMGS). Vol. 30(4), pp. 61-73.

[21]. Petters, S. W. (1978). Maastrichtian-Paleocene foraminifera from NW Nigeria and their Paleogeography. Acta, Paleont. Polonica, Vol. 23, pp.131-152.

[22]. Petters, S. W. (1979d). West African Cratonic Stratigraphic Sequence. Geology Vol. 7, pp. 528 – 531.

[23]. Petters, S. W. (1981). Stratigraphy of Chad and Lullemmenden Basins (West Africa). Eclogae Geol. Helv. , Vol. 74 (No.1), pp. 139-159.

[24]. Reading, H. G. (1982). Sedimentary Basins and Global Tectonics Proceedings of the Geological Association, Vol. 93, pp. 321-350.

[25]. Umeji, O. P. (2006). Palynological Evidence for the Turonian/Campanian boundary between the Abakaliki and the Anambra Basins, as exposed at Leru along the Enugu-Port Harcourt Expressway, Southeastern Nigeria. Journal of Mining and Geology Vol. 42(2), pp.141-155.

[26]. United States Geological Survey (2010). Assessment of Undiscovered Oil and Gas Resources of the Chad Basin Province, North-Central Africa. Fact Sheet 2010–3096

PLATE 1

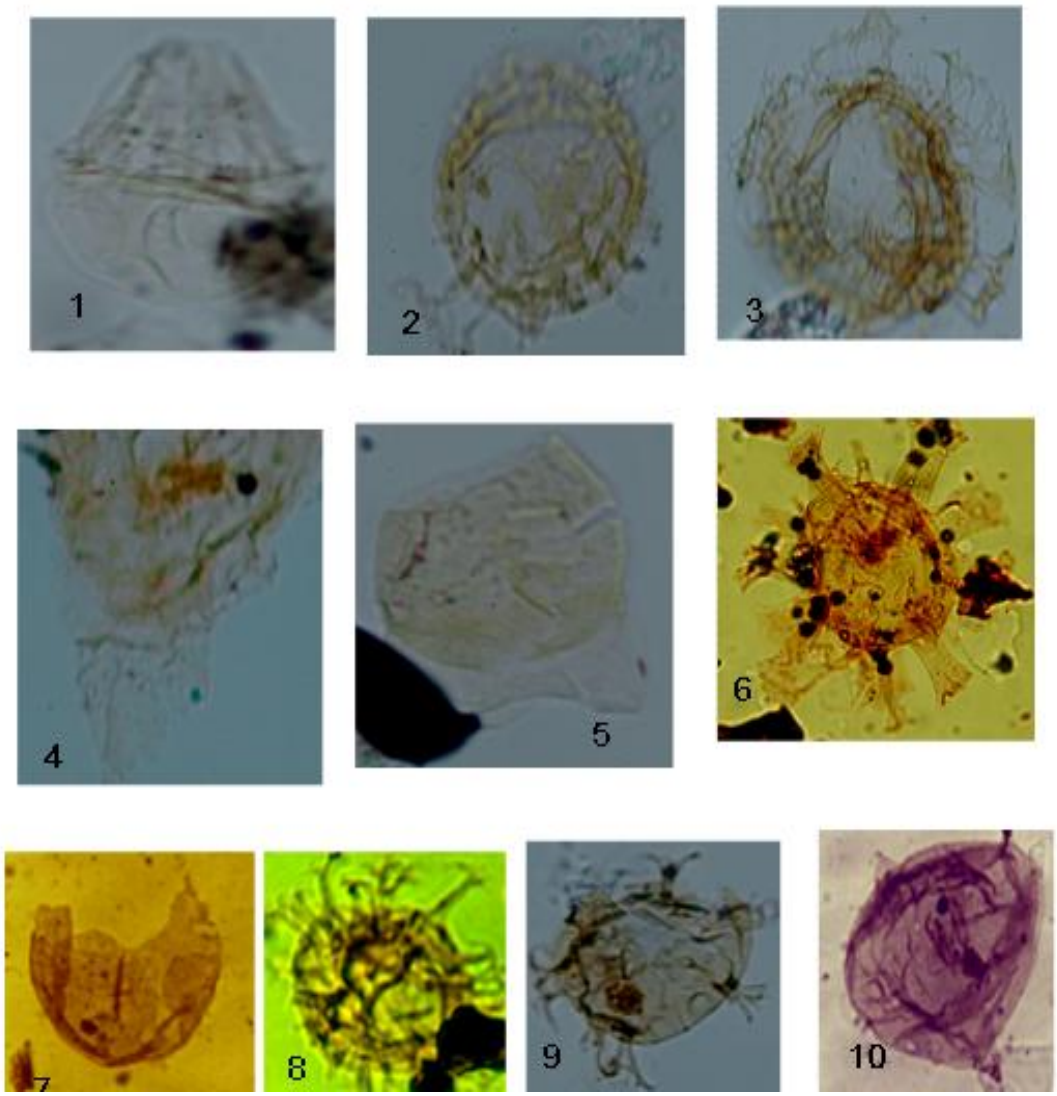

Plate 1: Photomicrograph of the Dinoflagellate cysts Mbeji 1 well, Chad Basin

1. *Dinogymnium acuminatum,*

2. *Indeterminate Dinoflagellate cyst*

3. *Nematosphaeropsis sp.*

4. *Odontochitina operculata,*

5. *Sutilisphaera inaffecta*

6. *Kallosphaeridium sp.*

7. *Canningia acuminate*,

8. *Spiniferites ramosus*

9. *Oligosphaeridium complex*

10. *Senegalinium bicavatum*

PLATE 2

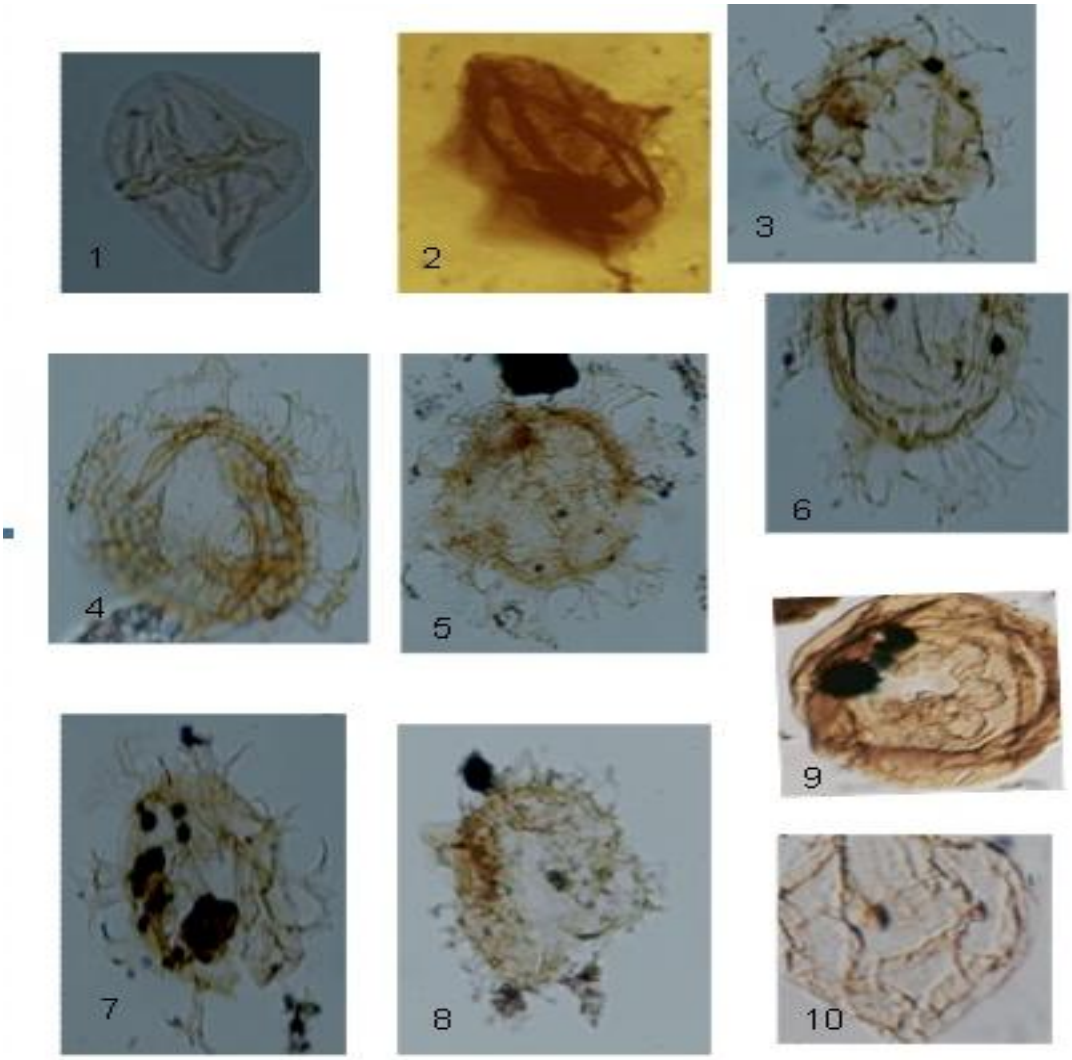

Plate 2: Photomicrograph of the Dinoflagellate cysts Mbeji 1 well, Chad Basin

1. *Dinogymnium euclaensis***,**

2. *Senegalinium laevigatum***,**

3. *Oligosphaeridium cf. porosum*

4. *Hystrichosphaerina turonica* ,

5. *Heterosphaeridium conjonctum*,

6. *Oligosphaeridium complex*

7. *Oligosphaeridium pulcherrimum* ,

8. *Palaeohystrichophora infusorioides,*

9. *Leiosphaeridia sp.*

10. *Gonyaulacacysta cretacea*

PLATE 3

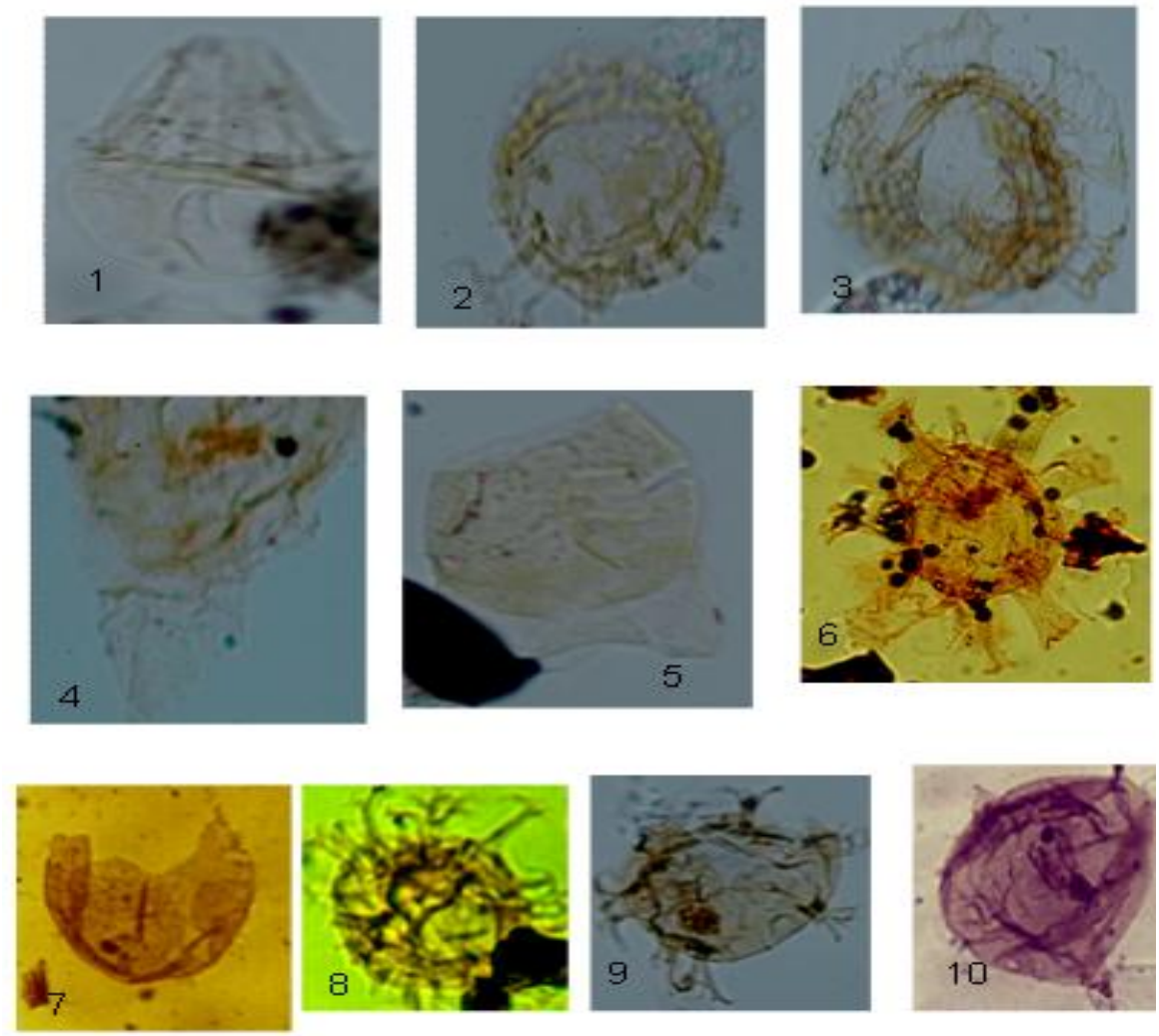

Plate 3: Photomicrograph of the Dinoflagellate cysts Mbeji 1 well, Chad Basin

1. *Dinogymnium acuminatum,*

2*. Indeterminate Dinoflagellate cyst,*

3. *Nematosphaeropsis sp.*

4. *Odontochitina operculata,*

5. *Sutilisphaera inaffecta,*

6. *Kallosphaeridium sp.*

7*. Canningia acuminate,*

8*. Spiniferites ramosus,*

9*. Oligosphaeridium complex*

10*. Senegalinium bicavatum*