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Dinoflagellate Cyst Biozonation for Upper Cretaceous Succession of Kinasar-1 Well, Central Chad Basin, North East Nigeria

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ABSTRACT

The Late Cretaceous succession penetrated by Kinasar-1 well in the Central Chad Basin, North East Nigeria was investigated for its palynological content (dinoflagellate Cyst). This investigation produced biostratigraphically significant dinoflagellate cyst species recovered from interval 1000m – 4700m. On the basis of the stratigraphic distribution of these dinocysts, five informal dinoflagellate cyst assemblage zones from the Cenomanian to Maastrichtian are erected. The zones in stratigraphically ascending order are as follows*: Leiosphaeridia sp* (Zone I), *Heterosphaeridium conjunctum* (Zone II), *Oligosphaeridium poculum* (Zone III), *Dinopterygium cladoides* (Zone IV) and *Deflandrea denticulata* (Zone V). The ages of these zones based on stratigraphic positions and series of first occurrences of key species are: Cenomanian-Santonian (Zone I), Campanian (Zones II and III) and Maastrichtian (Zone IV and V).

Keywords: *Dinoflagellate, Palynology, Chad Basin,, Nigeria, Cretaceous*

I. INTRODUCTION

The erection of the dinoflagellate cyst biozones of Kinasar-1 well is based essentially on the diagnostic dinoflagellate cyst assemblages observed within the various sections of the studied interval of the well. Kinasar-1 well is located in the Nigerian sector of 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 (Fig. 1).

Previously, there has been no detailed dinoflagellate studies for the Nigerian sector of the Chad Basin when compared to the numerous research 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 [8]**.** Late Cretaceous –Tertiary Succession Of Gbekebo-1 Well,Benin Flank, Anambra Basin [12], Middle Miocene Niger Delta [14], Maastrichtian section of the Nkporo shale of the Gbekebo-1 Benin Flank of the Niger Delta [16], the Cretaceous Upper Benue Trough [11], the Nkporo shale on the Calabar Flank of South Eastern Nigeria [9], the Maastrichtian-Lutenian succession of the Benin-1 well from the Western Anambra Basin flank of Southern Nigeria [2], the Paleocene - Lowermost Eocene successions in the Alo-1 well from the Anambra Basin, Southeast Nigeria [1], the Oshosun Formation in the Sagamu quarry, Dahomey Basin, South-Western Nigeria [4], and the Upper Cretaceous Patti Formation, Southeastern Bida Basin Nigeria [15].

II. RESEARCH OBJECTIVES

The purpose of carrying out this study is because of the lack of dinoflagellate studies in the Chad Basin as revealed above. It is the intention of the researchers to therefore 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.

III. GEOLOGICAL SETTING OF THE STUDY AREA

The Chad Basin is the largest intracratonic basin in Africa 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.

In Nigeria, only 10 percent of South-West corner of the basin is situated in the North-East part of the country, 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. The Chad Basin resulted from plate divergence along the West Africa continental margin [18,19]. 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 [10]. Initial deposition of non-marine clastics in Chad Basin probably resulted from reversal of paleo-drainage due to doming and rifting in the Cretaceous [18]. 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 Post Paleocene continental sedimentation in the Chad Basin had been sustained by renewed uplift of parts of the African continent [6].

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. 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 [3]. The transgression which began in the Turonian continued up to the Senonian during which the Fika shale was deposited [13]. 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.

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 .The Kerri-Kerri Formation was deposited unconformably on the eroded surface of the Gombe Sandstone in the Paleocene .

Finally, an unconformable Pleistocene deposit of the Chad Formation was deposited on the Kerri-Kerri Formation [7,13]. The Chad Formation is today covered in some part by recent alluvial (Table 1).

IV. MATERIALS AND METHODS

A total of one hundred and seventy ditch cuttings samples from 500ft – 3920ft depth intervals of Murshe-1 well were collected and sampled (Fig.1). 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 using a microscope connected to computer in which snapshot were taken.
(See Plate 1, 2 and 3)

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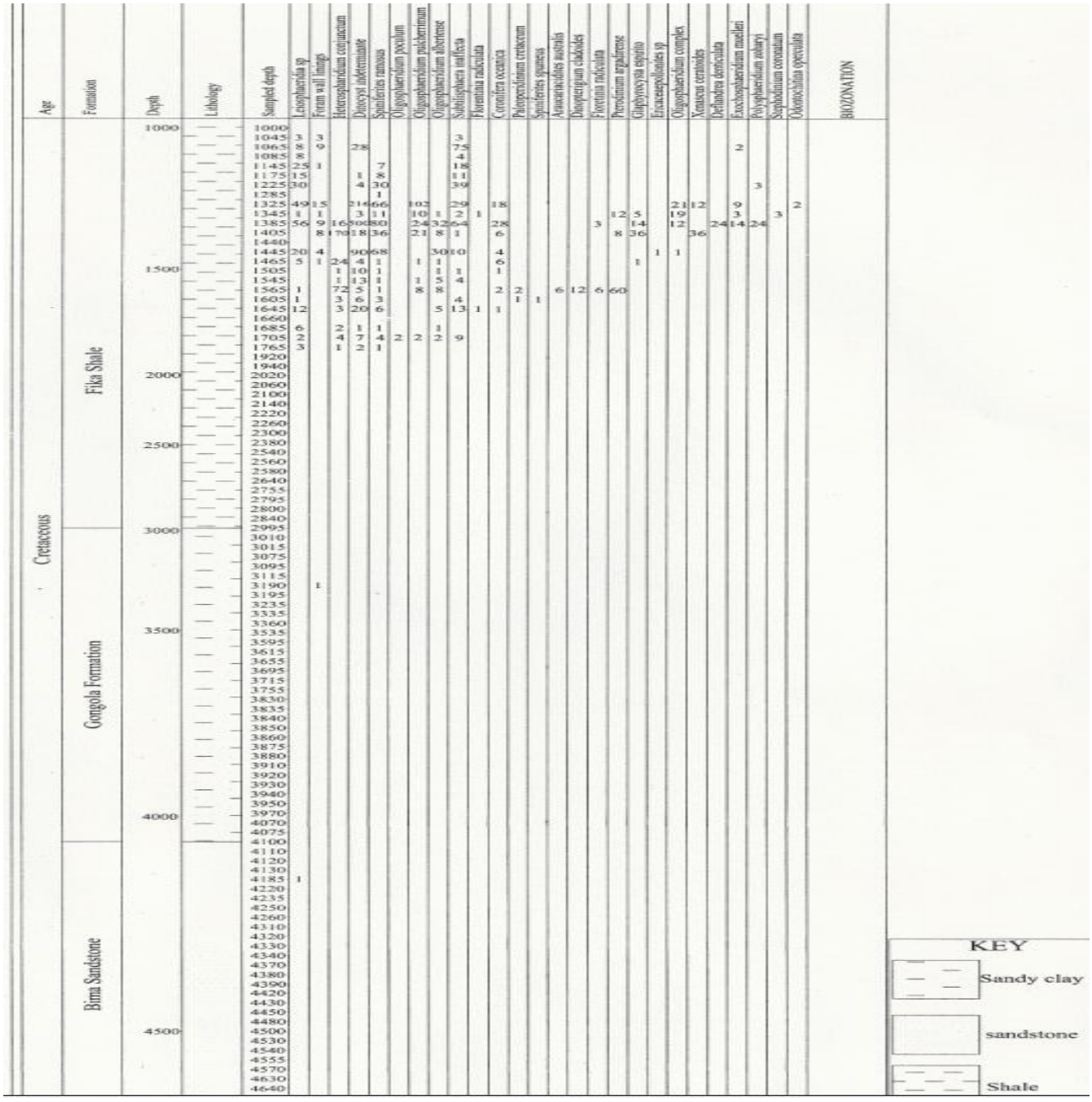

Fig. 1 Dinoflagellate Cyst Range Chart of Kinasar-1 Well

PLATE 1

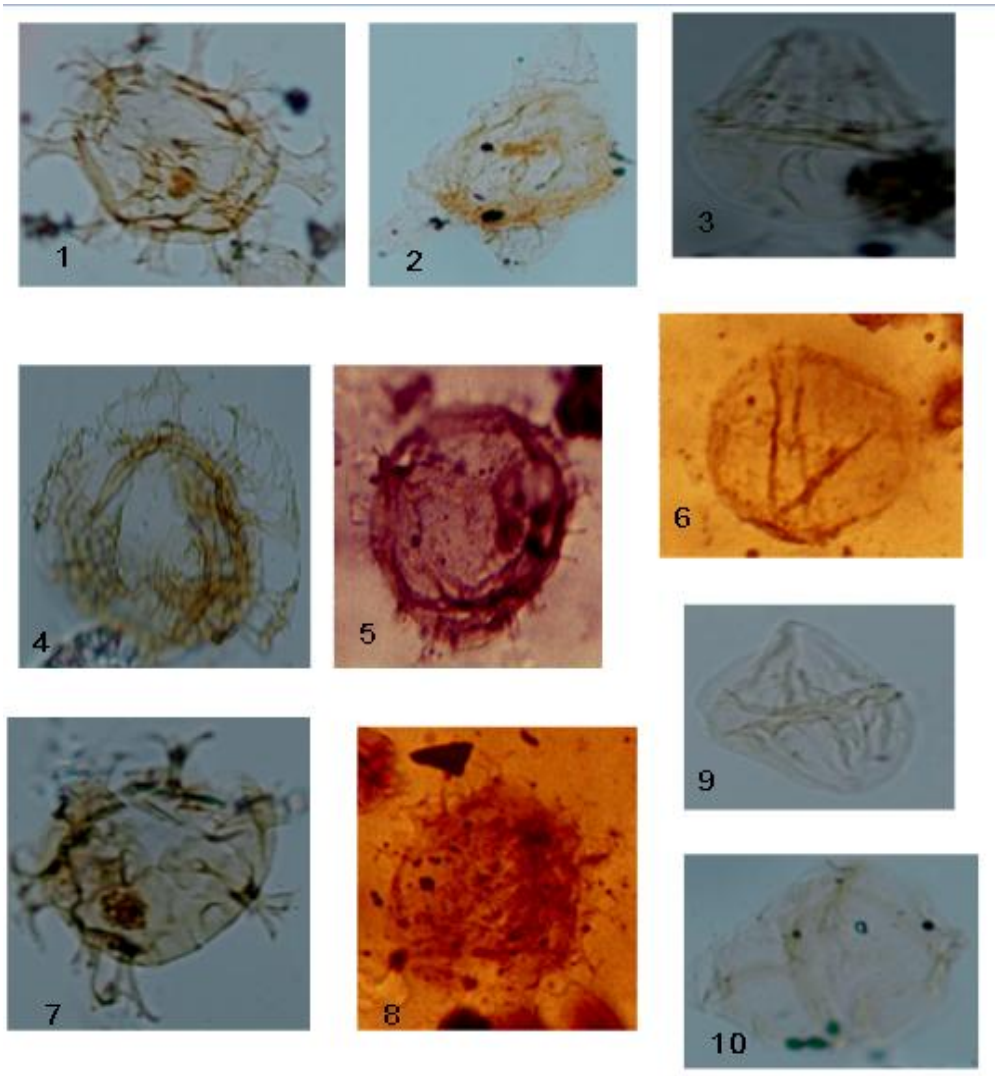

Plate 1:Photomicrograph of the Palynomorphs(dinoflagellate cysts) in the Study area

1.Oligosphaeridium pulcherrimum , **2.** Xenascus ceratoides, **3.** Dinogymnium acuminatum
4. Hystrichosphaerina turonica , **5.** Polysphaeridium zoharyi, **6.** Gonyaulacacysta cretacea

7. Oligosphaeridium complex , **8.**Spiniferites ramosus, **9.** Dinogymnium euclaensis

10. Subtilisphaera inaffecta.

PLATE 2

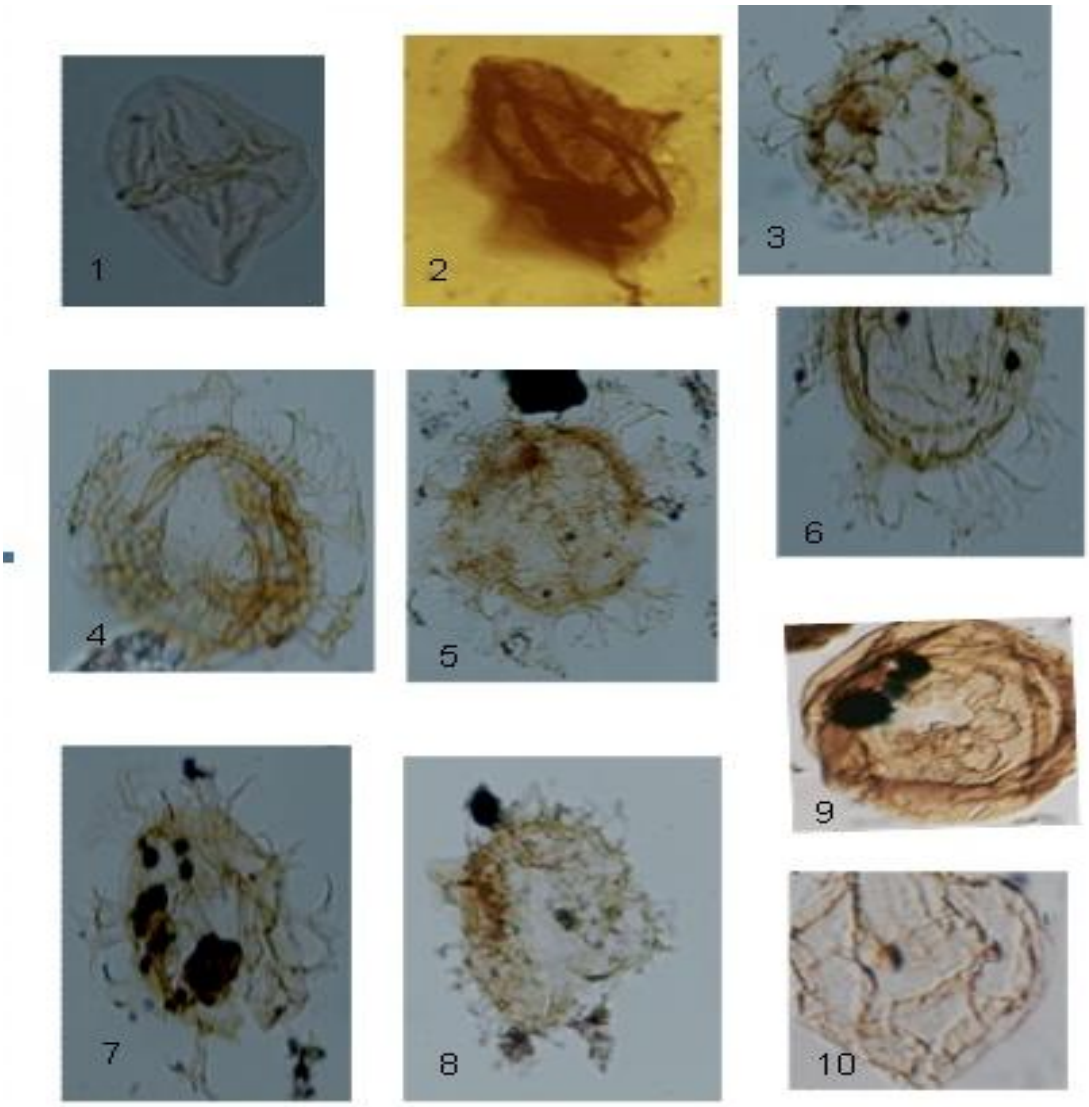

Plate 2: Photomicrograph of the Palynomorphs(dinoflagellate cysts) in the Study area

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

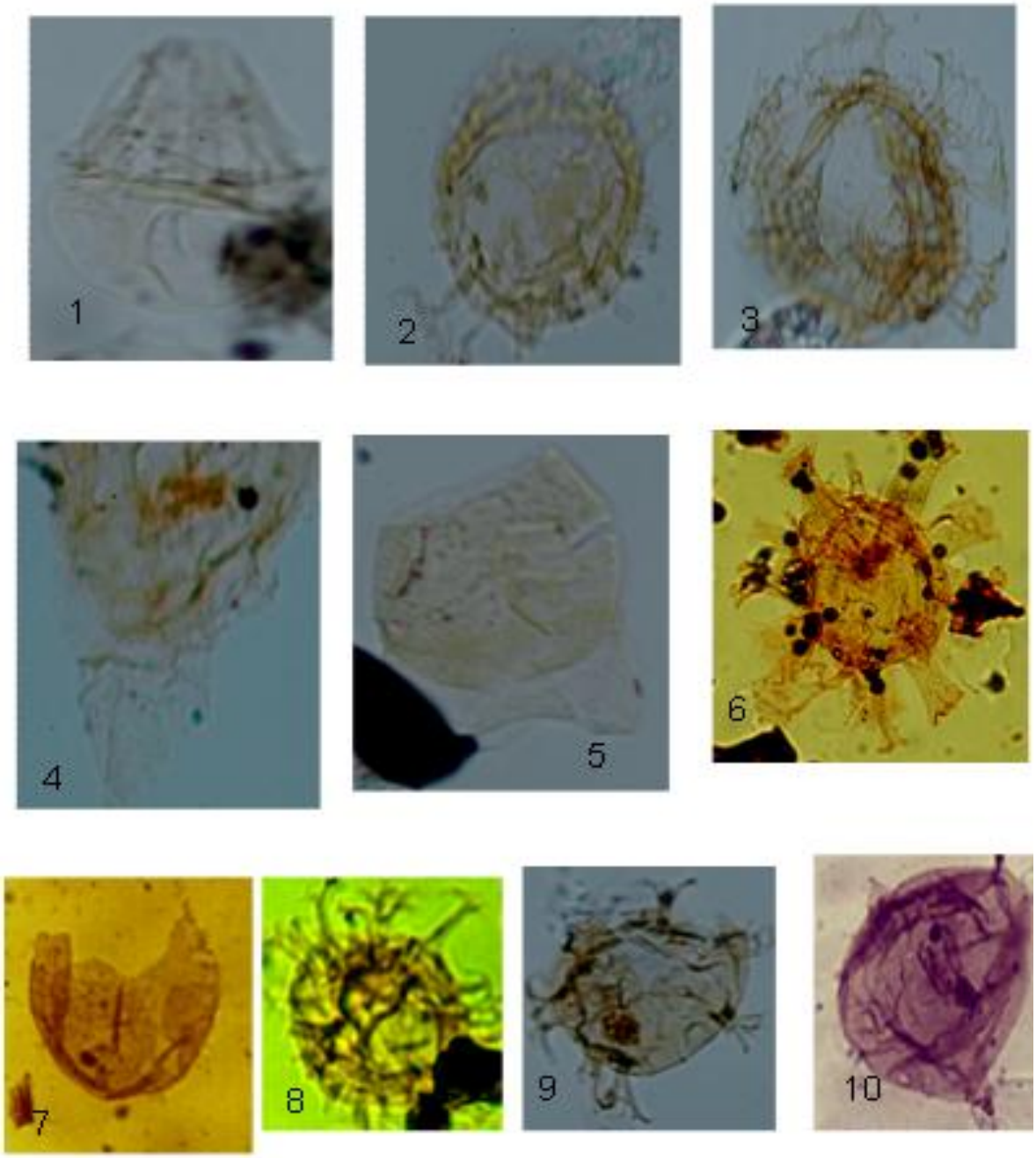

PLATE 3: Photomicrograph of the Palynomorphs(dinoflagellate cysts) in the Study area

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.*

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			

V. RESULT AND DISCUSSION

(A) Palynostratigraphy

Stratigraphic distribution of significant dinoflagellate cysts are displayed in Fig. 2. Interpretation of this distribution from bottom to top has yielded five informal biozones ranging in age from Cenomanian to Maastrichtian (Table 2). In general, dinocyst recovery is poor with most of the forms recovered from the upper most intervals and preservation is poor to moderate at best. 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 [16,17], Williams [20] and Williams and Bujak [21].

(B) Dinoflagellate Cyst Zones

(a) Biozone I- *Trichodinium magnum*

Reference section: 3928m-2820m.

The base of this zone is the same as the base of the well (fig.2). The species making their first appearance within this zone are *Leiosphaeridia sp, Protoperidinium subinerme, Trichodinium magnum, Gardodinium cf. elongatum, Subtilisphaeria inaffecta and Senegalinium laevigatum.*The top of this zone is defined by the last downhole occurrence of *Batiacasphaera baticulata, Nelsoniella aceras and Trichodinium delicatum.*

(b) Biozone I- *Leiosphaeridia sp*

Reference section: 4659m-21765m.

The base of this zone is the base of the well (fig. 2). The species recorded in this zone is *Leiosphaeridia sp.* The top of the zone is defined by the last downhole occurrence of *Heterosphaeridium conjunctum* and *Spiniferites ramosus.*

(c) Biozone II- *Heterosphaeridium conjunctum*

Reference section: 1765m-1705m.

The base of this zone is the same as the top of zone I. Events at the top are the last downhole occurrence of *Oligosphaeridium poculum, Oligosphaeridium pulcherrimum, Oligosphaeridium albertense and Subtilisphaera inaffecta.*

(d) Biozone III- *Oligosphaeridium poculum*

Reference section: 1705m-1565m.

The base of this zone is the same as the top of zone II. The top of the zone is defined by the last downhole occurrence of *Dinopterygium cladoides, Florentina radiculata and Pterodinium argadirense.* The species in the zone include *Oligosphaeridium poculum, Oligosphaeridium pulcherrimum, Oligosphaeridium albertense, Subtilisphaera inaffecta, Coronifera oceanic, Paleoperidinium cretaceum and Spiniferites spumeus*.

(e) Biozone IV- *Dinopterygium cladoides*

Reference section: 1565m-1385m.

The base of this zone is the same as the top of zone III. The top is characterized by the last downhole occurrence of *Deflandrea denticulata, Exochosphaeridium muelleri and Polysphaeridium zoharyi.*Species in the zone include *Dinopterygium cladoides, Florentina radiculata, Pterodinium argadirense, Glaphyrocysta espirito, Oligosphaeridium complex and Xenascus ceratoides.*

(f) Biozone V- *Deflandrea denticulata*

Reference section: 1385m-1000m

The base of the zone is the same as the top of zone IV. While the top of the zone represents the top of the studied interval. Species recorded within this zone include Deflandrea *denticulata, Exochosphaeridium muelleri, Polysphaeridium zoharyi, Stephodinium coronatum* and *Odontochitina operculata.*

(C) Age of Biozones

Palynological analyses of ditch cutting samples of Kinasar-1 exploration well has allowed the erection of five dinoflagellate cyst biozones. The erected dinoflagellate assemblage zones are compared with the zonation schemes defined by Williams [20] and Williams and Bujak [21]. Assemblage zone I of Kinasar-1 well is dated Cenomanian-Santonian as a result of the stratigraphic position of the dinoflagellate specie which corresponds to the *Bacchidinium polypes, Surculosphaeridiu longifurcatum, Callaioshaeridium asymmetricum /Oligosphaeridium pulcherimum* and *Cordosphaeridium truncigerum* zones by Williams [20] and Williams and Bujak [21]. Dinoflagellate assemblage zones II and III fall within the Campanian age. *Exochosphaeridium phragmites, Dinogymnium euclaensis* and *Hystrichodinium pulchrum* have been reported in Campanian-Maastrichtian sediments by Williams [20]. This zone corresponds to the *Odontochitina operculata* dinoflagellate zone defined by Williams [20] and Williams and Bujak [21] which is aged Campanian. Assemblage zones IV and V fall within the Maastrichtian age. The occurrence of *Spiniferites ramosus, Deflandrea denticulata* and *Dinopterygium cladoides* have been reported in Maastrictian sediments by Anthonia and Lucas [2],. This zone corresponds to the *Dinogymnium euclaense* zone defined by Williams [20] and Williams and Bujak [21] which is aged Maastrichtian.

VI. CONCLUSION

The evaluation of dinoflagellate cyst recovered from Kinasar-1well Chad Basin, North East Nigeria has allowed for the erection of five informal assemblage biozones ranging in age from Cenomanian to

Maastricthian. On the basis of recognized diagnostic dinoflagellate cyst assemblages within the various sections studied, Cenomanian-Santonian age was assigned to biozone I, Campanian age to biozones II and III and Maastrichtian for biozones IV and V.

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