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# Dinoflagellate cyst biozonation of upper cretaceous succession of Murshe-1 Well, Central Chad Basin, North East Nigeria

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## ABSTRACT

*Palynological (Dinoflagellate Cyst) analyses of the Upper Creataceous succession in the Central Chad Basin, North East Nigeria was investigated. Thirty –three biostratigraphically significant dinoflagellate cyst species were recovered from interval 800m – 3928m of Murshe-1 Well. Based on the stratigraphic distribution (i.e. FAD and LAD) of these bioevents, six informal Dinoflagellate cyst assemblage zones from the Cenomanian to Maastrichtian are proposed.The zones in stratigraphically ascending order are as follows: Trichodinium magnum (Zone I), Batiacasphaera baticulata (Zone II), Cometodinium whitei (Zone III), Areoligera senonensis (Zone IV), Andalusiella laevigatum (Zone V) and Exchosphaeridium phragmites (Zone VI).The ages of these zones based on stratigraphic positions and series of first occurrences of key species are: Cenomanian (Zone I), Turonian (Zone II), Turonian (Zone III), Coniacian (Zone IV), Santonian (Zone V) and Campanian-Maastrichtian (Zone VI).*

**Keywords:** Chad Basin, Palynology, Diniflagellate, Cretaceous

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## INTRODUCTION

The erection of the dinoflagellate cyst biozones of Murshe-1 well is based essentially on the diagnostic dinoflagellate cyst assemblages observed within the various sections of the studied interval. Murshe -1 well, is one of the twenty-three exploratory oil wells drilled by the Frontier Exploration Service of the Nigerian National Petroleum Corporation (FES-NNPC). It is located in the Nigerian sector of the Chad Basin in North East Nigeria (Fig. 1). On the basis of the stratigraphic distribution of the recovered dinoflagellate cysts in the well, a palynological range chart suitable for erection of the six dinoflagellate cyst biozones was generated (Fig. 3).

Before now, 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 [1], 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].

**AIM AND OBJECTIVES OF THIS RESEARCH WORK**

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

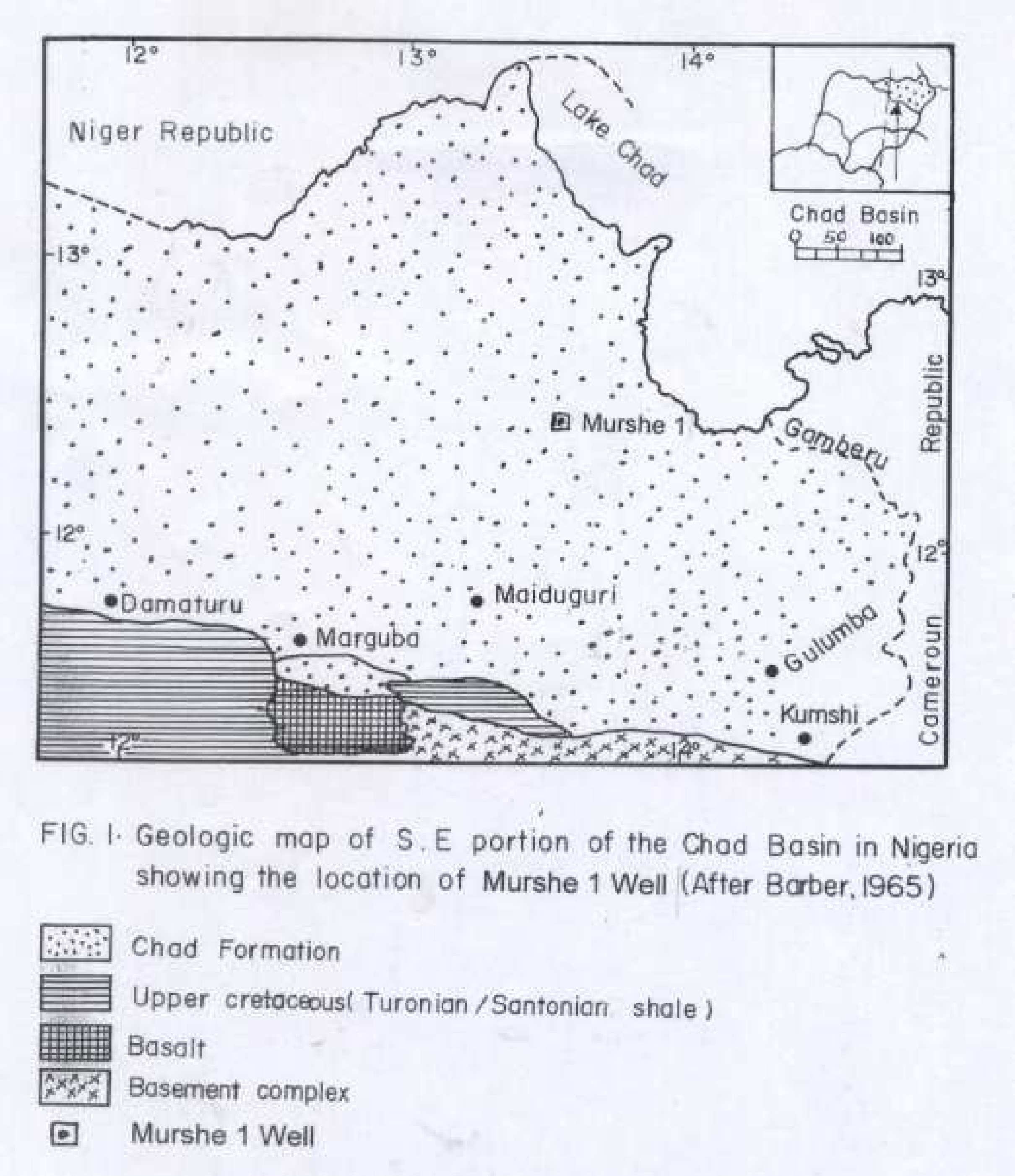


**FIG. 1 Location map showing the Chad Basin and Murshe-1 well**

**GEOLOGY 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 [5,19]

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.

The Chad Basin resulted from plate divergence along the West Africa continental margin. 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 [18].

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. 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 (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 [3]. 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[13].

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. The Chad Formation is today covered in some part by recent alluvial

## MATERIAL 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.3). 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 used for palynological microscopic study.The Slide were properly labelled and observed under research microscope through which snapshot was taken. **See Plate 1 and 2** for the photomicrograph of the palynomorphs.

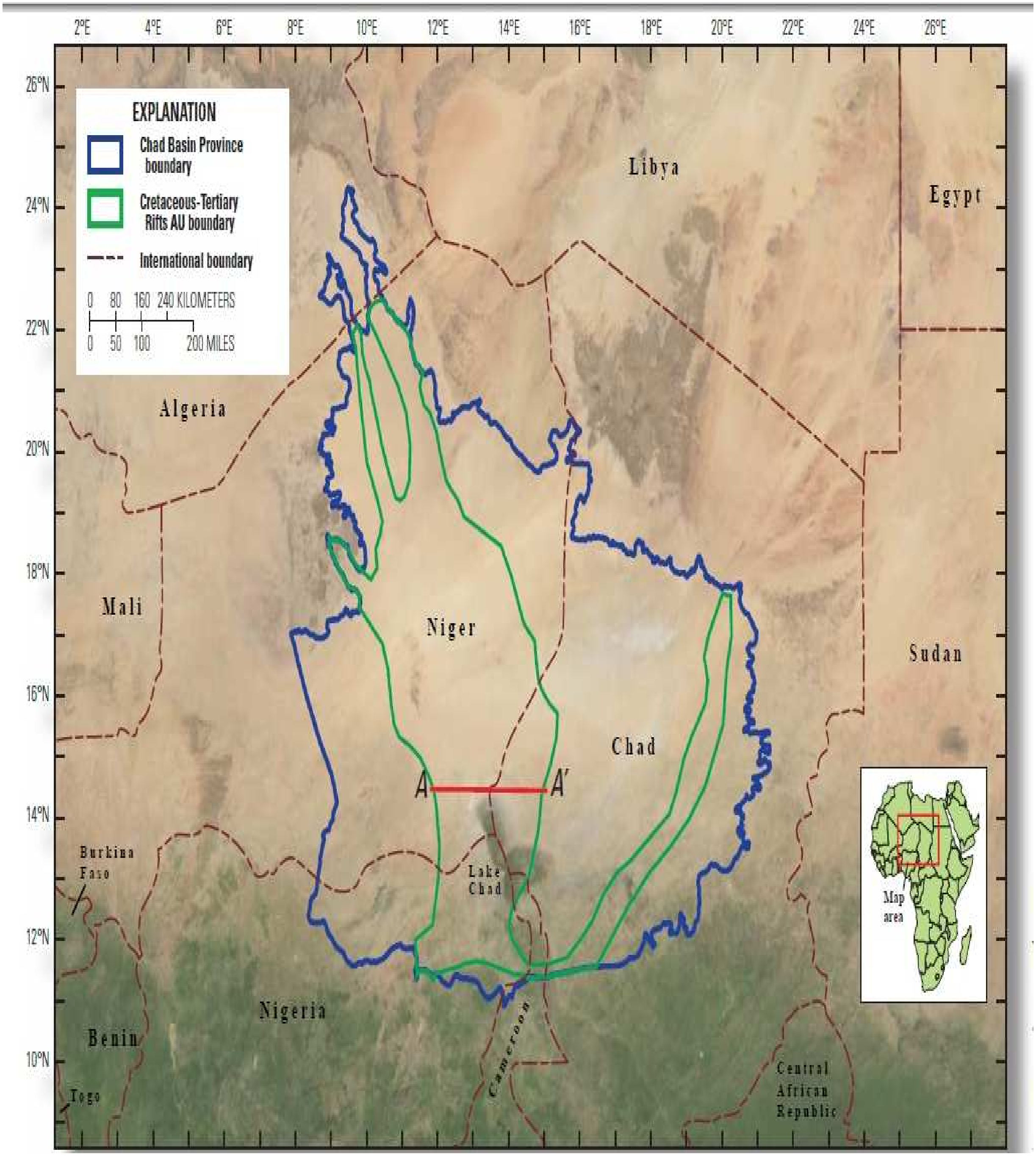


**FIG. 2 Map showing the Extent of Chad Basin (adapted from USGS, 2010)**

## RESULTS AND DISCUSSION

### (A) PALYNOSTRATIGRAPHY

Stratigraphic distribution of significant dinoflagellate cysts are displayed in Fig. 3. Interpretation of this distribution from bottom to top has yielded six informal biozones ranging in age from Cenomanian to Maastrichtian (Table 1). 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 [17], and Williams [21] .

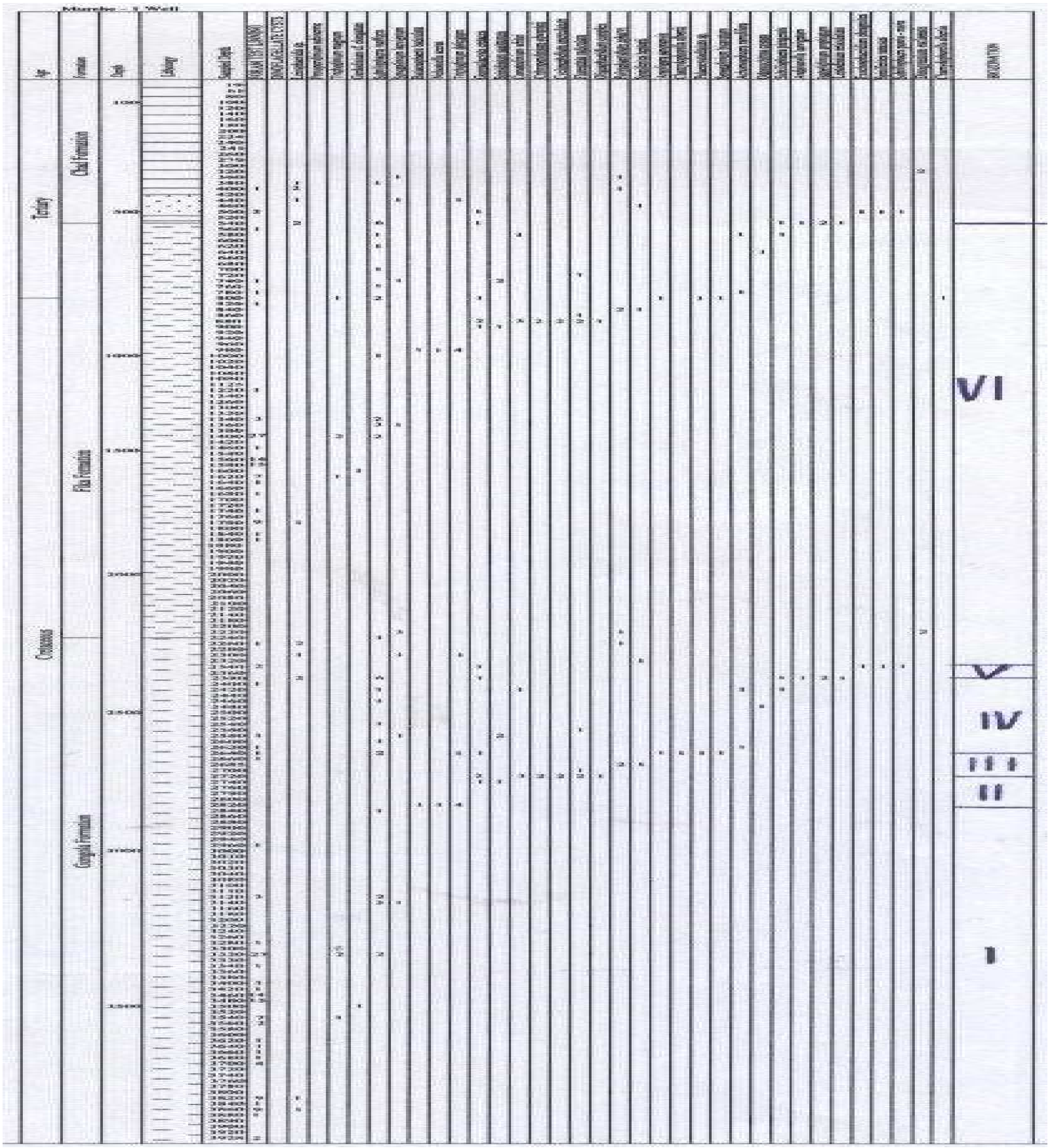

**FIG.3. Dinoflagellate Cyst Range Chart of Murshe-1 Well**

**(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.3). 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 II- *Batiacasphaera baticulata***
Reference section: 2820m-2720m
The base of this zone is the same as the top of zone I. The top events are characterized by the last downhole occurrence of *Cometodinium whitei, Cribroperidinium edwardsii, Cyclonephelium operculatum, Florentinia radiculata and Oligosphaeridium complex.* The species making their first appearance include *Batiacasphaera baticulata, Nelsoniella aceras, Trichodinium delicatum, Gonyaulacysta cretacea and Spinidinium sagittutum.*

**(c.) Biozone III- *Cometodinium whitei***
Reference section: 2720m-2640m
The base of this zone is the same as the top of zone II. The top of this zone is defined by the last downhole occurrence of *Areoligera senonensis, Chlamydophorella albertii, Palaeocystodinium sp and Senegalinium bicavatum.* The forms in this zone include *Cometodinium whitei, Cribroperidinium edwardsii, Cyclonephelium operculatum, Florentinia radiculata, Oligosphaeridium complex, Polysphaeridium zoharyi and Spiniferites bentorii.*

**(d.) Biozone IV- *Areoligera senonensis***
Reference section: 2640m-2380m
The base of this zone is the same as the top of zone III. The top is characterized by the last downhole occurrence of *Andalusiella laevigatum, Isabelidium amphiatum and Leptodinium reticulatum.* Species encountered include *Areoligera senonensis, Chlamydophorella albertii, Palaeocystodinium sp, Senegalinium bicavatum, Achemosphaera sp, Odontochitina costata and Subtilisphaera pimaensis.*

**Table 1: DINOFLAGELLATE CYST BIOZONATION OF MURSHE-1 WELL**

<table>
<tr><th>PERIOD</th><th>AGE</th><th>FORMATION</th><th>DINOCYST ZONE</th><th>DINOCYST ZONATION ( OLOTO, 1994)</th><th>DINOCYST ZONE (WILLIAMS, 1977, WILLIAMS AND BUJAK,2000</th></tr>
<tr><td rowspan="7">CRETACEOUS</td><td>MAASTRICHTIAN</td><td rowspan="2">GOMBE</td><td rowspan="2">Exochosphaeridium phragmites</td><td>Dinogymnium euclaensis</td><td>Dinogymnium euclaensis</td></tr>
<tr><td>CAMPANIAN</td><td></td><td>Odontochitina operculata</td></tr>
<tr><td>SANTONIAN</td><td rowspan="3">FIKA</td><td>Andalusiella laevigatum</td><td></td><td>Cordosphaeridium truncigerum</td></tr>
<tr><td>CONIACIAN</td><td>Areoligera senonensis</td><td></td><td>Callaioshaeridium asymmetricum/ Oligosphaeridium pulcherimum</td></tr>
<tr><td rowspan="2">TURONIAN</td><td>Cometodinium whitei</td><td></td><td rowspan="2">Surculosphaeridium longifurcatum</td></tr>
<tr><td rowspan="2">GONGILA</td><td>Batiacasphaera baticulata</td><td></td></tr>
<tr><td>CENOMANIAN</td><td>Trichodinium magnum</td><td></td><td>Bacchidinium polypes</td></tr>
</table>

**(e.) Biozone V- *Andalusiella laevigatum***
Reference section: 2380m-2340m
The base of this zone is the same as the top of zone IV. The top of the zone is defined by the last downhole occurrence of *Exochosphaeridium phragmites, spiniferites ramosus and Subtilisphaera pontis-maria.* Species recorded in the zone include *Andalusiella laevigatum, Isabelidium amphiatum and Leptodinium reticulatum.*

**(f). Biozone VI- *Exochosphaeridium phragmites***
Reference section: 2340m-540m
The base of this zone is the same as the top of zone V. While the top of the zone represent the top of the studied interval. Species encountered in this zone include *Exochosphaeridium phragmites, Spiniferites ramosus, Subtilisphaera pontis-maria, Dinogymnium euclaensis and Chlamydophorella albertii.*

**(C.) AGE OF BIOZONES**
Palynological analyses of ditch cutting samples of Murshe-1 exploratory well has allowed the erection of six dinofllagellate cyst biozones. The erected dinoflagellate assemblage zones are compared with the zonation schemes defined by Williams [21]. Cenomanian age was assigned to assemblage zone I on the basis of recognized diagnostic dinocyst assemblages within the section 3928m-2820m which corresponds to the *Bacchidinium polypes*

dinoflagellate zonation scheme by Williams [21] which is assigned the Cenomanian age. Assemblage zones II and III is aged Turonian. The occurrences of *Batiacasphaera baticulata* and *Cometodinium whitei* have been reported in the Turonian by Umeji [20] and Williams [21] respectively. This zone corresponds to the *Surculosphaeridium longifurcatum* dinoflagellate zone defined by Williams [21] which is aged Turonian. The dinoflagellate zone IV well corresponds to the *Callaioshaeridium asymmetricum/Oligosphaeridium pulcherimum* zone by Williams [21] which is aged Coniacian. The dinoflagellate assemblage zone V is dated Santonian age. The occurrences of *Dinogymnium acuminatum* and *Coronifera oceanic* have been reported in Santonian sediment by Williams [21] and this zone corresponds to the *Cordosphaeridium truncigerum* dinoflagellate zone of Williams and Bujak [21] which is aged Santonian. Dinoflagellate assemblage zone VI is assigned Campanian-Maastrichtian age. *Exochosphaeridium phragmites, Dinogymnium euclaensis* and *Hystrichodinium pulchrum* have been reported in Campanian-Maastrichtian sediments by Umeji [20] and Williams [21] respectively. This zone corresponds to the *Odontochitina operculata* and *Dinogymnium euclaense* dinoflagellate zone defined by Williams [21] which is aged Campanian and Maastrichtian respectively.

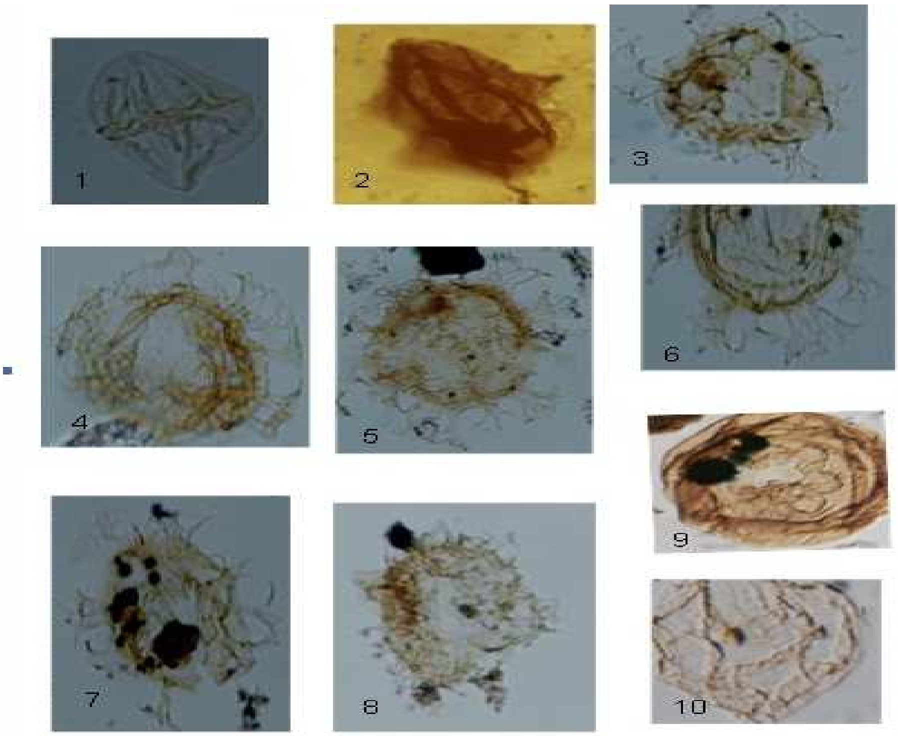


**Plate 1: Photomicrograph of the dinoflagellate cysts Mushe 1 well,Chad Basin**

*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*

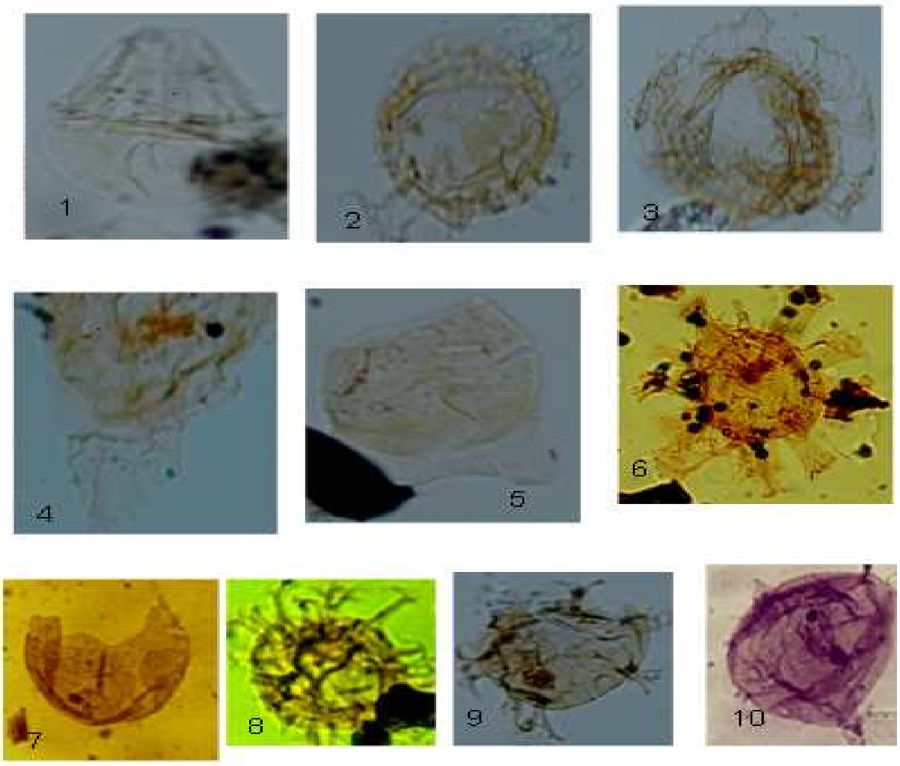


**Plate 2: Photomicrograph of the Dinoflagellate cysts Murshe 1 well, Chad Basin**

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*

## CONCLUSION

The evaluation of dinoflagellate cyst recovered from Murshe-1well Central Chad Basin, North East Nigeria has allowed for the erection of six 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 age was assigned to biozone I, Turonian to biozones II and III, Coniacian to biozone IV, Santonian for biozone V and Campano-Maastrichtian for biozone VI.

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