

# Palynological Study Of Igbomotoru - 1 Well, Central Coastal Niger Delta, Nigeria

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**Abstract:** The 127 samples consisting of 55 side wall and 72 ditch cutting samples from Igbomotoru-well in the Niger delta yielded some dinoflagellate cysts. Pollen/spores, foraminifera test linings, fungal spores, rare specimens of pyritized diatoms. The dinoflagellate cyst assemblages indicate an upper Miocene to Pleistocene age for the 11,542 feet thick deltaic complex. The samples yielded 30 dinocyst genera and 53 species. The pollen and spore components included 32 genera, 35 species and fungal spores. The deposits have been subdivided into beds of Upper Miocene, lower Pliocene and Upper Pliocene to Pleistocene age. The palynostratigraphic subdivisions observed consist of four zones. Zone 1 at the base with a dominance of *Spiniferites pseudofurcatus*, Zone 2 directly above, dominated by *Multispinula quanta*, Zone 3 dominated by *Chytrioeisplaeridium* sp and Zone 4 at the top dominated by *Sumatradinium hispidum*. The pollen and spore zonations consisted of *verrucatosporites usmensis* and *Megastriatites howardii* zones. Combined palynologic, maceral and sedimentological date indicate that deposition occurred close to shore in a marine environment that became progressively shallower upsection.

**Index Terms:** Palynology, Niger Delta, Biostratigraphy, Age, Zonation, Igbomotoru, palynomorphs.

## I. INTRODUCTION

Late Cenozoic sediments in the Niger delta have attracted the attention of micropaleontologists for decades, most especially in the oil companies. Published studies of foraminifera and pollen/spores are regional, and the worldwide biostratigraphic zonations based on both fossil groups have been used in the Niger delta. The lack of published studies concerning the late Cenozoic dinoflagellate cyst (dinocyst) biostratigraphy of the Niger delta contrasts sharply with the accumulated knowledge of calcareous microfossils and pollen/spores. The purpose of this study is to document the stratigraphic distribution of dinocysts in addition to other pollen and spores in the Igbomotoru-1 well from the upper Miocene through Pleistocene in the Niger delta. Also considered are palynostratigraphic zonation and paleoenvironmental implications of the palynomorphs assemblages.

**Previous Study** This investigation constitutes the first comprehensive Niger delta Neogene dinocysts. Biffi and Grignani (1984) defined morphological criteria for speciating the *Lejeunecysta* cysts from the Oligocene of the Niger delta in order to identify potential useful stratigraphic markers amongst this group, but did not elaborate on their biostratigraphic use and distribution. Pertinent Late Cenozoic dinocyst studies in areas outside the Niger delta include those from the Gulf of Mexico (Wren et al, 1986), Bering sea (Bujak 1984), British Isles (Reid, 1974,1977), Caribbean sea (Wall, 1967), Denmark (Piasecki, 1980), Northern Italy (Habib, 1971), Japan (Matsuoka, 1974, 1983, 1985), Eastern Mediterranean sea (Rossignol, 1964), North Atlantic Ocean (Brown and Downie, 1984; Costa and Downie, 1979; Edwards, 1984; Harland, 1979) and Spain (Jan du Chene, 1977).

**Geologic Setting** Large areas in the eastern part of the Niger delta downdip of the Abakaliki plunge and of the Calabar Flank show repeated periods of erosion and/or non-deposition during the Middle and Upper Eocene, whereas a large deltaic complex was deposited in the downdip Anambra Basin. These positive movements of blocks bounded by north-east south west and North-West, South-east trending faults, preceded the subsidence of the Oligocene and younger Niger Delta Basin along the north-

west, south-east fault trend (Niger Delta Hinge Line, Figure 3). The newly formed basin extends from the Benin Hinge line to the Cameroon volcanic range, crossing several of the previous main structural units. The sedimentary cycle of the basin was controlled by the tectonic phases and by epeirogenic movements which resulted in major transgressive – regressive cycles. These cycles display a remarkable constant depositional pattern: during the transgressive phases, shales, locally calcareous, were deposited in the structural depressions whereas shoal carbonates developed on submerged structural highs (platforms) protected from Clastic influx. The regressive phases are characterized by extensive deltaic sediments filling the subsiding basins and by predominantly fine clastics (shallow marine shales) deposited over the structural highs (Murat, 1967). During Miocene times there was widespread emergence of the coastline with the re-establishment of conditions favourable for the deposition of fresh water sediments, carbonaceous beds and lignites. The sands, lignites and occasional clay streaks of the Ogwashi – Asaba Formation are in turn overlain by the yellow and white continental sands and gravels of the Miocene to Recent Benin Formation. The lateral transition, which was shown to exist in the deposits of the present Niger Delta, reflects a strong progression of the delta since the Lower Eocene (Frank/ and Cordry, 1967).

## II. METHODOLOGY

**Sample Material and Procedures** The 127 samples from Igbomotoru-1 well, drilled on the central part of the Niger Delta were studied. They are composed of 55 sidewall and 72 ditch cutting samples sampled between an interval of 2558 feet and 14100 feet. The samples varied from silty shale, lignite/carbonaceous shales and sandstone and gravel. The location of the well is on Central part of the Niger Delta. Preparation of the palynologic samples was conducted according to the standard procedure using hydrofluoric acid. The palynomorphs were counted on each of the two slides per sample. The numbers of fungal spores, foraminiferal test linings and pyritized diatoms were also recorded. Leitz Wetzlar Universal microscope belonging to the university Port. Harcourt. was used for the analysis

### III. RESULT AND DISCUSSION

The 127 samples studied yielded dinocysts genera with 46 species; 33 pollen and spores genera with 35 species, abundant paediastrum in certain horizon,. Rare specimens of diatoms with abundant foraminiferal test linings, and fungal spores were also encountered in the study

**(A) AGE DETERMINATION** The distribution of the taxa in the Igbomotoru-I well section and the age determinations based on those mainly encountered in the sidewall samples are discussed below. The lower most sidewall sample (13548 feet) yielded few cysts of *Spiniferites pseudofurcatus* (Upper Eocene-Upper Miocene). The presence indicates a maximum age for interval 13548-14100 feet of Late Eocene or younger.. The next sample at depth of 12638 feet yielded biostratigraphically significant taxa, which included *Spiniferites pseudofurcatus* (Upper Eocene – Upper Miocene), *Multispinula quanta* (Upper Miocene – Recent), *Dapsilidinium pseudocolligerum* (Eocene – Lower Miocene), *Nematosphaeropsis labyrinthea* (Middle Miocene – Pleistocene), *Sumatradinium hispidum* (Middle Miocene – Pliocene), *Lingulodinium Macheorophorum* (Upper Miocene – Pleistocene), *Dapsilidinium pastielsii* (Early Eocene), *Lejeunecysta pulchra* (Oligocene), *Lejeunecysta diversiforma*. (Miocene – Recent) and *Operculodinium Centrocarpum* (Miocene). The maximum age of the time interval is set by the first appearance of *Nematosphaeropsis Labyrinthea* (Middle-Miocene) and the minimum age is set by the last occurrence of *Lejeunecysta diversiforma* (Recent). The overlapping ranges of these species and their co-occurrence at the depth of 12638 feet in Igbomotoru – I well indicate an Upper Miocene age. The underlying sequence of ditch cuttings between 12705-14100 feet also contain most of the species characterizing depth 12638 feet (Upper Miocene), and is probably coeval. The presence of *Dapsilidinium bastielsii*, *D pseudocolligerum* amongst others, which are Lower Eocene elements, probably indicate reworking of Eocene bed into the Upper Miocene. The sequence between 10510-12638 feet contains most of the species characterizing the depth of 12638 feet (Upper Miocene) and is probably coeval. The boundary between the Upper Miocene (10510-14100 feet) and the overlying sequence is conveniently placed at the unconformity recognized, in this study at the depth of 10510 feet ,above which occurs on association of diagnostic upper Miocene to Recent species, which includes, *Multispinula quanta*, *Quinquecupis concreta* amongst others. The unconformity is recognized by the presence of pebbles overlain by shale. It is interpreted as indicating the termination of a cycle of sedimentation ,when regression of the sea resulted in conditions favorable for the deposition of fresh water sediments, carbonaceous beds and lignites. The sequence between 6707-9820 feet yielded stratigraphically significant species whose age ranges in literature include *Multispinula Quanta* (Upper Miocene – Recent), *Nematosphaeropsis labyrinthea* (Middle Miocene – Pleistocene), *Sumatradinium hispidum*(Middle Miocene – Pliocene), *Lingulodinium macheoropheorum* (Miocene – Pleistocene), *Spiniferites Lazus* (Middle Miocene – Recent), *Selenepemphix nephroides* (Middle Eocene – Holocene), *Selenepemphix selenoides* (Oligocene – Miocene), *Impagidinium patulum* (Middle Miocene- Holocene). The maximum age of the time

interval is set by the first appearance of *Selenepemphix nephroides* (Middle- Eocene) and the minimum age is set by the extinction of *M. quanta* (Recent), *S. lazus* (Recent), *S. nephroides* (Holocene) and *Impagidinium Batulum* (Holocene). The overlapping ranges of these species, their co-occurrence in this section and their stratigraphic position above the lower Pliocene sequence (9820-10510 feet) indicate an Upper Pliocene age for the sequence between 6707 and 9820 feet. The boundary between the Upper Pliocene and the overlying sequence (2558-6707 feet) is placed at the unconformity recognized at the 6707 feet. The unconformity is recognized by the presence of pebbles overlain and underlain by shale, which is interpreted as indicating the termination of a cycle of sedimentation. The sequence between 2558 and 6707 feet yielded, at scattered intervals, stratigraphically significant taxa and their age ranges in literature include *Impagidinium patulum* (Middle Miocene- Holocene), Forma D (of Wrenn and Kokinos, 1986) which is Upper Pliocene to Pleistocene, *Multispinula quanta* *Sumatradinium hispidum* (Upper Miocene-Pliocene). In view of the above association of species which consist of Miocene to Quaternary species and their stratigraphic position above the Upper Pliocene boundary, the sequence between the depths of 2558 feet and 6707 is dated Pleistocene to probably Recent.

**(B) PALYNO STRATIGRAPHY** The zonal division is based on the distribution of dinocyst species between the depths of 2558 feet and 14,100 feet in the Igbomotoru I well. They are compared with the pollen/spores encountered based on the interpretation of Cermeradd *et al* (1968).; Oloto, 1994 are recognized based on the total dinocyst assemblages present (American Commission on Stratigraphy Nomenclature, 1961) and are discussed from the oldest to the youngest. The zones are defined by the first occurrences of two or more species. Two dinocysts zones equivalent to the *sumatradinium hispidum* (R) and *Tuberculodinium vancampoeae*(s) Zones of Oloto 1994 and Four pollen/spore zones equivalent to the *verruca tosporites usmensis* and *Magnastriatites howardii* (Germeraad *et al*, 1968); and *Lygodiumsporites adriennis* (L-1), *parchydermites diderixi* (M-I) and *Ctenolophonidites lisamae* (O-I) of Oloto ,1994 were recognized. They represent Miocene to probably Recent Sequences. Ages of the delineated zones have been determined by comparison with assemblages from other areas. Within each zone, data are presented in the stratigraphy sequence in which it is recognized and the species that have their first and last occurrence in the zone. The top of and underlying zone is equivalent to the base of the zone.

#### Zone 1

##### Reference section:

Igbomotoru - I well, 12638 feet to 14100 feet. Sample numbers 111 to 127.

##### Definition:

Species first appearing at the base of the zone – *Spiniferites pseudofurcatus*, *Multispinulosa quanta*, *Depsilidinium pseudocolligerum*. Species first appearing within the zone-*Operculodinium gigateum*, *Nematosphaeropsis Labyrinthea*, *Chytroeisphaeridium Sp*, *Sumatradinium Hispidum*, *Lingulodinium macheorophorum*,

*dapsilidinium pastielsii*, *Tuberculodinium vancamppoe*, *Lejeunecysta globosa*. Species last occurring within the zone – *Operculodinium giganteum*, *Tuberculodinium vancamppoe*. No species have their last occurrence at the top of the zone.

#### Comment:

All the samples from the horizons within this zone except two (13548 and 12638 feet) are ditch cutting samples and their reliability, in age indication is doubtful. The two-sidewall samples have however been used as palynostratigraphic control. Dinoflagellate species having their first appearance are difficult to differentiate because this zone represents the base of the well. Miospore, *Verrucatosporites usmensis* is common in this zone but sparingly represented, as indicated, in the distribution chart. The combined ranges of the dinoflagellate cysts for this zone indicate a lower upper Miocene age. The presence of *Dapsilidinium pastielsii* (Early Eocene), *D. pseudocolligerum* (Early Oligocene – Early Miocene) and *Lejeune-cysta globosa* (Oligocene) which are species from older rocks, probably indicate reworking from older rocks to the upper Miocene. The presence of *Operculodinium giganteum* (Pleistocene – Holocene) in some ditch cutting horizons within this zone probably indicates contamination from younger beds due to caving-in.

#### Zone 2

##### Reference section:

Igbomotoru – I well, 11307 feet to 12638 feet. Sample numbers 97 to 111

##### Definition:

Species first appearing at the base of the zone – *Lejeunecysta pulchra*, *Lejeunecysta diversiforma*, *Baltisphaeridium nanum*, *Operculodinium centrocarpum*. Species first appearing within the zone – *Quinquecuspis concretum*, *Xandarodinium sp.*, *Heteraulacacysta campanula*, *Spiniferites multibrevis*, *Dinocyst A*, *apectodinium of Homomorphum*. *Spiniferites lazus*, *Diphyes Colligerum*, *Cordosphaeridium of Cracenospinosum*. Species last occurring within the zone – *Lejeunecysta globosa*, *Xandarodinium sp.*, *Heteraulacacysta campanula*, *Diphyes colligerum*.

##### Comment:

The combined ranges of the *dinoflagellate cysts* for this zone indicate an upper Miocene age. The presence of *D. colligerum* (Early Eocene), *A. homomorphum* (Early Eocene) *S. multibrevis* (Hauterivian – Middle Eocene) and *H. Campanula* (Middle Eocene) probably indicates reworking of older beds into the upper upper Miocene bed. The dominant *dinocyst* is *Multispinula quanta*. This zone represent part of the *Sumatradinium hispidum*(R) subzone of Oloto, 1994 The dominant *miospores* include *Verrucatosporites usmensis* and *Lygodiumsporites adriennis*. This zone is equivalent to the *Verrucatosporites usmensis* zone of Germeraad *et al* 1968.

#### Zone 3

##### Reference Section:

Igbomotoru – I well, 8695 feet to 11307 feet sample numbers 71 to 97.

##### Definition:

Species first appearing at the base of the zone – *Chiropteridium sp.*, *Hystrichokolpoma poculum*, *Hystrichokolpoma sp.2*, *Pentadinium sp.* Species first appearing within the zone – *Lejeunecysta brassensis*, *Impagidinium sp.* *Lingulodinium sp.* *Trivalvadinium Plenum*, *Concentricytes rubinus*, *Tuberculodinium sp. 1*, *Spiniferites sp.* Species last occurring within the zone – *Chiropteridium sp.*, *Hystrichokolpoma Poculum*, *Hystrichokolpoma sp.2. cf. Pentadinium sp.*, *Impagidinium sp.*, *Lingulodinium sp.*, *Dapsilidinium pseudocolligerum*, *D.pastielsii*, *Quinquecuspis Concretum*, *Spiniferites lazus*, *Cordosphaeridium of cracenospinosum*, *Impagidinium sp.*, *Lingulodinium sp.*

##### Comment:

The combined ranges of the dinoflagellate cysts for this zone indicate an upper Miocene – Upper Pliocene age. The reworked species include *Dapsilidinium pseudocolligerum* (Oligocene – early Miocene), *D. pastielsii* (early Eocene), *Trivalvadinium plenum* (Early Eocene), and *Cordosphaeridium cf. Cracenospinosum* (Early Eocene). This zone belongs to the *Verrucatosporites usmensis* zone of Germeraad *et al* 1968. The dominant *dinocyst* is *Chytroisphaeridium sp.*

#### Zone 4:

##### Reference section:

Igbomotoru – I well, 2558 feet to 8695 feet. Sample numbers 1 to 71.

##### Definition:

Species first appearing at the base of the zone – *Selenepemphix nephroides*, *Saepodinium sp.*, *Tectatodinium sp. B* (of Wrenn and Kokonis, 1986). Species first appearing within the zone - *Selenepemphix selenoides*, *Impagidinium cf. patulum*, *Hystrichosphaeropsis obscura*, *Lejeunecysta sp. 2* (of Biffi and Grignani, 1984), *Dinocyst B*, *Hystrichokolpoma sp. 3*, *Lejeunecysta sp. 1* (of Biffi and Grignani, 1984), *Polysphaeridium subtile*, *Batiacasphaera hirsuta*, *Impagidinium patulum*, *Tuberculodinium sp. 2*, forma D (of Wrenn and kokinos , 1986).

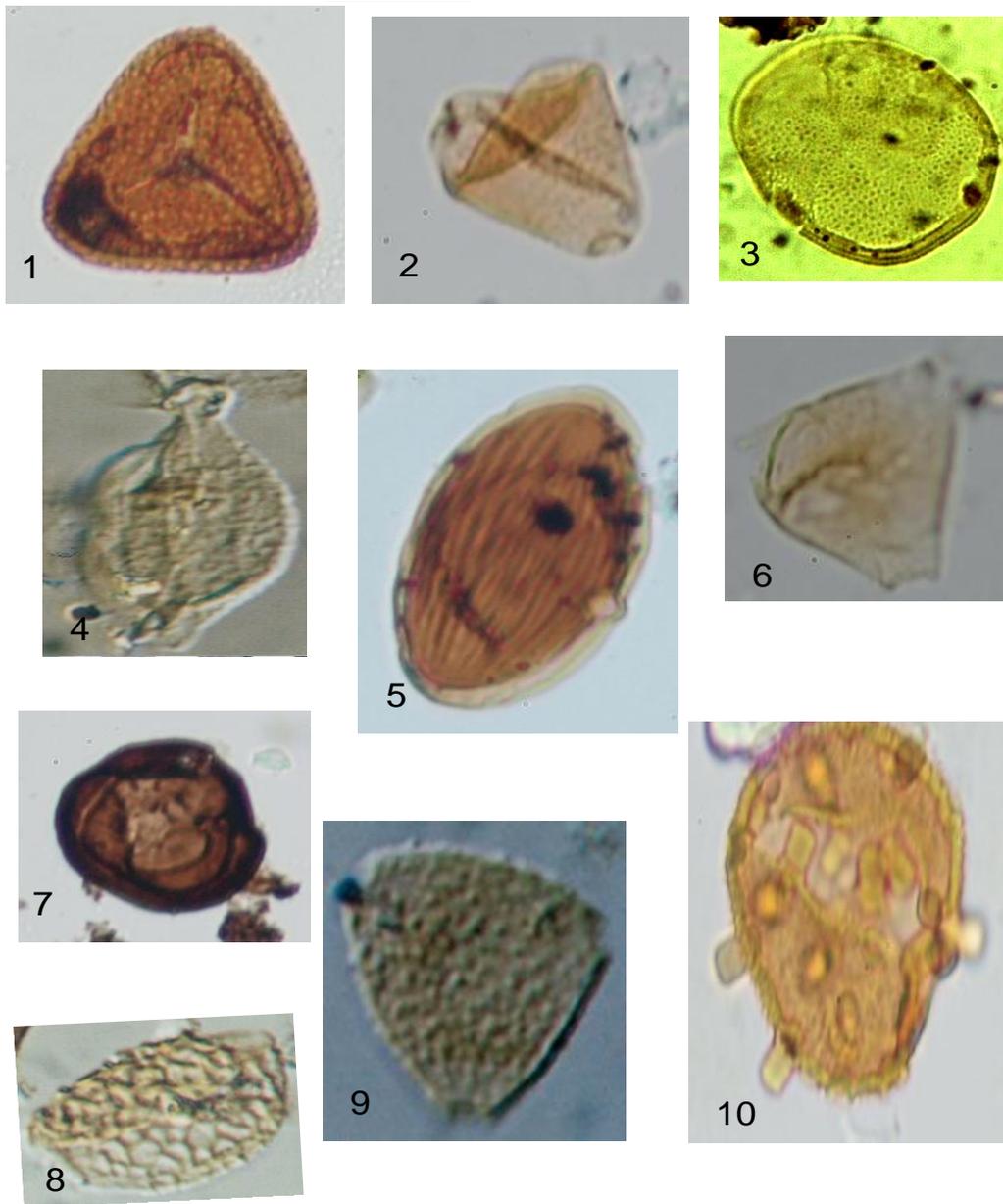
##### Comment:

The base of this zone is marked by the first and only abundance of *Sumatradinium hispidum* in Igbomotoru – I well. The combined ranges of the dinoflagellate cyst for this zone indicate an upper Pliocene age. The rapid reduction in numbers coincides with the onset of regressive phases and development of terrestrial environment. This zone is equivalent to the *Verrucatosporites usmensis* zone of Germeraad *et al*, 1968.

#### (C) Palaeoenvironmental Interpretations.

The palaeoenvironmental Interpretations is based on palynological and lithological analyses. During the Miocene times there was widespread emergence of the coastline with the establishment of conditions favorable for the deposition of freshwater sediments, carbonaceous beds and lignites Swardt and Casty, 1963; Reymont, 1965;) Murat, 1967. These environmental changes are reflected in the palynologic assemblages and are especially noticeable in the composition and relative proportions of different

groups of palynomorphs. The interval between 12570 feet and 14100 feet sample numbers 112-127 is composed of predominantly silty shale with plant remains and sandy and silty horizons. This interval is of upper Miocene age and belongs to the lower part of the dinocyst zone 1. It is very poor in palynomorphs, the total count not exceeding 51 with foraminiferal test linings accounting for the greater number. Plant debris are abundant. Dinocysts are very few with a maximum count of 6 cyst which consists of *Spiniferites pseudofucatus*, *Multispinula quanta*, *Dapsilidinium pseudocolligerum*, *D.pastielsii*, *Nematosphaeropsis labyrnthea*, and *Sumatradinium hispidum*. The presence of these species shows *Spiniferites* association of Downie et al, 1971 and is interpreted to indicate open marine environment. Pollens are absent from most horizons and the spores attain a maximum count of 10 grains. The miospores are however, dominated by *Verrucatosporites usmensis*. Fungal spores and foraminiferal test linings attain maximum counts of 7 and 33 respectively at various horizons. The foraminiferal test linings are composed of planispiral evolutes, uniserial and biserial agglutinated forms. They represent benthonic foraminifera test linings (Muller, 1959; Cross et al 1966) and probably indicate an inner neritic environment, which is in agreement with the dinoflagellate interpretation. Sample number 111 at the depth of 12638 feet is composed of slightly silty shale. This horizon is of upper Miocene age and belongs to the base of the dinocyst zone. This horizon is fairly rich in palynomorphs, which attain maximum count of 186 grains. The composition is dinocyst (95), pollen/spores (12), foraminifera test linings (59) and fungal spore (20). Plant debris are also present. The dinocysts are dominated by *Spiniferites pseudofurcatus*, *Sumatradinium Hispidum* and *Chytroeispheriduum sp.* The dinocyst is represented by the *Spiniferites* association of Downie et al, 1971, which is interpreted to indicate an open marine environment. There is no dominant pollen/spores. Foraminifera test linings are abundant and composed of planispiral evolute, biserial (*Textularia*) forms. These forms are benthonic and probably indicate an inner neritic marine environment. This confirms the interpretation based on dinocysts. The fungal spores are varied in form and their relative abundance probably indicates closeness to the coast

**PLATE 1**

**Plate 1:** Picture plates showing some of the palynomorphs encountered in the study

The interval between the depths of 12300 feet and 12574 feet is composed of silty shale with a few plants remains and a silty sand horizon. This interval is of upper Miocene and occurs at the base of dinocyst zone 2. This interval is very poor in palynomorph, the total count not exceeding 32 grains, composing of maximum count of dinoflagellate cysts (6), pollen/spores (18), foraminiferal test lining (7) and fungal spore (4). Plant debris is also abundant. Dinoflagellate cysts include *Quinquecuspis concertum*, *Sumatradinium hispodum* amongst others. The interval indicates a *Wetzelella* association of Downie *et al*, 1971 which is interpreted as indication lagoonal, estuarine or brackish water environment. The spores are more represented than the pollen, with a relative dominance of *Verrucatosporites usmensis*. Foraminiferal test linings

include mainly the planispiral evolute and biserial (*Textularia*?) forms. The interval between the depths of 11195feet and 12105 feet is composed of silty shale with a few horizons of silty sandstone. This interval is of upper Miocene age and it cuts across the boundary between dinocyst zones 2 and 3. The interval consists of horizons containing combination of both rich and poor palynomorphs which from 4 to 159 grains. The dinocysts (2-38), pollen (1-6), spores (4-87), foraminiferal test lining (3-83), fungal spores (1-5) and two horizons with *Pediastrum* (2). The dinoflagellate cyst assemblage indicates an estuarine environment. The cysts show a high species diversity. The interval between the depths of 2558 feet and 11100 feet is composed of carbonaceous lignitic, silty shale, alternating with sand to coarser grained pebbles, in an upward-

shoaling trend. pollens are poorly represented while spores are fairly well represented. Foraminiferal test linings are also poorly represented up section. Fungal spores are present and there is an abundance of terrestrial plant fragments in all samples. Generally, there is observed fluctuations from marine to continental environment up section, which favoured the accumulation of terrestrial debris. This may be attributed to sea level oscillations which are ascribed to volumetric changes in continental ice sheets as was the case in the Northern Gulf of Mexico (Williams, 1984). The greater the accumulation of terrestrial ice sheets, the lower the sea level fall. During this period, there was the Pleistocene glaciations and this must have affected a lowering withdrawal of the sea level (regression) resulting in accumulation of terrestrial debris and pollen/spores.

#### IV. CONCLUSIONS

The Igbomatoru – I well sequence is Upper Miocene to Pleistocene in age based on dinoflagellate cysts. The sequence between the depth of 10510 feet and 14100 feet (sample numbers 89-127) is Upper Miocene; 9780 feet to 10510 feet 9780 feet (sample numbers 81-89) is lower Pliocene; 6705 feet to 9780 feet (sample numbers 43-81) is Upper Pliocene and 2558 feet to 6705 feet (sample numbers 1-43) is Pleistocene. The boundaries are marked by unconformities recognized by the presence of gravel horizons in a predominantly silty shale sequence. It is interpreted as indicating the termination of a cycle of sedimentation when regression of the sea resulted in conditions favourable for the deposition of terrestrial material. Four dinoflagellate cyst zones (1-4) have been recognized. The dominant species are *Spiniferites Pseudofurcatus* (zone 1), *Multispinula quanta* (zone 2), *Chytroesphaeridium*, sp. (zone 3) and *Sumatradinium hispidum* (base of zone 4). These zones correspond to the *Verrucatosporites usmensis* zone (Germoraad *et al*, 1968). Combined palynologic, maceral and sedimentological data indicate that deposition occurred close to shore in a marine environment that became progressively shallower up section. This is indicated by: The dominance and abundance of terrestrial plant fragments in all samples; A marked increase in spores up section; A decrease in the abundance of microplankton, in dinocyst species diversity and in chorate species diversity up section; and an increase in the diversity of cavate and proximate dinocysts, in the abundance of reworked palynomorphs in sediment grain size and in sediment grain-size variability up section.

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