Palynostratigraphy Analysis of Middle to Southern Benue Trough, Nigeria

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ABSTRACT

Palynological baseline data acquisition and analysis were carried out within longitude 60° 3' - 90° 4'E and latitude 8° 23' - 40° 45'N spanning the area from middle to southern Benue Trough for the purpose of forensic studies. A total of seventeen samples were collected from Northern to Southern town axis from Akunza Migili Lafia town to Ikot Ekpene road Abia state. A lithologic section was prepared using latitude from the northern to southern axis. The lithologic and palynological analysis based on field samples were tied up with the geologic formation based on published geologic maps. The rocks were compose of shale and sandstone, therefore found to traverse within middle Benue Trough (Akunza Migili Lafia Nasarawa State-Oturkpa Benue State), lower Benue Trough (Nkalagu-Enohia-Nkalu Afikpo Ebonyi State) and Niger Delta (Abia state boundary between Umuahia and Imo State-Ikot Ekpene road Abia State) from a geographic spread between longitude 60° 3' - 90° 4'E and latitude 8° 23' - 40° 45'N. Palynological analysis yielded; Echitricolpites spinosus, Fenetrites spinosus; from middle Benue Trough, Echimonocolpites rarispinosus, Cingulatisporites ornatus, Macrotyloma brevicaulus, Tubistephanocolpites cylindricus, Hexaporotricolpites emelianovanov, Retidiporities magdanensis, Retistephanocolpites gracilis, Elaeis guineensis; from Nsukka Formation, Multiarolites formosus, Echitricolpites spinosus, Nymphapollis clarus; from Benin Formation. These data were used to generate palaeogeographical distribution of pollen, spore, fungal spore, dinoflagellate, acritarch, foram test wall lining and diatom. The palaeogeographical distribution charts were converted into percentage charts which shows the comparative occurrences of the different palynomorph groups. These are represented in step-like manner indicating the entrance of two to three new species marks a biozones. The occurrences of environmental diagnostic palynomorphs within a specific latitude range leads to the interpretation of the environment of deposition indicating sedimentation from alluvial plain to transitional/tidal zone and the diagnostic palynomorphs shows that the paleoecology consists of rainforest to mangrove.

Keywords: Palynology, Benue Trough, Nigeria, Forensic, Paleoecology, Paleoenvironment and Biozonation.

1. INTRODUCTION

This research work on palynological baseline data acquisition of middle to southern Benue trough for forensic studies. It has been established that the crime rate in Nigeria is at alarming rate, which in most cases culprits sometimes usually go unpunished. This is as a result of the fact that there are no adequate tools and facilities to use to expose and put the criminal elements on check. Accordingly, the primary aim of this proposed research work is to generate a data base of pollen and spores assemblages for forensic studies in Nigeria. The outcome result will serve as reference point or “baseline” for which further forensic studies could be carried out. Thus the main aim of this work is to generate a comprehensive data base of pollen/spores and dinoflagellate within the study area, interpret Paleoenvironment of deposition using identified diagnostic palynomorphs and palaeoecological reconstruction.

2. GEOLOGICAL SETTING

The Benue Trough is itself a part of the very expansive west and central African rift system in which it opened as an extensive sinistral wrench complex (Emery et al., 1975; Whiteman, 1982; Genik, 1993). A reconstruction by Murat (1972) shows the southern part of the Benue Trough as longitudinally faulted, with its eastern half subsiding preferentially to become the Abakiliki depression. During the filling of the Abakiliki-Benue sector of the Benue Trough in the Albian-Santonian times, the proto-Anambra Basin was a platform that became only thinly sediment-draped (Nwajide and Reijers, 1997). Basin subsidence in the southern Benue Trough was spasmodic. It was at a high rate in pre Albian time, low in lower Cenomanian, and very high in Turonian; the latter was an...
important phase of platform subsidence (Ojoh, 1990). This is thought to be the actual time of initiation of the Anambra Basin; a process that gained momentum in the Coniacian and climaxed during the Santonian thermotectonic event (Nwajide, 2005).

Careful synthesis of the works of several authors (Murat, 1972; Nwachukwu, 1972; Weber and Doukoru, 1975; Benkhelil, 1982; Nwajide and Reijers, 1996; Mode and Onuoha, 2001; Obi, 2000) reveals that the Santonian movement or tectonic pulses (or compressional uplift) dating back to 84 Ma, was accompanied by widespread magmatism, folding and faulting that caused the Abakiliki area to become flexurally inverted to form the Abakiliki Anticlinorium. These forces displaced the depocentres to the west and southeastwards, forming the Anambra Basin and Afikpo syncline, respectively (Murat, 1972; Burke, 1972). Thereafter, the anticlinorium served as a sediment dispersal centre from which mineralogically mature detritus was shed into the Anambra Basin and Afikpo Syncline (Akaegbobi and Schmitt, 1998; Akaegbobi and Boboye, 1999). Other provenance areas for texturally mature sediments of the Anambra Basin include the crystalline Basement areas of the Oban Massif, southwestern Nigerian craton and Cameroon basement granites which had undergone prolonged chemical weathering (Hoque and Ezepue, 1977; Amajor, 1987; Nwajide and Reijers, 1996; Akaegbobi and Schmitt, 1998; Akaegbobi and Boboye, 1999).

Table 1: Stratigraphic Sequences in Anambra Basin (after, Nwajide, 2005)

<table>
<thead>
<tr>
<th>Age</th>
<th>Basin</th>
<th>Stratigraphic Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thanetan</td>
<td>Niger Delta</td>
<td>Imo Formation</td>
</tr>
<tr>
<td>Danian</td>
<td>Anambra Basin</td>
<td>Neukden Fm</td>
</tr>
<tr>
<td>Maastrichtian</td>
<td>Measures</td>
<td>Ajelli Fm</td>
</tr>
<tr>
<td>Campanian</td>
<td>Nkporo Fm</td>
<td>Memu Fm</td>
</tr>
<tr>
<td></td>
<td>Nkporo Shale</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Enugu Fm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Owelli Fm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Afikpo Fm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Otobi Fm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lafia Fm</td>
<td></td>
</tr>
<tr>
<td>Santonian</td>
<td>Southern Benue Trough</td>
<td>Awgu Fm</td>
</tr>
</tbody>
</table>

Sediment deposition in the Anambra Basin started in the Campanian with a short marine transgression followed by a regression. The Nkporo Shale and its lateral equivalents, the Enugu Shale and Owelli Sandstone (Nkporo Group), constitute the basal beds of the Campanian period. The broad shallow sea gradually became shallower because of
gradual subsidence, initiating regressive phase during the Maastrichtian that deposited deltaic foresets and flood plain sediments of the Mamu Formation (Lower Coal Measures). The Mamu Formation is overlain by the continental beds of Ajali Sandstone (False bedded Sandstone), followed by a return to partially paralic conditions and the deposition of the Nsukka Formation. The stratigraphic sequence presented in table 1 and graphically illustrated in Fig. 1 represents the totality of the lithic fill of the study area and adjoining Tertiary Niger Delta.

3. LOCATION AND ACCESSIBILITY
The study area is located between latitudes 6000’N and 6030’N of the equator and longitudes 7020’E and 7030’E of the Greenwich meridian. (Fig. 2).

4. METHOD OF STUDY
There are two methods of study, laboratory and field study.

(a) Sample collection: The field work was carried out with the aid of some basic Global Positioning System (G.P.S), digital camera, marker, field notebook, pencil, eraser, masking tape, sample bags (used to collect samples from different locations). Hand auger and hand trowel was used to collect both surface and sub-surface samples (few meters deep). A total number of seventeen control samples were collected.

Figure 2: Map Showing Location of Study
using the “pinch” method: collecting 10 pinches of soil throughout each sampled locations of about 50 to 100 square meters. These pinches were combined into a single, sterile, plastic bag and then sealed. Multiple pinches from each sample area were combined to prevent the possibility of over from different locations were well-labelled with sample and location number and then kept in a sample bag.

(b) palynological preparation: Samples were prepared for palynological studies. About 5 gram of each sample was placed in a labeled cup in which 100ml of 70% hydrofluoric acid (HF) was added with palynomorphs from the other rock debris by digesting the silica in sample. The samples were then washed and the slides prepared. A portion of the kerogen was mixed with 0.1% PVA solution, pipette onto a cover slip and allowed to dry. The remainder of the kerogen was sieved at 20μ. A portion of the sieved material was mixed with PVA solution pipette onto a cover slip and allowed to dry. The cover slips were mounted upon a microscope slide using norland adhesives. The slides were properly labeled and observed under research microscope through which snapshot was taken (see list of plate).

5. RESULTS AND INTERPRETATIONS
The results have been separated into Lithology, Percentage distribution of palynomorphs, Pollen assemblage zones, Paleoecology and Paleoenvironment. (figure. 3, 4 and 5).

5.1 Lithology
The lithological and textural characteristics were derived by washing the samples under running water using the 90μm, and 53μm mesh size set of sieves to remove the mud. The samples were dried on a hot plate, examined and described with the aid of a Leitz-Wetzlar binocular microscope. The samples were divided into five horizons (A-E) on the basis of textural characteristics. These units from top to the base are shown in Fig. 3. It was characterized by sandstone and shale with the sand grains exhibiting fine to coarse grained size. They were well to moderately sorted with abundant calcareous, minor rootlets, ferruginous materials and minor shale occurrence at the upper unit. The sand grains sub-angular to sub-rounded and light to dark grey in color. The shale in unit B and D was sub-fissile to fissile, moderately hard to hard with micaceous and carbonaceous detritus. The color of the shale was light to dark grey.

5.2 Percentage Distribution of Palynomorphs
The distribution of palynomorphs varied considerably from one geographic location to another. The sampling points of the samples were arranged using their coordinates (latitudes) in a descending order, starting with the locations that have the highest latitude from north to south. Pollen and spores preservation was good in most of the samples and the microflora was rich and well-diversified. The total number of palynomorphs counted per gram of the analyzed samples ranged from 1 to 158, with the lowest abundance at sample 23 and 24, while the highest abundance palynomorphs is at samples 17.
<table>
<thead>
<tr>
<th>BASIN</th>
<th>FORMATION</th>
<th>AGE</th>
<th>COORDINATES (LATITUDE)</th>
<th>LITHOLOGY</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIDDLE BENG TROUGH</td>
<td>?</td>
<td>Late Miocene - Pliocene</td>
<td>N08°00'00&quot;</td>
<td>sand smoky white, sometimes red, very fine to fine grained, well sorted, subangular to subrounded and slightly calcareous</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>N07°00'00&quot;</td>
<td>shale light grey, sub fissile, moderately hard to hard and carbonaceous.</td>
</tr>
<tr>
<td>LOWER BENG TROUGH</td>
<td>Nıgde Formation</td>
<td>Miocene - Pliocene</td>
<td>N06°00'00&quot;</td>
<td>sand, smoky white, very fine to fine grained, well sorted, subangular to angular and calcareous.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>N05°00'00&quot;</td>
<td>shale, light grey, subfissile to fissile, moderately hard to hard and carbonaceous rootlets also occur.</td>
</tr>
<tr>
<td>NIGER DELTA</td>
<td>Benin Formation</td>
<td>Miocene - Pliocene</td>
<td>N05°00'00&quot;</td>
<td>sand, smoky white, very fine to fine grained, well sorted subangular to angular with rootlets.</td>
</tr>
</tbody>
</table>

**LEGEND**

- **SANDSTONE**
- **SAND**
- **SANDSTONE**
- **SAND**

**Figure 3:** Lithology of the Studied Samples
Table 2: Sample Number, Towns, Distance and GPS Reading Collected from the study area

<table>
<thead>
<tr>
<th>Sample Number</th>
<th>Towns</th>
<th>Distance (kilometres)</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Akunza Migili (Nasarawa State)</td>
<td>57.6</td>
<td>08°20’27.3”N</td>
<td>008°03’28.8”E</td>
</tr>
<tr>
<td>15</td>
<td>Oturkpo (Benue State)</td>
<td>47.4</td>
<td>07°05’49.9”N</td>
<td>007°40’36.1”E</td>
</tr>
<tr>
<td>16</td>
<td>Oturkpa (Benue State)</td>
<td>36.5</td>
<td>06°49’36.6”N</td>
<td>007°40’36.1”E</td>
</tr>
<tr>
<td>17</td>
<td>Ozalla (Enugu State)</td>
<td>40.8</td>
<td>06°01’34.2”N</td>
<td>007°42’16.4”E</td>
</tr>
<tr>
<td>19</td>
<td>Isi Ewaa (Enugu State)</td>
<td>19.1</td>
<td>06°05’30.9”N</td>
<td>007°28’14.5”E</td>
</tr>
<tr>
<td>23</td>
<td>Agwu (Enugu State)</td>
<td>24.2</td>
<td>06°18’41.9”N</td>
<td>007°29’04.0”E</td>
</tr>
<tr>
<td>24</td>
<td>Agwu (Enugu State)</td>
<td>18.5</td>
<td>06°08’20.2”N</td>
<td>007°31’21.1”E</td>
</tr>
<tr>
<td>26</td>
<td>Nkalagu (Ebonyi State)</td>
<td>11.5</td>
<td>06°28’13.5”N</td>
<td>007°40’22.1”E</td>
</tr>
<tr>
<td>30</td>
<td>Afikpo (Ebonyi State)</td>
<td>16.7</td>
<td>05°51’25.9”N</td>
<td>007°46’35.8”E</td>
</tr>
<tr>
<td>31</td>
<td>Afikpo-Mgbom (Ebonyi State)</td>
<td>19.7</td>
<td>05°56’26.6”N</td>
<td>007°55’10.0”E</td>
</tr>
<tr>
<td>32</td>
<td>Enohia-Nkalu Afikpo(Ebonyi State)</td>
<td>17.4</td>
<td>05°49’10.7”N</td>
<td>007°47’33.8”E</td>
</tr>
<tr>
<td>33</td>
<td>Macgregor College Afipko (EbonyiState)</td>
<td>18.6</td>
<td>05°50’53.9”N</td>
<td>007°56’47.9”E</td>
</tr>
<tr>
<td>38</td>
<td>Boundary between Umnchia and Imo (Abia State)</td>
<td>17.1</td>
<td>05°39’38.1”N</td>
<td>007°18’08.9”E</td>
</tr>
<tr>
<td>39</td>
<td>Amainyi Ihitte(Imo State)</td>
<td>19.1</td>
<td>05°34’51.8”N</td>
<td>006°34’51.1”E</td>
</tr>
<tr>
<td>41</td>
<td>Ohia-Abia State)</td>
<td>15.20</td>
<td>05°27’36.7”N</td>
<td>007°35’40.1”E</td>
</tr>
<tr>
<td>42</td>
<td>Mkpuka Junction (Abia State)</td>
<td>16.4</td>
<td>05°15’54.7”N</td>
<td>007°28’24.4”E</td>
</tr>
<tr>
<td>44</td>
<td>Ikot Ekpene (Abia State)</td>
<td>11.6</td>
<td>05°02’02.1”N</td>
<td>007°12’47.7”E</td>
</tr>
</tbody>
</table>

5.3 Percentage Distribution of Palynomorphs

The distribution of palynomorphs varied considerably from one geographic location to another. The sampling points of the samples were arranged using their coordinates (latitudes) in a descending order, starting with the locations that have the highest latitude from north to south.

Pollen and spores preservation was good in most of the samples and the microflora was rich and well-diversified. The total number of palynomorphs counted per gram of the analyzed samples ranged from 1 to 158, with the lowest abundance at sample 23 and 24, while the highest abundance palynomorphs is at samples 17.
Figure 4: Percentage distribution of palynomorphs generated from the seventeen (17) samples that were collected in a lateral geographic trend from the study area.

In sample 3 consist of 69% pollen, 6% spore 13% fungal spore, 6% dinoflagellate and 6% foram test lining. The dominance of pollen and spore indicate terrestrial depositional environment. The low number of chitinous foraminifer test lining probably indicates the environment of deposition was not favorable. Sample 3 is poor in palynomorphs but the numerical counts show that they are dominated by pollen and spore and in sample 15 is poor in palynomorphs and of the numerical counts show that they are dominated by pollen and spore with 56% pollen, 33% spore 11% fungal spore. These indicate terrestrial depositional environment. The presence of fungal spore probably indicates a swamp environment with no marine indicator and sparse flora content.
Sample 16 consist of 33% pollen, 33% spore and 34% foraminifera test lining. This indicates a terrestrial depositional environment. Chitinous foraminifera test lining are abundant and consist of planispiral forms. They represent benthonic foraminifera lining (Muller, 1959, Cross et al, 1966). Their abundance indicates a favorable environment for their survival.

In sample 17 is rich in palynomorphs and is composed of 73% pollen 21% spore, 3% dinoflagellate and 3% fungal spore. These indicate a terrestrial environment. The presence of few dinoflagellate cysts in a pollen and spore dominated assemblage probably indicate infiltration of marine water.

Sample 19 is rich in palynomorphs and is composed of 63% pollen, 25% spore 4% fungal spore and 8% dinoflagellate. The assemblage consists of a few dinoflagellate cysts, and dominated by pollen and spores; in addition to the presence of leaf cuticles indicate a terrestrial depositional environment. Sample 23 is rich in fungal spore which is composed of 100% fungal spore. The presences of fungal spore probably further confirm a swamp depositional environment while sample 24 is devoid of pollen and spore and is rich in dinoflagellate cyst which is composed of 100% dinoflagellate cyst? No comprehensive environmental interpretations are made because there are no palynomorphs counts.

Sample 26 is rich in palynomorphs, but devoid of dinoflagellate and is composed of 25% pollen, 60% spore 10% fungal spore and 5% of Acritarch. Pollen and spore show a relative dominance over fungal spore and Acritarch. These indicate a terrestrial depositional environment. Acritarch are low in number probably indicate that the environment of deposition was not favorable. Invariably sample 30 is rich in palynomorphs and is composed of 38% pollen, 38% spore, 8% fungal spore, 8% dinoflagellate and 8% Acritarch. Pollen and spore show a relative abundance than other forms. These indicate terrestrial depositional environment. The presence of a few dinoflagellate cysts in a pollen and spore dominate assemblage probably indicate infiltration of marine water. In sample 31 is devoid of dinoflagellate cysts and is composed of 11% pollen, 78% spore and 11% fungal spore, but rich in pollen and spores. This indicates a terrestrial depositional environment. No marine indicator, with sparse flora content. The presence of fungal spores probably further confirms a swamp depositional environment.

Sample 32 is composed of 62% pollen, 23% spore, 6% fungal spore, 3% dinoflagellate, 3% foraminifera test lining, and 3% Acritarch. The abundant of pollen and spore indicate a terrestrial depositional environment. Chitinous foraminifera test lining are few and composed of planispiral forms, the low number probably indicates that the environment of deposition was not favorable. They lining are probably derived from benthonic foraminifera (Muller, 1959, Cross et al, 1966) which indicate a near shore marine and also the presence of plant debris indicate a more terrestrial depositional environment. More over the presence of Monoporities annulatus indicate high savanna but probably near grassland.
In sample 33 is devoid of dinoflagellate cyst and is composed of 50% pollen 24% spore and 25% fungal spore. Pollen and spore shows a relative dominance over fungal spore. These indicate a terrestrial depositional environment. The presence of fungal probably further confirms a swamp depositional environment.

Sample 38 is devoid of dinoflagellate cyst but rich in palynomorphs and is composed of 43% pollen, 29% spore, 14% fungal spore and 14% Acritarch. The presence of fungal spore probably indicate transportation from a swamp to the estuarine environment. The presence of Acritarch indicate marine environment but base on high percentage of pollen and spore it indicate a terrestrial environment. The presence Charred gramminae cuticle and Multiaredite formosus indicate savanna and montane area.

In sample 39 consist of 43% pollen, 43% spore, 7% fungal spore and 7% Acritarch but are devoid of dinoflagellate cysts, pollen and spore show relative dominance, these indicate a terrestrial depositional environment. The presence of fungal spores probably confirms a swamp depositional environment. Acritarch are few, the low number indicates that the environment of deposition was not favorable.

Sample 41 consist of 42% pollen, 19% spore, 14% fungal spore, 5% dinoflagellate cyst, 5% Foraminifera test lining, 10% Acritarch and 5% Diatom. The presence of a few dinoflagellate cyst in a pollen and spire dominated assemblage probably indicates infiltration of marine water. Forum test lining, Acritarch and Diatom are low in number these probably indicate that the depositional environment is moving from terrestrial to marine.

Sample 42 is devoid of dinoflagellate cyst but rich in pollen and spores and is composed of 38% pollen, 44% of spore, 12% fungal spire and 6% Acritarch. Pollen and spore shows relative abundance. These indicate a terrestrial environment. The presence of fungal spores probably further confirms a swamp depositional environment and sample 44 is devoid of dinoflagellate cyst but rich in pollen and spores which is composed of 22% pollen, 64% spore, 7% fungal spire and 7% Foraminifera test lining. This indicates a terrestrial depositional environment. Chitinous Foraminifera test lining are few and composed of planispiral and universal benthonic forms but the low number probably indicates that the environment of deposition was not favorable. The presence of plant debris also confirms a swamp condition.

5.4 Biozonation

The pollen diagram in fig showed the most important taxa for different locations of the study area. These have been classified according to their paleoecological zone and thus consider being ecologically significant the species were not ubiquitous, but belonging to distinct ecological zones.

Furthermore they have been identified to species level or to types identifiable with species. According to marked vegetation change reflected in the pollen diagram, six pollen zone were recognized in the studied sections.
Zone I
Family: Asteraceae (compositae)
Echitricolporites spinosus
Subzone: Late Miocene-Pliocene
Location 3-15

Rich in palynomorphs assemblages: from the top it showed the species first occurring with presence of Psilamonocolpites sp, Striatricolpites sp, Echiperiporites sp, Retidiporites sp, Multiareolites formsus, Nymphaeapollis clarus, Magneperiporites Polyadopollnites sp, Cycadopites sp, Zonocostites ramonae showed a slight increase in abundance.
Species last occurring at the base marked zone Psilatricoporites sp, Echritricolporites Spinosus, Retitricolporites sp, Fenestries spinosus
Note: Although some of the genera which produce this pollen type a pantropical distribution. The occurrences in the Neogene appear to be restricted to the Caribbean area and Nigeria. It is possible that the extension of the range to the indo-malesian area took place relatively late Mio-Pliocene.
Paleoenvironment of deposition showed a significant of alluvial plain Poumot (1989) previously recognized pollen and spores in relation to present vegetation; the paleoecological zone with the present of Retitricolporties sp, Psilatricolporites sp and Echiperiporites sp sparsely represent a fresh water swamp/rain forest vegetation these indicate a high percentage of pollen 77%

Zone II
Family: Arecaceae
Elaeis guinensis
Subzone: Late Maastrichtian-Early Miocene
Location 15-26

The top showed a slight increase in palynomorphs
Species first appearing at the top; Zonocostites ramonea, Psilatricolporites sp, Echritricolporites spinosus, Retitricolporites sp, Fenestries spinosus. Species last occurring at the base marked the zone. The base showed an increases in pterydophyle spore; Seleginella Myosurus, Polypodiaceiosporites retirugatus, Acrotichum aureum, stereisporites sp and some pollen like Peregrinipollis nigricus Elaeis guineensis, Brevicolporites grunette; the base marks a quantitative increases in Elaeis guneensis Paleoenvironment of deposition showed a significant of alluvial plain Poumot (1989). Previously recognized pollen and spore in relation to present vegetation; the paleoecological zone with the present of Brevicolporites guinetti Peregrinipollis nigricus showed a lowland rain forest vegetation which is characterize by a decrease in pollen with percentage of 48%.

Zone III
Family: Ctenolophonaceae
Retistephanolcolpites grecillis
Subzone: Maastrichtian
Location 26-19
Top defined by first quantitative increase of Elacis guineensis with a high increase of pterydophyte spore. The base show an increase in palynomorph species first appearing at the bottom- Retistephanocolpites, gracillis, Pslastephanocolpites leavigatus, Auriculiiidetes, sp, Ariadnaesporites sp, Psilatriporites sp, Acanthaecas sp, Fenestris spinosa, Monoporites annulatus, synocolporites sp. The base marked by slight increase in pterydophyte spore. Paleoenvironment of deposition showed a significant of alluvial plain; from Poumot (1989) recognized pollen and spore in relation to present vegetation; therefore the paleoecological zone with the present of Retistephanocolpites gracillis indicates fresh water rain forest vegetation (Riparian).

Zone IV
Family: Proteaceae
Protcacidites longispinosus
Subzone: Maastrichtian
Location 19-17
Top is marked/distinct increase in palynomorph assemblages.
Presences of Monoporites annulatus, Syncolporites sp, pollen in association with Psilatriporites sp and common Fenestries spinosa.
Reduction of pteridophyte spore toward the base.
Species first appearing at the bottom show an increase in abundance of palynomorph: Psiladiporites Syndemicolpits sp, Adenantherites sp, Macrotyloma brevicacule; with high pollen grains of Proteacidites longispinosus.
Paleoenvironment of deposition showed a significant of alluvial plain Poumot (1989) previously recognized pollen and spores in relation to present vegetation; the paleoecological zone with the present of Longapertitis, Hexaporotricolpites emelianova Monocolpites sp, Constructipollenites ineffectus, Echimonocolpite rarispinosus and Retidiporites Magdalenensis indicate a freshwater swamp/rain forest vegetation with high percentage of pollen 65%.

Zone V
Family: Boribacaceae
Echritriporites Spinosus
Subzone: Maastrichtian
Location 17-32
The top is rich in palynomorphs
Species first appearing from the top with increase in pollen grain:-Echrimorocolpites rainspinosus Retidiporite magdalenensis, Macrotylone breviculle, Constructipollenites ineffectus, Echiritriportes trianguliformis, Adenanthers sp, Proteacidites Longispinosus, with an increase in pterydophyte spore minimum.
Species first appearing at the bottom: Fenestrate sp, Echritriporites spinosus, Cyperepollis sp, Retitriporites sp, Paleonvironment of deposition showed a significant of alluvial plain.

Poumot (1989); recognized pollen and spore in relation to present vegetation; the paleoecolgical zone with the present Cyperpollis sp indicate freshwater swamp rain forest in other hand Echritriporites spinosus is a diagnostic forms of freshwater swamp rain forest.

Zone VI
Family: Asteraceae (compositae)
Retitricolpites sp
Subzone: Miocene-Pliocene
Location 32-44

Top marked/distinct increase in abundance of mangrove pollen Zonocostites ramonae near the top.

Species first appearing from the top:- Auriculidites sp, Psiletricolpites sp, Psilastephanocolpirites sp, Retritricolpites sp:

Subzone species Nymphapollis sp, Zonocostitite ramonae species last occurring at the bottom Psilaperiporites minimus, polypodiidetes sp, increases of Aletesporites sp, Laveigatospirites discordetus, Paleoenvironment of deposition showed a significant of transition/tidal zone Poumot 1989; recognized pollen and spore in relation to present of vegetation; Paleoecological zone with the present of Zonocostite ramonae indicate mangrove forest.

6. DISCUSSION

Zone I: The high percentage occurrence of pollen and spore suggest a period of unstable environmental condition which might be cause on the one hand by variations in the extent and intensely of the alluvial plain fluctuations in the occurrence of Asteraceae (composite) and by extension to the coast as well as by drier conditions inland resulting in the presence of freshwater swamp/rain forest and extensive expansion of savanna southwards.

Zone II: The high percentage occurrence of pollen in this zone was an indication that lowland forest was well established during the period covered by this section. It also shows that there was an extent and intensely of alluvial plain resulting in fluctuations in the occurrence of Elacies guneensis (Arecaceae) this conclusion was further strengthened by the very low percentage occurrence fungal spore and total absence of the pollen of other savanna elements, elements in the zone. Other vegetation communities in existence during this period were fresh water swamp forest and lowland rain forest suggesting wet and warm climate for this period.

Zone III: The period covered by this zone can be suggested to be a period of rapid and unstable cometic conditions culminating in rapid sea-level change (rise and fall), this may account for the rapid changes noted in the pollen assemblages in this zone particularly, Riparian. However, the non-occurrence of motane forest vegetation typified by Podocarpus Miliajanus in this zone indicates that the climate was probably more open. Furthermore, it can be suggested that during the lowering of the sea level, there was an extensive development of savanna vegetation indicated by the highest percentage occurrence of Acritarch and fungal spore in this zone. This unstable wet/dry period may have accounted for the extensive development of the savanna as Germeraad et al, (1968) have reported that a drier climate with marked rainy season favors the development of extensive grass areas. Prevalence of wet conditions during this period was corroborated by the existence of fresh water rainforest.

Zone IV: These high percentages of Proteaceae pollen indicate that freshwater swamp/rain forest was well established during this period and that there was a rise in sea level with the freshwater swamp/rainforest being dominant over the alluvial plain. Furthermore, the representation of freshwater swamp rainforest suggests their continued existence during this period. The climatic inference deducible from this zone is that the climate was wet and warm.
Zone V: The high percentage occurrence of pollen and spore suggest a period of unstable environment conditions which might be cause on the one hand by variations in the extent and intensely of the alluvial plain in fluctuation in the occurrence of Asteraeece (compositate) and by extension to the coast as well as by drier conditions inland resulting in the presence of freshwater swamp/rainforest and extensive expansion of savanna southwards.

Zone VI: The high percentage of occurrence of Rhizophora species. In this same was an indication that mangrove swamp vegetation has well established during the period covered by this section. These fluctuations in percentage occurrence of Rhizophora and Poaceae suggest a period of unstable environmental conditions which might be caused on the other hand by variations in the extent and intensity of the tidal flow resulting by fluctuation in the occurrence of Rhizophora and by extension mangrove vegetation on the coast as well as by drier conditions inland resulting in the absence of lowland rain forest and extensive expansion of savanna southwards.

6.1 Paleoecology and Paleoenvironments

Pollen and spores are generally dominant throughout the whole section (fig.4). Pollen and fungal spores show a high values, and aquatic elements (freshwater and marine together) are only important within certain formation (pollen) in the percentage diagram a clearer definition can be seen than using only presence/ absence data (fig.4). Dominant and less abundant show little variation across the section although pollen and spore is slightly more abundant in the location 3 to location 25, 16, and 26 (Elaeis guinensis – Echitriclopintes zone). Within location 23 and 24 were non deposit of pollen and spore palynormorph but with abundant of fungal spire and acritarchs which shows a clear distinctive characteristic of freshwater rain forest (Retistephanocolites gracillis) characteristic of the Benin formation are the mangrove elements, zonocostites ramonae and Psilatricolpollnites, the marine representative (foraminiferal test livings, dinoflagellate, acritarchs and diatom), indicating sedimentation incoustal and shallow marine environments, close to mangrove vegetation, although mere typical of freshwater environment, can also occur in slightly brackish water, due to its tolerance to salinity (Rull, 1997b). The main palynomorph that characterize the Nsukka formation and member of the Maastrichtian are (Aletepollolmtes sp, Multiareocites formusus, Magnepericritites spinosus, Psilatricolporites sp, Echitricolporties spinosus, Retidiporites magdalenensis, Constructripollenites effectus, Echimonomocolpitee rarispinosus. This is consistent with the presence of alluvial plain environments environments flooded by freshwater. From the vegetation point of view, the Benin formation with age Miocene – Pliocene, it is considered to be a mangrove assemblage which show a high numerical count of zonocostites ramonae which is compose of palynonurph of vegetation flooded by fresher low salinity water and is characterize by transitional / tidal zone environmental conditions (fig.5). But fungal spores represent another type of coastal swamps (palm/ fern swamps common in the Neotropics). In the freshwater swamp/ rain forest of alluvial plain beyond the limit of tidal influence. Therefore, this assemblage is thought to represent the more inland vegetation required in this research work the pollen from mangroves was believed to have substantially increase to a very high grains, probably transported landward by wind: the first zone which is Echitricolpontes spinosus; therefore, the
significant could be due to environment and evolutionally factors (fig.5), considering that (1) it could have originated in these environments, (2) the major transport agents for playnomorphs in alluvial plain are wind and (3) were deposited in more distal environments freshwater swamp/ rain forest, this can be explained by an increased of wind capacity. Current paleogeographic reconstructions support these points. Therefore in the study area more work is needed to establish or infer a better formational history. Similar numbers of this pollen occur only inland, in freshwater environment, most probably due to wind transport (Muller, 1959).

7. CONCLUSION
This study of the palynological baseline data acquisition of middle to southern benue trough for forensic studies has characterized the environment and biological change that have taken place in the past. The goal of these works is to understand the event of the past, present and future behavior of the earth system using palynological tools. Accordingly, the most primary aim of this research work is to generate a baseline data of pollen and spores assemblages for forensic studies in Nigeria. The outcome result will serve as reference point or “baseline” for which further forensic studies could be carried out. It also shows that palynologic record and the environment have a direct relationship with respect to vegetation and climate. The study identified six pollen zones on which the palaeoenvironment and paleoecology were inferred; with the palaeoenvironment ranging from alluvial plain to transitional/tidal zone while the paleoecology is within the rain forest swamp to mangrove vegetation respectively.

PLATE 1: Palynomorphs Encountered In the Study
Fig. 3, 5 and 6: Fungal spore
Fig. 1, 2, 7 and 8: Cyperatollis sp
Fig. 4: Concentricyst circulus
Fig. 9: Echitriporites sp
Fig. 10 and 11: Polyadopollenites sp
Fig. 12 and 13: Elaeis gueensis

Figure 6: Summary chart of Palaeogeographical and percentage distributions of palynomorphs from north to south latitude, Towns, Paleoenvironment, Paleoecology and Zones.
REFERENCES


