



# Palynology of Late Miocene to Pliocene Agbada Formation, Niger Delta Basin, Nigeria

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## ARTICLE INFO

### Article history:

Received: 26 November 2012;

Received in revised form:

5 March 2013;

Accepted: 5 March 2013;

### Keywords

Palynozones,  
Miocene,  
Palynology,  
Microplanktons,  
Palynostratigraphy.

## ABSTRACT

A palynological study of forty ditch-cutting samples from CHEV-2 well drilled offshore in the Niger Delta showed that the sediments were mainly deposited during the Miocene age. Palynological assemblage was dominated by pollen and spores with rare occurrence of dinoflagellate cysts. The stratigraphic ranges of *Retitricolporites irregularis*, *Psilatricolporites crassus*, *Echitricolporites spinosus*, *Zonocostites ramonae*, *Foveotricolporites crassius*, *Monoporites annulatus*, *Psilatricolporites operculatus*, *Multiaerolites formosus*, *Podocarpus milanjanus* and some other marker species were used to demarcate five informal palynological zones in the study area.

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## Introduction

The Niger Delta Basin is economically important because of its petroliferous nature. The economy of Nigeria depends largely on the oil and gas derived from it. Up to 12km of Late Eocene-Recent deltaic and shallow marine sediments have accumulated in the triangular-shaped basin in a series of southerly prograding offlapping cycles (Michele *et al.*<sup>1</sup>). The combination of source rock, lithologic types, structures and thermal history of the basin are favourable for the generation, accumulation and retention of hydrocarbons (Whiteman<sup>2</sup>, Stacher<sup>3</sup>, Sonibare and Ekweozor<sup>4</sup>). Exploration activities started in the basin in 1937. This was rewarded in 1956 with the drilling of the first producing well at Oloibiri by Shell-BP, the sole concessionaire at the time (SNEPCO<sup>5</sup>). Nigeria joined the ranks of oil producers in 1958 when its first oil field (Oloibiri) came on stream producing 5,100 barrel per day (bpd). Though petroleum exploration has taken place in five major sedimentary basins in Nigeria, namely the Niger Delta, Benue Trough, Anambra, Chad and the Benin basins, all oil production to date has occurred in the Niger Delta Basin. Nigeria had proved oil reserves of 36.22 billion barrels and 5.29 trillion cubic metres of gas at the end of 2007 (Mbendi<sup>6</sup>). Niger Delta province is the tenth richest in petroleum resources in the world, with 2.92% of the world-discovered oil and 2.98% of the world-discovered gas (Petroconsultants<sup>7</sup>, Klett *et al.*<sup>8</sup>, Reijers *et al.*<sup>9</sup>, Mbendi<sup>6</sup>).

So far, the traditional exploration targets in the basin have been discovered and developed but the national target of four million barrels per day (bpd) and 40 billion barrels in reserve by the end 2010 was yet to be met. Hence the new focus of exploration should be towards the non-traditional targets such as stratigraphic traps, using high-resolution techniques like the integration of palynostratigraphic studies with other oil related disciplines (Well logging, Sequence Stratigraphy, Geophysics, Sedimentology and Petroleum Geochemistry) that can delineate subtle traps and accumulations to enhance the discovery and

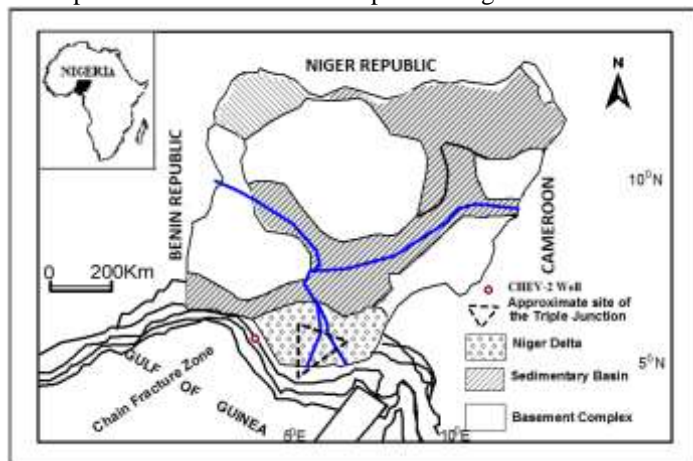
exploitation of petroleum. This will provide a more realistic information for predicting the lateral variability in reservoir/source rock quality than is possible with only the traditional lithostratigraphic and seismic stratigraphic approach. According to Morley<sup>10</sup>, stratigraphic resolution can be substantially improved through the application of quantitative palynological methods, which are aimed at the identification of events reflecting climatic, tectonic, orographic and sea level changes but without resulting in widespread extinction of plant taxa. Unfortunately, up till now, few papers were published on the stratigraphic values of palynological data in the Niger Delta basin, although an extensive amount of confidential data exists in the oil industry. The most comprehensive work to-date on the palynology of the Niger Delta is that of Germeraad *et al.*<sup>11</sup>. A few palynomorphs were illustrated by Van Hoeken-Klinkenberg<sup>12</sup>, Oboh<sup>13</sup>, Oloto<sup>14</sup>, Adebayo *et al.*<sup>15</sup>, and Ojo and Adebayo<sup>16</sup>.

This paper presents palynological data to elucidate the configuration of oil and/or gas bearing beds within that basin. This will lower the risks associated with oil exploration and production and provide a rational help for the expensive operations of petroleum prospecting.

## Geological Setting of the Basin

The present day Niger Delta Basin is located in the Gulf of Guinea in the southern part of Nigeria (Fig. 1). It lies between longitudes 4°E and 8.8°E and latitudes 3°N and 6°N. It occupies the coastal oceanward part of the Benue-Abakaliki Trough; hence its evolution has been linked with that of this larger sedimentary complex (Murat<sup>17</sup>, Reijers *et al.*<sup>9</sup>). Various authors have identified the Benue-Abakaliki Trough as the failed arm of the three radial rift systems that met at an R-R-R triple junction in the Gulf of Guinea that was active in early Cretaceous due to crustal doming (Burke *et al.*<sup>18</sup>, Burke<sup>19</sup>, Burke and Whiteman<sup>20</sup>, Lehner and De Ructer<sup>21</sup>). Niger Delta now occupies the centre of the triple junction. The Niger Delta Basin represents the third

cycle in the evolution of the trough and its associated basins. The first cycle (Aptian-Santonian) brought about the evolution of the trough as the failed arm of a rift triple junction (RRF-type) associated with the separation of South American and African plates (Burke and Whiteman<sup>20</sup>, Mascle<sup>22</sup>). Two platforms (Anambra and Ikpe) were formed on both sides of the trough during this period. The second cycle (Santonian-Eocene) began after the Campanian-Santonian folding episode. The Abakaliki Trough was uplifted to form Abakaliki Anticlinorium whilst the Anambra platform was downwarped to form the Anambra Basin (Murat<sup>17</sup>, Weber and Daukoru<sup>23</sup>) resulting in the westward displacement of the trough's depositional axis. During the Paleocene- Early Eocene, the upliftment of Benin and Calabar flanks initiated a major regressive phase. By the end of this cycle, rifting has diminished considerably. The third cycle (Eocene-Recent) brought about the development of the modern Niger Delta. The general agreement is that the present-day Niger Delta is built on oceanic crust. Evidence for this came from pre-drift continental reconstruction (Stoneley<sup>24</sup>) which indicates an overlap of northeast Brazil on the present Niger Delta.



**Fig. 1 Sedimentary Basins in Nigeria Showing the Niger Delta Basin and the Location of CHEV-2 Well (Modified from Whiteman<sup>2</sup>, Benkhelil<sup>25</sup>).**

#### Materials and Methods

A total of forty ditch-cutting samples from CHEV-2 well were prepared for palynological analysis. Cleaned, crushed and weighted samples (10g) were treated with HCl and HF following standard palynological preparation techniques (e.g. Faegri and Iversen<sup>26</sup>, Wood *et al.*<sup>27</sup>). Light photomicrographs were taken using an Olympus CH30 light microscope, equipped with a camera. Preservation of the palynomorphs varies between good and excellent (see plate).

#### Results and Discussion

The studied sediments consist of shales and sands. The lower section (8950-5920 ft) is dominated by light to dark grey shales. The shaly content reduces gradually upward until the sediments became predominantly sandy between 4,240-1,600 ft (see chart). The heteroliths contain sands that are medium to coarse grained, angular to rounded and mainly moderately well sorted, although with fine to small pebbles and poorly sorted in a few places. There was the continuous occurrence of calcareous and ferruginous materials while muscovite flakes and shell fragments showed spot occurrences.

The palynological assemblage consists of pollen, spores (fungal and pteridophytic) and dinocysts. Rich and diverse palynomorphs species were recovered and concentrations are high, ranging from 245 to 31,650 (average, 7,328) grains/g. The

assemblage consists of pollen (92%), spores (2.5%), indeterminate species (1%), Botryococcus (3.9%) and fungal spores (1.40%). There are rare occurrences of microplanktons (dinoflagellate cysts and microforaminiferal wall lining) (see chart).

The recovered palynomorphs were dominated by angiospermous pollen. The angiosperms consist of several species of *Tricolporites*, *Stephanoporites*, *Stephanocolpites*, *Echaporites*, *Monocolpites*, *Monoporites*, *Striatricolporites* and *Brevitricolporites* (see chart and plate).

#### Palynostratigraphy

The palynostratigraphic analysis was based on the works of Evamy *et al.*<sup>28</sup>, Morley<sup>29</sup>, Morley and Richards<sup>30</sup>. The correlation of the informal zones established in the well with that of Evamy *et al.*<sup>28</sup> enabled the recognition of P800 zone. This zone was further subdivided into P850, P860, P870 and P880 subzones with high degree of reliability using the recovered palynomorphs. Floral zones M2, M1, P1-P2 and P1-P0 of Morley and Richards<sup>30</sup> and Morley<sup>31</sup> were also recognized. The established zones are designated 'JM' and 'JP' as in Ojo and Adebayo<sup>16</sup>. They are:

#### **JM7 ZONE (8,950-8,350FT); P800 zone, subzone P850, Late Miocene**

The base of this zone was marked at 8,950ft, being the base of the analyzed interval in the well. The top of this zone was defined by a marked maximum and the uphole decrease of *Monoporites annulatus*. The zone is characterized by the acme of *Foveotricolporites crassiexinous*, high proportion of *Pachydermites diderixi*, abundance of *Triorites* spp. and *Striatricolporites catatumbus*. The zone was subdivided into JM7a and JM7b, in ascending order, using the base occurrence of *Foveotricolporites crassiexinous* at 8,850ft and peak event of *Carapa procera*.

#### **JM8 ZONE (8350-7900FT); P800 zone, subzone P850, Late Miocene**

The base of this zone was defined by a marked maximum and the uphole decrease of *Monoporites annulatus*. The top was recognized by the top occurrence of *Racemonocolpites hians* and quantitative event of *Nymphaea lotus*. The defining feature of this zone is the base regular occurrence of *Elaeis guineensis*, quantitative base of *Uacapa acuminata* and base occurrence of *Carapa procera* and *Nymphaea lotus*. The base occurrence of *Nypa* type (*Spinizonocolpites echinatus* – a Maastrichtian form), revealed the effect of reworking at this level.

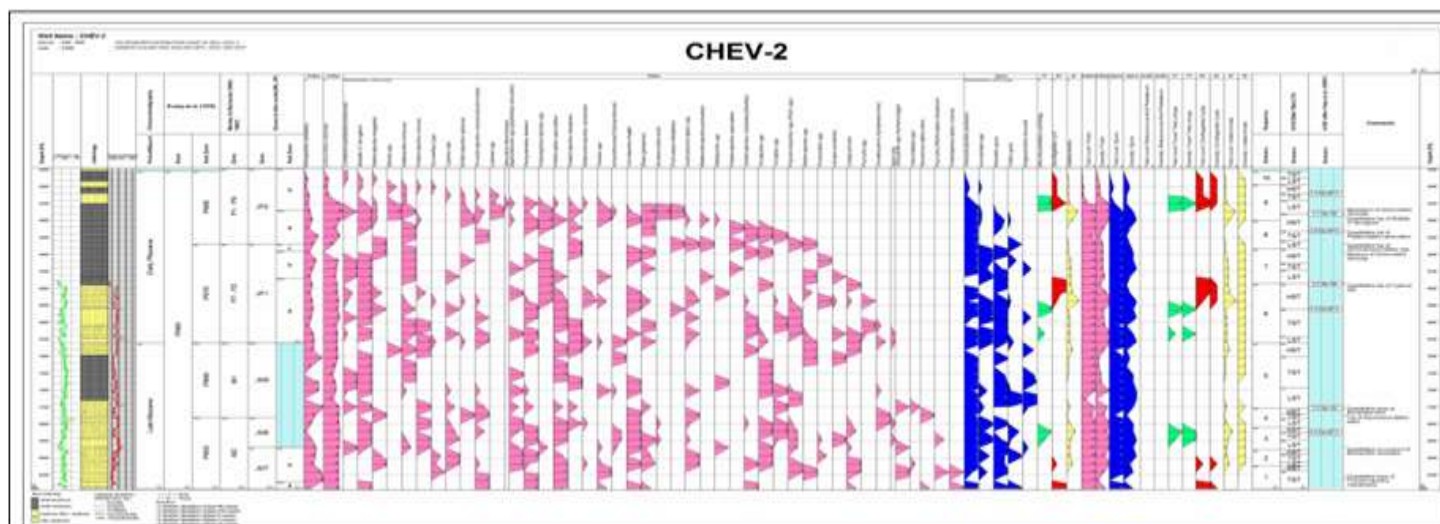
#### **JM9 ZONE (7,900-6800FT); P800, P860, Late Miocene.**

The base of this zone was recognized by the top occurrence of *Racemonocolpites hians* and quantitative event of *Nymphaea lotus*. The top was recognized by the quantitative top of *Nymphaea lotus*. Low occurrence of *Gemmamonocolpites* spp. and *Foveotricolporites crassiexinous*, and the maximum occurrence of *Multiareolites formosus*, *Psilatricolporites crassus* and *Tricolporites* spp. occurred within this zone.

#### **JP1 ZONE (6,800-5,350FT); P800 zone, subzone P870, Early Pliocene.**

The quantitative top of *Nymphaea lotus* defined the base. The top was marked by the quantitative top of *Gemmamonocolpites* spp. Characteristics: The zone was subdivided into three- JP1(a), JP1(b), JP1(c). Quantitative top of Cyperaceae marked the top of JP1(a) subzone while a low proportion of *Bridellia cf ferruginea* demarcated JP1(b) and JP1(c).





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