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# Palynology and Paleoenvironmental Studies of Kinnasar -1 Well in Bornu Basin, Nigeria

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## Abstract

Palynological analysis was carried out on ditch cutting samples obtained from Kinnasar-1 well penetrating the Gongila and Fika Formation of Cenomanian to Turonian age in the Bornu basin. Lithostratigraphic studies revealed that the well mainly intercept shale lithology. Based on palynomorphs associations, three main palynological zones was established in Kinnasar-1 well. Quantitative approach applied to paleoenvironmental reconstruction of the basin indicated a shallow non – depositional environment with moderately high content of terrestrial influence than the marine origin. The dominance of index species of miospores, pollen taxa and few dynocyst are indicative of marginal marine environment. However, the predominance of shallow marine environment is attributed to strong terrestrial influence and weak marine dynocyst.

**Keyword**: Palynology, Cenomanian, Turonian, Paleoenvironment

## 1. Introduction

The Federal Government of Nigeria in pursuance of exploration activities in the Nigerian inland basins are sourcing for relevant information for a successful location of productive wells in the region. A notable number of oil wells has been drilled by the Nigerian National Petroleum Corporation through its frontier exploration services arm, National Petroleum Investment Management Services, with little or no single hydrocarbon discovery. Recently, the Chad Republic and Sudan, which are of the same rift trend with the Nigerian Chad Basin (Bornu basin) has commercial accumulation of hydrocarbon.

A number of palynological studies have been reported in order to reduce exploration risks and also solve quite a number of lithological and paleoenvironmental issues. Several authors such as Okosun, (1992); Ola et al. (2017); Mc carthy et al. (2011); Asadu et al. (2016); Ola – Buraimo and Abdulganiyu (2017) and Adepehin et al. (2021) had reported and provided relevant information on the palynological studies of the Bornu basin. This study tends to support and contribute to existing information. Efforts will also be geared towards providing lithostrastigraphic framework, establish different biozonations, date the palynomorph assemblages and reconstruct the paleoenvironment of the studied wells.

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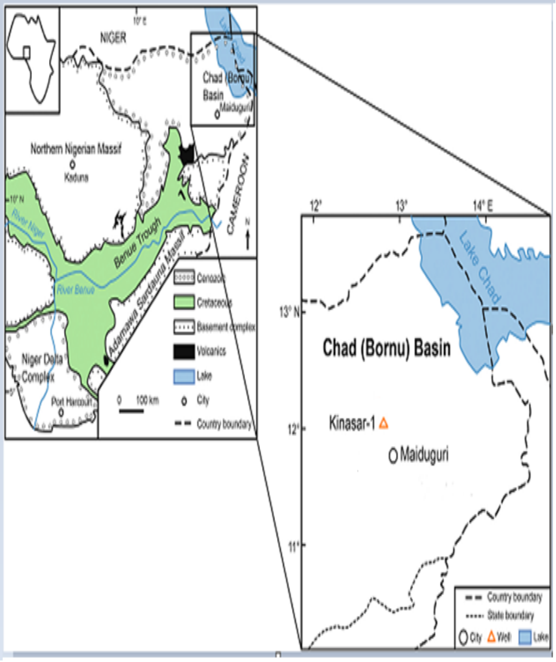


Fig. 1: Geological map of Nigeria showing the Bornu Basin (*After* Whiteman, 1982).

Table 1: Stratigraphic succession for the Chad (Bornu) Basin NE, Nigeria (Okosun, 1995; *et al.*, 2004a)

| Age | Thickness (m) | Formation | Lithology | Depositional Environment |
|---|---|---|---|---|
| **Quaternary** | 400 | Chad | Clay, with Sand interbeds | Continental |
| **Paleocene** | 130 | Kerri –kerri | Predominantly Iron – rich Sandstone and Clay with plinth of laterite | Continental |
| | | **UNCONFORMITY** | | |
| **Maastrichtian** | 315 | Gombe | Sandstones, siltstones and Clay beds | |
| **Turonian - Santonian** | 590 - 1850 | Fika | Dark grey to black Shale, gypsiferous with limestone beds | Marine |
| **Turonian** | 750 - 1920 | Gongila | Alternating limestone and Shale with Sand beds | Marine – Estuarine |
| **Albian - Cenomanian** | 800 | Bima | Poorly Sorted feldspathic Sandstone | Fluvial |
| | | **UNCONFORMITY** | | |
| **Precambrian** | - | Basement complex | | |

## 1.1 Geology and Stratigraphic Settings of the Bornu Basin

The Chad basin is the largest intracratonic rift basin in Africa (Matheis, 1976) covering an area of about 233,000km$^2$ (Fig. 1). It spreads to part of the Republic of Niger, Chad Republic, Cameroon and the Central African Republic (Obaje *et al.*, 2004) and the stratigraphy of the Chad basin has been documented by several authors such as Barber and Jones (1960); Carter *et al.*, (1963); Kogbe, (1972); Avbovbo *et al.*, (1986) and Mathies (1976) (Table 1).

## 2. Materials and Methods

This study focused on Gongila and Fika Formation of the Cenomanian, Turonian to Santonian sediments. Samples were collected from Geological survey, Kaduna, Nigeria and the portion logged intercepts mainly shale lithology. The palynological study is based on ten (10) samples of shale in the exploratory well of Cretaceous sediment. The lithological description of the shale samples was done through composite logs supplied. The lithostratigraphic column for the well was then constructed based on description made. The samples were prepared for palynological analysis according to standard extraction techniques involving HF and HCI treatments, wet sieving with 10µ polyester sieve and mounting on glass slides using glycerine jelly. The palynomorphs recovered were counted whilst identification and description were made for as many forms as possible. The recorded palynomorphs on the log analysis sheet were transferred into the computer for chatting using Stratabug biostratigraphic software.

## 3. Result and Discussion

The results of lithological description are presented in Fig. 3. The Late Cretaceous sediments of Chad (Bornu) basin generally show shale lithology with increase in depth. The shale is pronounced bulky and dark to grey in colour dominating the lower part of the sequence in the studied section of the well. The Cenomanian – Turonian sediments under investigation were encountered in the Kinnasar-1 well. (Fig. 3). The stratigraphy of the well from the present study is only one litho unit. As earlier recorded, the interval under investigation is the Gongila and Fika Formation and therefore there is a general increase of shale content with increasing depth. In Kinnasar-1 well, the Litho unit varies from 1500m – 4635m. This unit is viewed as shale unit (Fig. 3). The shale is a thick continuous sequence with shale unit of 98%. The shale is dark grey in colour and laminated. It is rare in mica flakes and shell fragments. The studied interval is fossiliferous and it yielded both land and marine palynomorphs that is used to depict the age and paleoenvironment of the interval. However, the studied interval is 3135m thick.

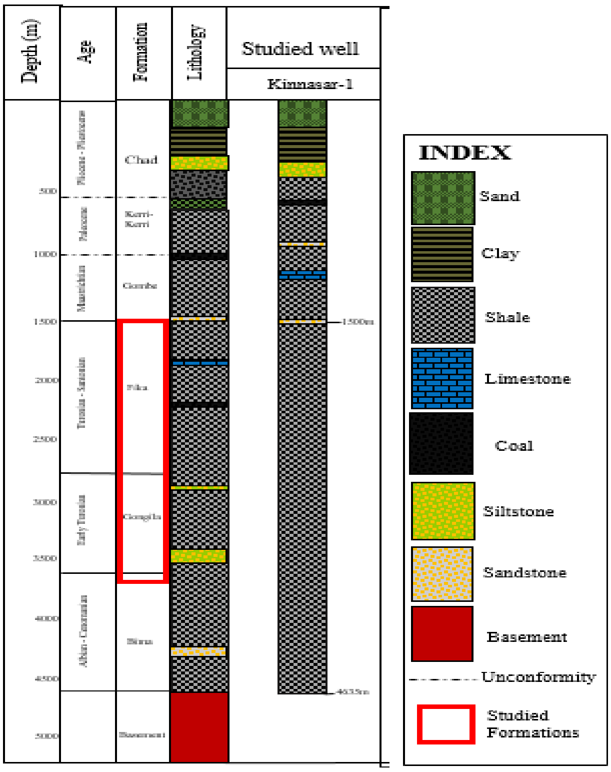


Fig. 3: Lithological Section of Kinnasar-1 well

### 3.1 Palynostratography

Palynological studies of the Cretaceous sediments of Cenomanian to Turonian age was examined and about 85% of the analyzed samples in Kinnasar-1 well yielded abundant, diverse and well-preserved pollen, spores and dinoflagellates at all depth intervals. The palynological interpretation of the analyzed interval was based on marker species and the palynological zones. The characteristics of each zone are described as follows:

#### 3.1.1 Palynoflora Biozonation (Kinnasar – 1 well, 1500 – 4695m)

The Cretaceous stages (Albian to Turonian) were subdivided into three (3) informal zones each for pollen, spores and dinoflagellate. The zonal scheme recognized in the Kinnasar-1 well (1500 - 4635m) namely; the *Elaterosporites* sp. (CBI), *Classopollis* sp. (CBII), *Cretacaeiporites* sp (CBIII) palynozones based on Top First Downhole Occurrence (FDO) (Fig. 4) which range from Albian to Turonian in age (Lawal and Moullade, 1986; Salard-Cheboldaeff, 1990).

#### 3.1.2 Pollen and Spores Zonation

##### 3.1.2.1 ***Elaterosporites sp. (CBI) Zone*** (3270m - 4635m)

***Age***: Early Cretaceous (Albian)

***Characteristics***: This biozone is the oldest in the well. The base occurrence of *Elaterosporites* sp. was not encountered as at the last sample analyzed and as such the base of the zone is stratigraphically deeper than the last sample analysed at 4635m. The top is defined by the top occurrence of *Afropollis* sp. and *Triorites africaensis* at 3270m (Fig. 5). The occurrences of Hexaporotricolpites sp., Triorites sp., and Araucariacites australis (Plate 1) also characterized this zone. The Elaterosporites sp. (CBI) is correlated to the Afropollis jardinus - Hexaporotricolpites potoniei combined zones of Lawal and Moullade (1986) and assemblage zone of Salard -Cheboldaeff (1990). According to Brenner (1963) Elatere bearing form were reported in Albian to Cenomanian of Brazil, Senegal, Ivory Coast, Algeria, Gabon and Nigeria have high diversity. Kotova (1978) also used the Elasterosporite sp in the Eastern North Atlantic to date sediments as Albian to Cenomanian.

#### 3.1.2.2 ***Classopollis* sp. (CBII) Zone (**2050-3270m)

***Characteristics:*** The *Classopollis* sp. (CBII) zone correlates with the *Triorites africaensis* zone of Salard - Cheboldaeff 1990) and Lawal and Moullade (1986) palynological zones. Afropollis sp. is a characteristic and the main marker species for this zone. It has been recorded for the first time in the lower to middle Cenomanian deposit of Northern Gondwana (Doyle *et al.*, 1982). It marks the base of the studied interval and it shows a continuous regular occurrence (Fig. 4). This occurrence corresponds to the northeastern part of Cyrenaica shelf of Nigeria where Lawal and Moullade (1986) documented Afropollis sp. and Hexaporotricolpite sp. with an age not younger than early to middle Cenomanian in the lower part of the zone in the Upper Benue Trough. Jan du Chene and Salami, (1978) and Jan du Chene, (1998) also inferred that the Upper Albian sediment have been recognized based on palynological studies.

### 3.1.3 Dinoflagellate Zonation (1500m - 2050m)

#### 3.1.3.1 ***Cretacaeiporites* sp. (CBIII) Zone**

***Characteristics:*** This is the youngest palynozone in the study and is further characterized by the occurrence of *Tricolporopollenites* sp., *Monocolporopollenites* sp. and *Cyathidites australis* (Fig. 4). The dinoflagellates (Plate 1) include the Polysphaeridium sp. at interval of 1500m – 1560m, Spiniferites sp. at depth of 2350m - 2360m while the Cretaceaporite sp. at interval of about 3270m – 3280m (Fig. 5). In addition, common records of dinoflagellate cysts such as *Heterosphaeridium* sp., *Polysphaeridium* sp., *Florentina* sp., *Oligosphaeridium complex* and *Subtilisphaera* sp. were also identified. According to Lawal and Moullade (1986) Triorites sp. and Cretacaeiporite sp. were discovered in the Upper Albian to Lower Cenomanian deposit of the Senegal and Ivory Coast. Polysphaeridium sp and Spiniferites sp (Plate 1) which were defined in the Upper Albian to Lower Cenomanian deposit of the Senegal and Ivory Coast and it indicate a period of marine incursion (Lawal and Moullade, 1986).

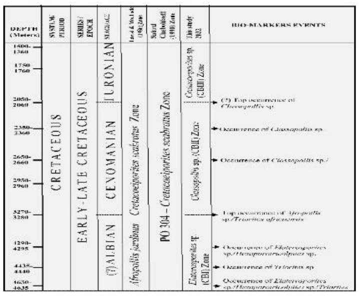

Fig. 4:Palynological Zones well

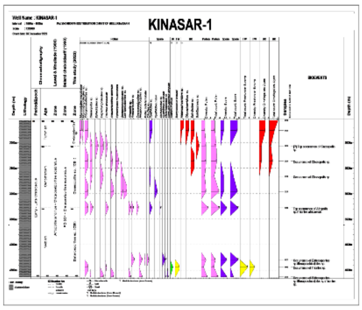


Fig. 5: Palynomorphs Distribution Chart

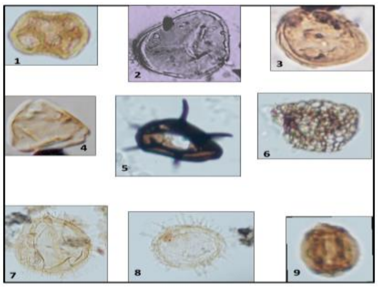

Plate 1: Photomicrographs of Palynomorphs (Mag. X400)

*1. Cretacaeiporites sp. (3270 – 3280m) 2. Cyathidites australis (1500 – 1560m) 3. Classopollis sp. (2050 – 2060m) 4. Triorites africanensis (3270 3280m) 5. Elasterosporites sp. (4290 – 4295m) 6. Afropollis sp. (3270 – 3280m) 7. Spiniferites sp. (2350 – 2360m) 8. Polysphaeridium sp. (1500 – 1560m) 9. Hexaporotricolpite sp. (4290 – 4295m)*

### 3.2 Paleoenvironmental Interpretation

Palynological data have been discovered as an important paleoenvironmental synthesis tool (Petters and Edet, 1996; Ojo, 1999; Ojo and Akande, 2009). The paleoenvironment of the Formations can be reconstructed by evaluating its palynological attributes. This is as a result of environmental changes reflected in palynological assemblages and are particularly shown in composition and relative proportion of different classes of palynomorphs (Ikegwuonu *et al.,* 2020). The pollen and spores in the studied well are also considered as one of the important constituents of the total palynomorphs content compared to dynocysts. These terrestrial palynomorphs content compared to dynocysts can be used as substantial indicators for paleoenvironmental reconstruction (Tyson, 1995; Tahoun *et al.*, 2017 and Mansour *et al.*, 2018). The paleonvironmental interpretations with the understanding of pollen and spores produced from strong terrestrial condition derived its source far off the shores into water bodies (lakes and oceans) as their marine counterpart could only have been brought to transitional environment by storms and creeks (Traverse, 1984 and Oboh-Ikuenobe *et al.*, 2005). The total palynomorphs assemblage obtained from the exploratory well (Kinnasar -1 well) studied are generally characterized by pollen, spores and dynocysts. The pollen and spores' taxa are derivative of land plants while the dynocysts are sourced from marine species. The pollen taxa such as Classopollis sp. Afropollis sp. and Hexaporotricolpite sp. suggests a shallow non – marine depositional environment (Njoh *et al.,* 2015). The index species of miospores in the well such as Triorites Africanensis and Elasterosporite sp. which are essentially the palynomorph assemblage is noted with moderately high content of land derived miospores of terrestrial influence. The dynocyst such Polysphaeridium sp. Spiniferite sp. Cretaceiporite sp. in the Kinnasar -1 well are indicative of marine origin. Further data analysis suggests that combined pollen and spore percentage for Kinnasar-1 (1500m – 4635m) well is approximately 90% while the dinoflagellate is 10%. This is evident from high dominance of miospore and pollen taxa with abundant of fresh water fern spore over the marine microplankton in the studied well. The studied samples particularly from the well has higher percentage of miospores species, pollen taxa than the marine species indicating deposition in the marginal marine or brackish water condition probably in a proximal estuarine environment whereas all the miospores species, pollen taxa are terrestrially derived while the dynocyst are of marginal marine settings (Ikegwuonu *et al.*, 2021).

## 4. Conclusion

Lithologically, the studied sections penetrated only the shale lithology with increasing depth. Palynological studies suggest that the palynomorphs recovered include miospores such as Triorites Africanesis and Elaterosporites sp. The pollen taxa include classopollis sp and Hexaporotricolpites sp., and occurrence of few dynocyst such as Cretacaeiporites sp. are in Cenomanian to Turonian age. The palynomorph assemblage is noted with moderately high content of land derived miospores and pollen taxa of terrestrial influence while the dynocysts are sourced from marine species. The paleoenvironmental studies are indicative of marginal marine environment.

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