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Palynostratigraphy and Age Determination of Bima Formation, Yola Basin, Northern Benue Trough, North East Nigeria

Fatima Saidu[1]*, Abubakar Sadiq Maigari[1], Bappah Adamu Umar[2], Timothy Peter Bata[1], Abdulkarim Haruna Aliyu[2], Nuru Abdullahi Nabage[1], Mohammed Mohammed[1], Yusuf Abdulmumin[1], Mustapha Aliyu[1], I. I. Kariya[1]

[1]Department of Applied Geology,
Abubakar Tafawa Balewa University,
Bauchi.

[2]National Centre for Petroleum Research and Development,
Abubakar Tafawa Balewa University,
Bauchi.

Email: sfatima@atbu.edu.ng

Abstract

Bima Sandstone which is known to be from Early Cretaceous is the oldest formation that has been identified in the Northern Benue Trough. Bima Formation whose age has been studied by several authors is known to be Aptian – Albian and older but no specific age has been pegged for the older sediments which has created a need for more work to be conducted on it. This study used cuttings from two boreholes, to enable a thorough investigation of the palynological content of Bima Formation and its age. A palynostrtigraphic studies was conducted on sediments of Bima Formation penetrated by of Tula 1 and Tula 2 boreholes. A total number of 64 spores, pollens and dinoflagelates species were recovered from 150 borehole cutting samples. These species comprise of 33 spores, 25 pollen, and 6 dinoflagellates. In terms of age determination species like the Afropollis zonatus and Afropollis operculatus are significant marker palynomorphs of Aptian age while Afropollis jardinus, and pollens like the Elaterosporites verrucatus and Elaterosporites klaszii indicates an age not older than Albian. Concavissimisporites punctatus, Elaterosporites Klaszii, together with Oligosphaeridium complex support an Aptian/Albian age. The presence of Appendicisporites spp., Cibotiumspora fuxingensis, Cicatricosisporites sinuosus, Gnetaceapollenites barghornii, and Clavatipollenites hughesii which are guide stratigraphic markers of Barremian sediments confirm the older Bima Formation sediments to be of Barremian age. Presence of Ephedripites is related to Barremian age, the abundance of Ephedripites aegyptiaca and Gnetaceapollenites barghornii, is an indication that the sediments is not older than Barremian.

Keywords: Bima Formation, Barremian, Aptian, Albian, Palynologicaly

INTRODUCTION

The use of palynology and palynostratigraphy to determine the age and correlation of sediments, is a method that has been accepted worldwide by palynologist and geologist in general. This is because most palynomorphs possess unique features that makes them suitable to be used as index fossils. The fact that palynomorphs occur in diverse environments, ranging

*Author for Correspondence

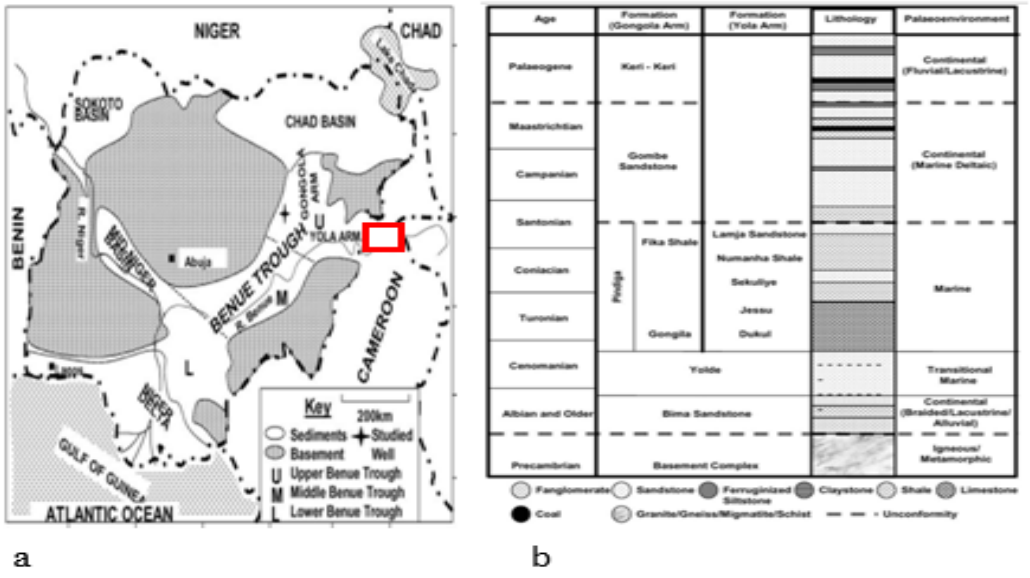
from the marine to the continental, is an added advantage over other methods of dating and correlation.

The non-marine Bima Sandstone is the name given to the continental intercalaire in the Upper Benue Trough of Nigeria. It was named by Falconer (1911) and described by Carter *et al.* (1963), whose work was the basis for subsequent reviews e.g., Guiraud (1990), Zaborski *et al.* (1997). Studies have been carried out by authors such as Akande *et al* (1998), Obaje (2004), Abubakar *et al* (2008), Tukur *et al* (2015) and Bukar *et al* (2020) on the Bima Formation in the Gongola Basin. The Aptian – Albian age has always been attributed to Bima formation (Allix *et al*., 1983; Guiraud, 1990). Although, many authors have suspected the presence of older sediments from Bima Formation, no definite confirmation has been made.

The stratigraphy and the age of Bima Formation were first proposed by Allix *et al*, (1983), to be from Aptian – Albian where he studied the basal argillaceous beds of the Bima Sandstone which yielded scant ostracod fauna and abundant microfloras, the latter being more stratigraphically diagnostic. Other workers such as Brunet *et al*, (1988) dated some rocks in the Mayo Oulo Lere Basin in the Northern part of Cameroun, which is also the lateral equivalent of lower parts of the Bima Formation, and assigned an age for the sediments to be Late Barremian. Poppof *et al,* 1983 and Baudin 1986 also dated some rocks in the Burashika Area of Gongola Basin, to be of Jurassic – Barriasian age.

The age of Bima Formation has hitherto been tagged as Aptian – Albian and older by all available literatures. This study intends to use palynological analysis to date the subsurface sediments of the two boreholes of the Bima Formation in the Yola Basin with a view to determining the specific age of the older sediments.

The Yola Basin is located in North Eastern Nigeria. It falls between latitude 90 45'N and 90 50'N and longitudes 110 50'E and 110 55'E. The basin has a border in the extreme north with the Bornu Basin and the Northwest with the Gongola Basin. Tula village where two boreholes were drilled, can be accessed off Gombe – Yola Road.



a b

Fig. 1. a. Generalized geological map of Nigeria showing the Benue Trough and the location of Yola Basin; b. Stratigraphic succession in Upper Benue Trough (After Abubakar 2006)

MATERIALS AND METHOD

Methods of field investigation

The methods used for the field investigation includes: Mapping along stream channels and road cuts to ascertain areas suitable for borehole drilling, location of the borehole points on the map with the help of the GPS, the boreholes drilled are up to a total depth of 50m and 100meters for Tula 1 and Tula 2 respectively and were sampled at an interval of 1m each. The samples were visually inspected for sedimentologic studies, and lithological logs of the boreholes were created. Physical attributes like texture, rock type and colour were recorded.

Palynology

The palynological preparation method of Batten and Stead (2005) was used to prepare the samples and also to recover the palynomorphs from the sediments that were investigated. 50 cuttings were taken from Tula 1 borehole and 100 samples were taken from Tula 2 borehole which were drilled at Tula village area which is part of Bima Sandstone in the Yola Basin. 20grams of each of the samples were prepared according to palynological techniques of Batten and Stead (2005). Each sample was treated with HCl (35 %) and kept for 24 hrs to ensure removal of all carbonates and HF (48 %) was added after 24 hrs so as to remove all silicates. After 24hrs, the sediments were diluted with distilled water and carefully decanted. After decantation, the remaining sediments were then washed thoroughly with distilled water which removes the flouro – silicate compounds formed due to its reaction with hydrofluoric acid. After which each sample was sieved with a 10 μm sieve mesh, the residues were then stained and prepared with glycerin jelly to produce palynological slides which were used for palynological analyses. Palynomorphs were then viewed and investigated in detail using a Nikon XPL 15 20B Biological Research Microscope. Residues of each sample were prepared and stored at the Centre for Petroleum Research and Development (NCPRD) ATBU Bauchi.

RESULTS AND DISCUSSION

Lithostratigraphy

The lithostratigraphy of the Tula 1 and Tula 2 boreholes was interpreted as shown in the lithology column of Figures 2 and 3. The Tula 1 borehole penetrated an alternating sequence of sandstone, mudstone and siltstone which shows that the sediments from the borehole belong to the Bima Formation. The lithology that predominates the uppermost layers is sandstone (1 - 30 m) of Tula 1 borehole and this is an indication that the uppermost layers of the section are the uppermost layers of Bima Formation. The lower Bima Formation starts from 30 - 50 m with thick mudstone portions (fig. 2). Similarly, the entire studied section (1 - 100 m) of Tula 2 boreholes with thicker shale and mudstones than the sandstone unit also belong to the lower section of Bima Sandstone (fig. 3)

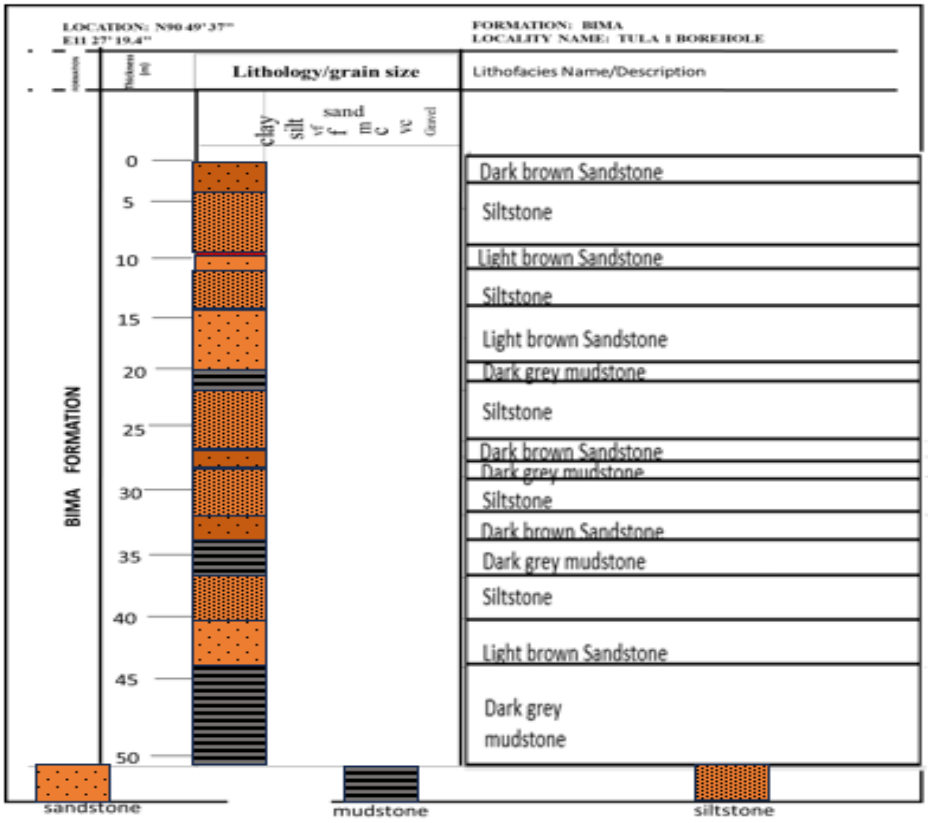


Fig. 2: Lithologic log of Tula 1 borehole section, Tula Village.

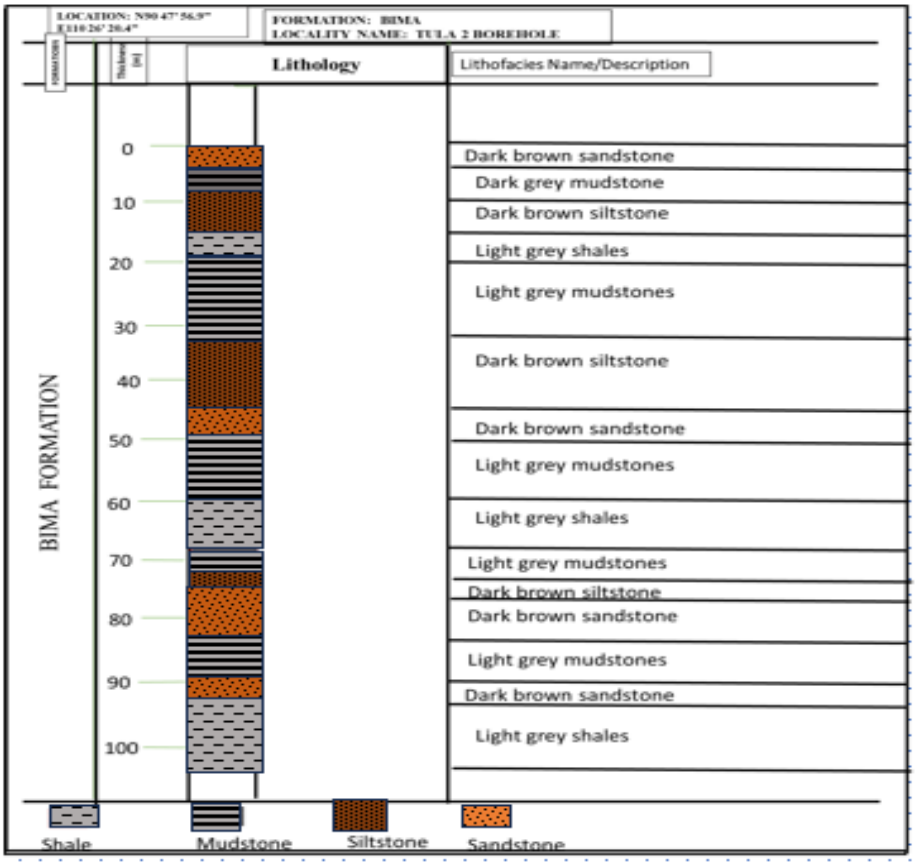


Fig. 3: Lithologic log of Tula 2 borehole section, Tula Village

Palynostratigraphy

From the investigated sections of the Tula 1 and Tula 2 borehole sections the palynomorphs recovery can be described as average - low abundance, which are well-preserved and diverse. The following notable and prevalent palynomorphs were discovered from the sediments gotten from the Tula 1 and Tula 2 borehole; *Circulodinium brevispinosum, Deltoidospora sp., Callialasporite turbatus, Elaterosporites verrucatus, cicatricosisporites spp., Cretacaeiporites polygonalis, , Crybelosporites pannuceus, Classopollis classoides, Afropollis zonatus Microfoveolatosporites skottsberghii, Matonisporites equexinus, Araucariacites australis, Stellatopollis spp., Ephedripites aegyptiaca, Dicheiropollis etruscus.* (Plate 1 and 2).

Microfossils encountered were studied and interpreted in detail; about 33 spores, 25 pollen grains, and 6 dinoflagellates were observed and classified according to the classification of Potonie` (1956) and Iversen and Troels-smith (1950). All the species which were identified were photographed using a light microscope camera (plates 1,).

150 samples were examined, and a palynomorph assemblage (64 species from 29 taxa) was found. An idealized succession of bioevents that accounts for sample intervals and natural variability is represented by the zonation. Numerous correlatable events of local and regional stratigraphic significance are reflected in the diversity and abundance fluctuation in the palynomorphs obtained from the investigated and analysed sediments. Numerous local consecutive palynological zones that could be traced regionally are constructed in part by these processes.

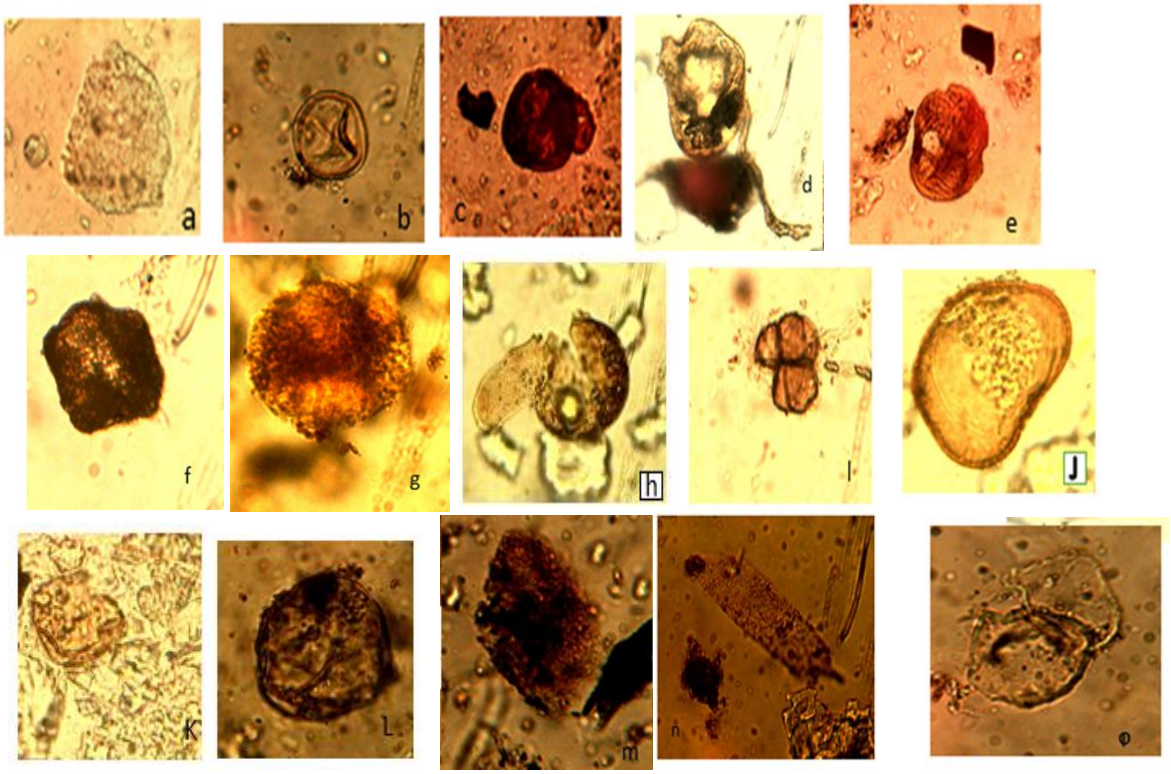


Plate 1: Photomicrographs of some recovered pollen and spores

a. *Circulodinium brevispinosum,* b. *Deltoidospora sp.,* c. *Callialasporite turbatus,* d. *Elaterosporites verrucatus,* e. *cicatricosisporites spp.,* f. *Cretacaeiporites polygonalis,* g. *Afropollis zonatus,* h. *Crybelosporites pannuceus,* I. *Classopollis classoides,* j. *Microfoveolatosporites skottsberghii,* k. *Matonisporites equexinus,* l. *Araucariacites australis,* m. *Stellatopollis spp.,* n. *Ephedripites aegyptiaca, o. Dicheiropollis etruscus*.

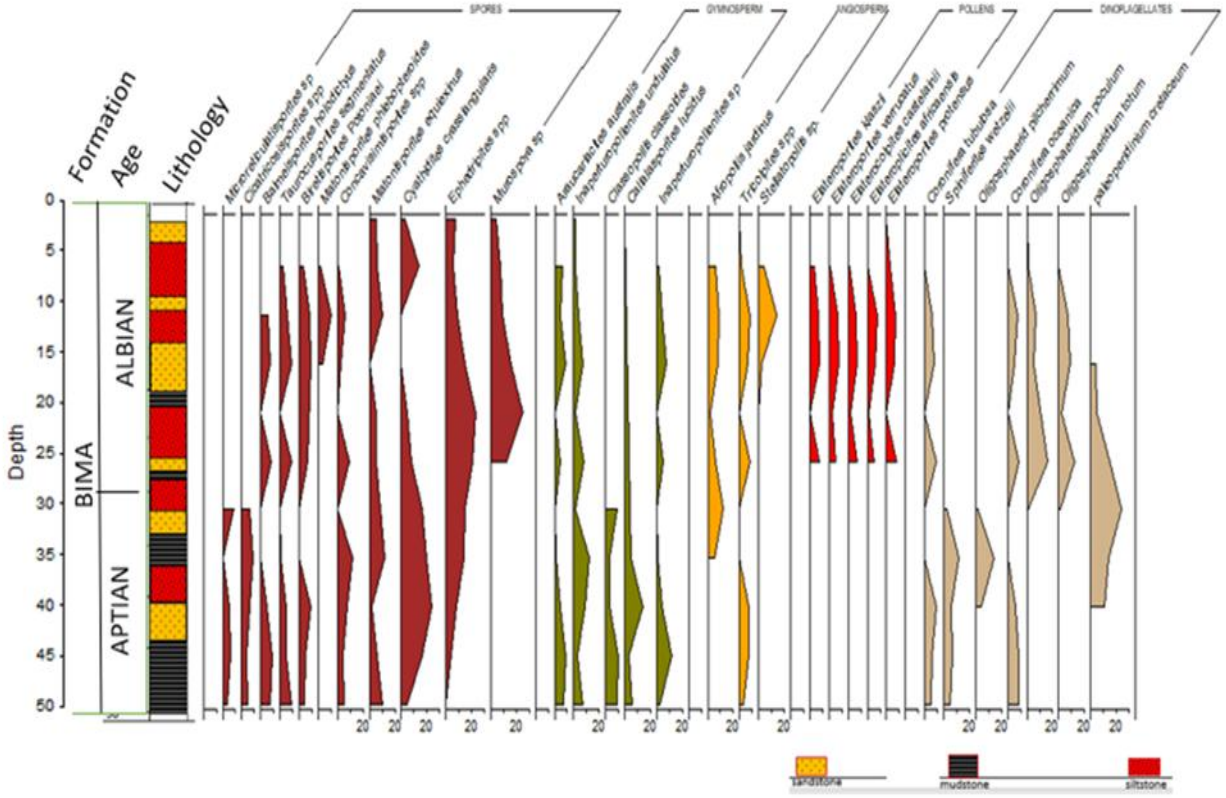


Figure 4: The Palynologic Distribution Chart of Tula 1 Borehole section showing the stratigraphic distribution of palynomorph

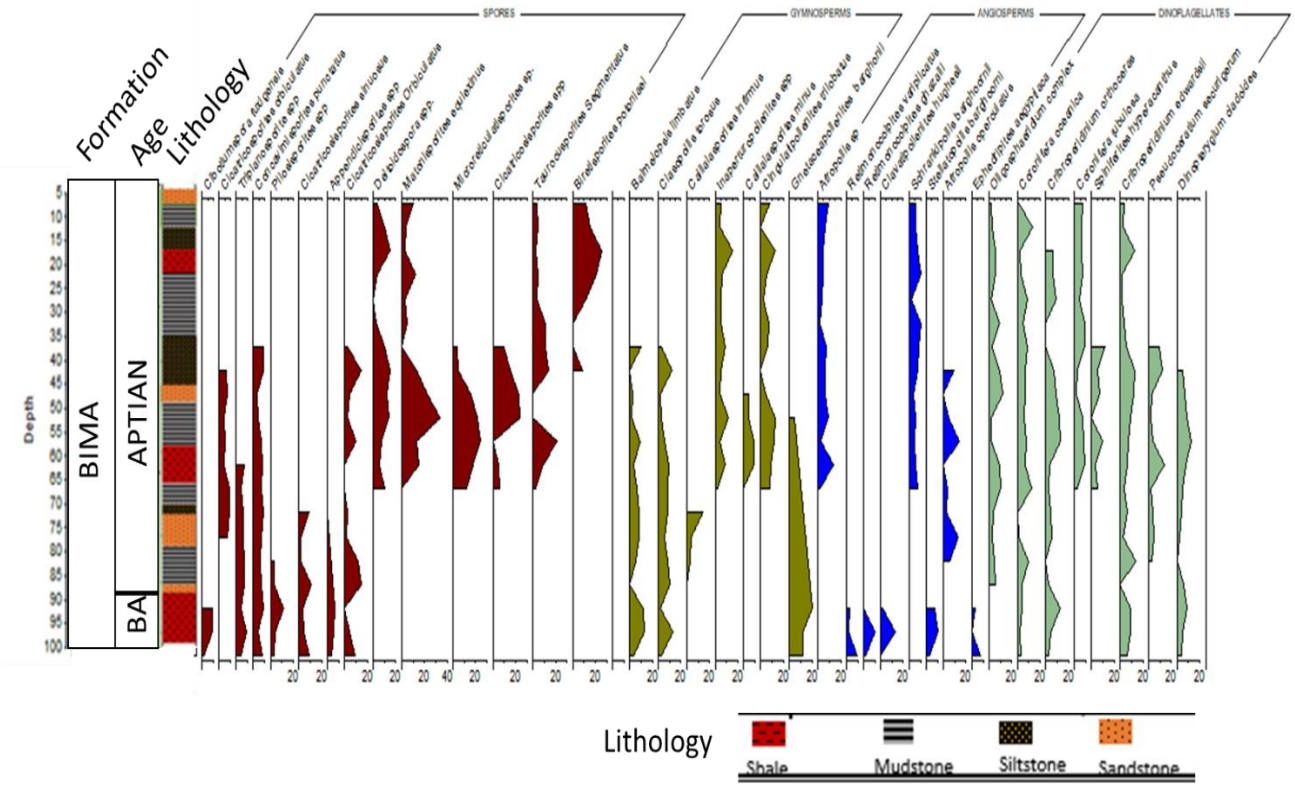


Figure 5: The Palynologic Distribution Chart of Tula 2 Borehole section showing the stratigraphic distribution of palynomorph.

Age Determination

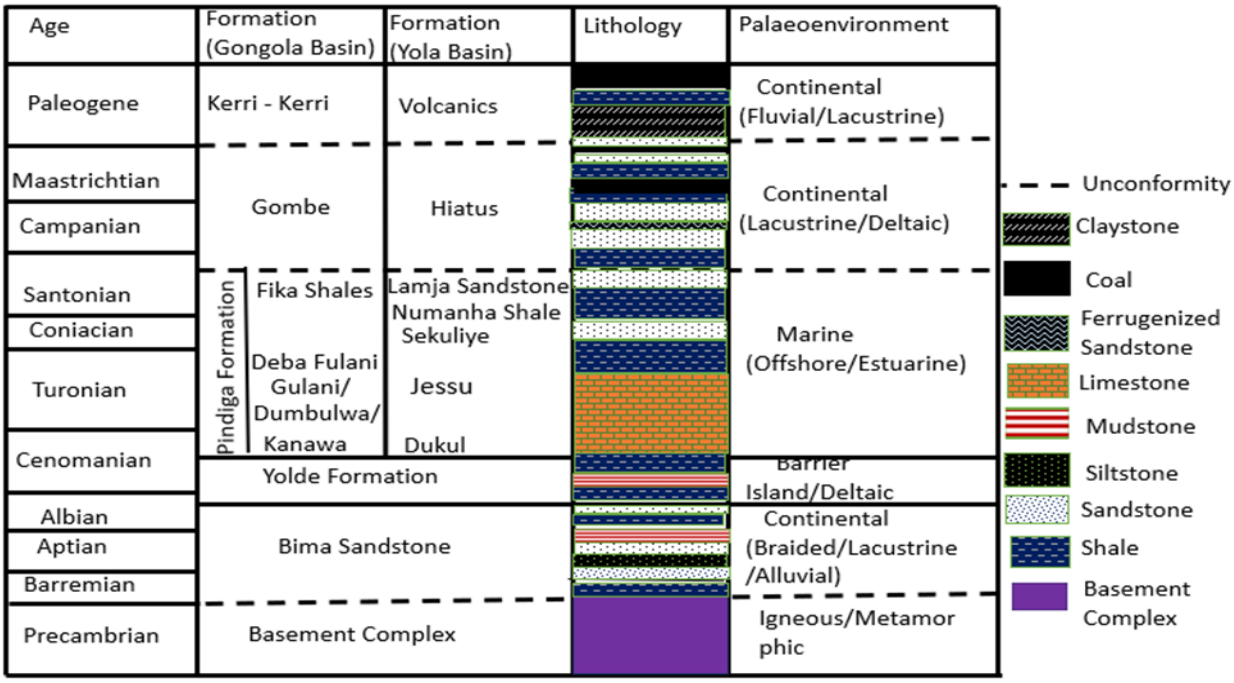


Figure 6: Stratigraphic Succession in the Northern Benue Trough showing the presence of Barremian sediments

Diagnostic palynomorph species and the relationship between them and contemporaneous assemblages are used in determining the age of the sediments obtained from the borehole. To deduce more precise interpretations, the index palynomorphs' highest appearance datum (HAD) is combined with others' lowest appearance datum (LAD). Figures 4 and 5 provide a summary of some biostratigraphic findings. Based on this study's new discoveries on the age and stratigraphy of the investigated Bima Formation in Yola Basin, A new stratigraphy of Northern Benue Trough has been reconstructed (fig. 6).

The apex of the interpreted Aptian period in the Tula 1 borehole is marked by Highest Appearrance Datum of Afropollis jardinus pollen, *Palaeoperidinium cretaceum* dinoflagellate, and *Balmeisporites holodictyus* and *Murospora* spores are important Aptian/Albian components in Egypt's regional palynofloras (Mahmoud and Moawad, 1999, 2002; Omran et al., 1990). Given the abundance of Cyathidites and Concavissimisporite punctatus, the fundamental palynological feature of some of the investigated stratigraphic layers can be viewed as a logical representation of palynomorphs found in the Albain period. The quantity of gymnospermous pollen *Araucariacites* has significantly decreased, while the main representative of angiospermous pollens is the rare *Afropollis jardinus*. The *Oligosphaeridium complex* is a good example of one of several kinds of dinoflagellates found in marine environments.

The consistent presence of *Concavissimisporites punctatus* combined with the preponderance of land-driven terrestrial microfloras of C*yathidites, Afropollis jardinus,* with some angiosperm pollen percentages were found to have significantly decreased, while gymnosperm pollen percentages, including those of *Afropollis australis,* were found to have significantly increased. These findings primarily summarized the palynological features of these sediments.

The commonest miospores in most of the sediments under investigation are cyathidites. The commonest angiosperm pollens in most of the sediments under investigation are

Retimonocolpites sp., Afropolis jardinus, and *Stellatopolis spp.* The three main gymnosperm pollen representatives are *Callialasporites turbatus, Afropolis australis,* and *Classopollis classoides. Concavissimisporites punctatus* is indicative of middle Albian, whereas *Concavissimisporites sp.* is suggestive of early Albian.

There are a few marine dinoflagelate cysts, including *Odontochitina operculata, Coronifera tubulosa,* and the *Oligosphaeridium complex.* The *oligosphaeridium complex* was found in northeastern part of Egypt (Ibrahim *et al*. 2002), and the late Albian of Canada (Singh 1971). According to Uwins and Batten (1988), the *Oligosphaeridium complex* last appeared in Later Albian.

During the Albian period, *Elaterosporites klaszii,* a significant palynomorph with potential Gnetalean affinities (Dino *et al*., 1999), entered the palynological records in South America and Africa (Herngreen *et al*., 1996). Age of not less than Albian is also supported by some other palynomorphs, like the *Cicatricosisporites sinuosus*, which was seen in this investigation (Omran *et al*., 1990). *Afropollis australis* and *Classopollis classoides* are two frequent gymnosperm pollens that indicates Albian age. This same particular taxon was found in late Albian from palynologically dated studies in Gabon and NE Nigeria (Lawal & Moullade, 1986).

The stratigraphic marker guide to some sediments in Neocomian Barremian age in Northern Gondwana and Australia, presence of *Appendicisporites spp., Cibotiumspora fuxingensis, Cicatricosisporites sinuosus, Gnetaceapollenites barghornii,* and *Clavatipollenites hughesii* in the investigated sediments was documented from numerous localities (Jardine *et al*., 1974; Doyle *et al*., 1977; Hoculi, 1981; Unwins and Batten, 1988; Ibrahim and Schrank, 1996, and Wagstaff *et al* 2020). -The Barremian age is associated with the prevalence of Ephedripites pollen (Sultan and Aly, 1986). - Using a comparable assemblage, Abdelmalik *et al*. (1981) came to the conclusion that it is of Barremian age due to the presence of *Ephedripites aegyptiaca* and *Gnetaceapollenites barghornii,* which was discovered in the investigated sediments.

CONCLUSION

The Tula 1 borehole section revealed a highly abundant and well-preserved palynomorphs, primarily composed of spores, pollen, and dinoflagellates, including some AOM and phytoclasts. The primary palynomorphs of the Bima Formation in the biostratigraphic analysis of the investigated sediments are representatives of the Afropollis association, the Murospora, and elaterospores. *Afropollis jardinus* with elater - bearing pollens like the *Elaterosporites klaszii* and *Elaterosporites verrucatus* indicates an age not later than Albian, whilst pollens like the *Afropollis zonatus* and *Afropollis operculatus* are characteristic of Aptian age.
The assemblages from the Tula 1 Borehole of the Bima Formation, which are identified by the *Oligosphaeridium complex, Elaterosporites Klaszii,* and *Concavissimisporites punctatus,* suggest an Aptian/Albian date. The assemblages from the Tula 2 borehole of the Bima Formation include *Retimonocolpites variplicatus, Retimonocolpites sp., Cibotiumspora fuxingensis, Cicatricosisporites sinuosus, Epheridipites aegyptiaca, Gnetaceapollenites barghornii,* and *Clavatipollenites hughesii*. These assemblages point to a Barremian/Aptian age, whereas those from Tula 1 Borehole of the Bima Formation, which are identified by *Concavissimisporites punctatus, Elaterosporites Klaszii,* and *Oligosphaeridium complex,* support an Aptian/Albian age, The investigated sediments from Bima Formation are suggested to be Barremian/Aptian/Albian in age based on previously stated grounds.

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