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Biostratigraphy and depositional environment of the sediments in Borno Basin, North Eastern Nigeria

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Abstract

A biostratigraphic study was carried out on 83 drill cutting samples retrieved from Kemar-1 well, Borno Basin, northeastern Nigeria. They were subjected to palynological and foraminiferal analyses to determine their biozonation, age and depositional paleoenvironments. The studied intervals ranged between 600 and 1745 metres and were sampled at 30- and 20-metre intervals for the palynological and foraminiferal analyses respectively. Lithologically, the drill cutting samples are made up mainly of predominantly grey to dark grey shale, sandy mudstone and silty mudstone. An igneous rock with argillaceous sandstone and argillaceous siltstone intercalations was also observed. Three major palynological assemblage zones were recognised in the study area. They are *Cretacaeiporites scabratus/mulleri* Assemblage Zone, which correlates with the basal sequence, *Droseridites senonicus* Assemblage Zone, and *Proteacidites dehaani/Dinogymnium euclaense* Assemblage Zone of the well section's upper part. Also, two foraminiferal biosequences were established for the studied interval. The environment of deposition of the well was generally shallow. It ranges from Coastal Deltaic in the upper part through Fluviomarine to Shallow Inner Neritic in the lower part of the Fika 'Shale' Formation. The age of the fossiliferous interval of the studied section of the well ranges from Early Turonian at the base to Early Campanian at the top. Three unconformities were observed and mapped within the studied section of the well at 790m, 1300m and 1700m. The unconformities were marked by noticeable faunal discontinuities, associated with reduction in paleowater depth and abrupt shift in the environment of deposition. Biostratigraphy is a valuable tool in oil and gas exploration when it is integrated with other geological and geophysical data sets, such as outcrops, seismic lines or well logs. This paper constitutes a significant contribution to the understanding of the biostratigraphy of Borno Basin, which is currently the focus of intensive hydrocarbon exploration activities.

Keywords: Biostratigraphy, Depositional environments, Bornu Basin, Fika "Shale" Formation, Turonian

Introduction

Borno Basin is one of Nigeria's frontier inland sedimentary basins which the Government currently targets for the expansion of the country's hydrocarbon exploration and production base and augmentation of proven reserves asset. It is the Nigerian part of the much larger Chad Basin which covers several African countries. To date, no commercial petroleum deposits have been discovered in the Borno Basin unlike in the Chad Basin parts in the neighbouring countries [Chad, Niger, and Sudan] with similar structural settings. This has prompted intensive studies in the area (Obaje *et al*., 2004). The Borno Basin is underlain by mostly Precambrian crystalline rocks, which are overlain by sedimentary and volcanic rocks of Cretaceous to Quaternary ages. The sedimentary rocks have a cumulative thickness of about 5 km. They consist of a thick basal continental sequence, overlain by transitional beds, followed by a thick Quaternary limnic fluviatile succession and Aeolian sands and clays (Matheis, 1976; Adegoke *et al*., 1978; Whiteman, 1982).

The integration of geophysical and other exploration techniques with biostratigraphy, well logs analysis, geochemistry, etc. has contributed enormously to oil and gas exploration all over the world (Payne *et al.,* 1999; Farley & Armentrout, 2000; Valenti, 2002; Giwa *et al.,* 2005). Biostratigraphy's application to hydrocarbon exploration and production is based mainly on foraminifera, palynomorphs, nannofossils, and other microfossil groups.

Compared to other Nigerian basins, Borno Basin's Cretaceous sediments biostratigraphy has not been adequately studied even though few published studies are available (Carter *et al*., 1963; Adegoke *et al*., 1978; Poppof *et al*., 1986; Adegoke *et al.,* 1986; Ola-Buraimo & Boboye, 2011). Poppof *et al*. (1986) investigated the Upper Cretaceous Gongilla and Pindiga Formations' ammonite assemblages and recognized seven ammonite zones in the Upper Cenomanian – Lower and Middle Turonian strata. Adegoke *et al*. (1978) dated the Kerri-Kerri Formation Paleocene on the basis of pollen and spores while Carter *et al.* (1963) age assignment to Kerri-Kerri Formation was based on Shell-BP Palynologists dating. The coal in the Kerri-Kerri Formation yielded palynomorphs on the basis of which Shell_BP Palynologists dated it Paleocene. Ola-Buraimo and Boboye (2011) also dated the Bima Formation based on the palynomorphs content. Other studies are documented in propriety reports belonging to the various oil companies.

This present study attempts a high-resolution stratigraphic differentiation of the basin's strata penetrated by Kemar-1 well (Fig.1) based on microfloral and microfaunal assemblages. Index fossils useful in delimiting locally defined zones and which provide a means of correlation with adjoining basins were identified

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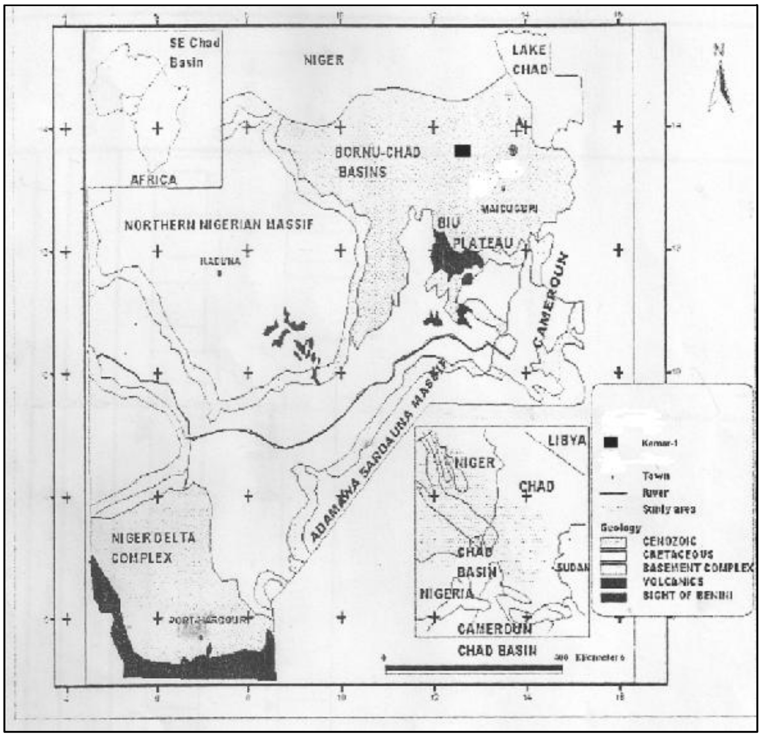
Fig.1. Geological Map of Nigeria showing the location of the Nigerian sector of the Chad Basin (Bornu Basin) and Kemar-1 well (Genik, 1993)



and employed. The strata's ages and depositional environments were also determined.

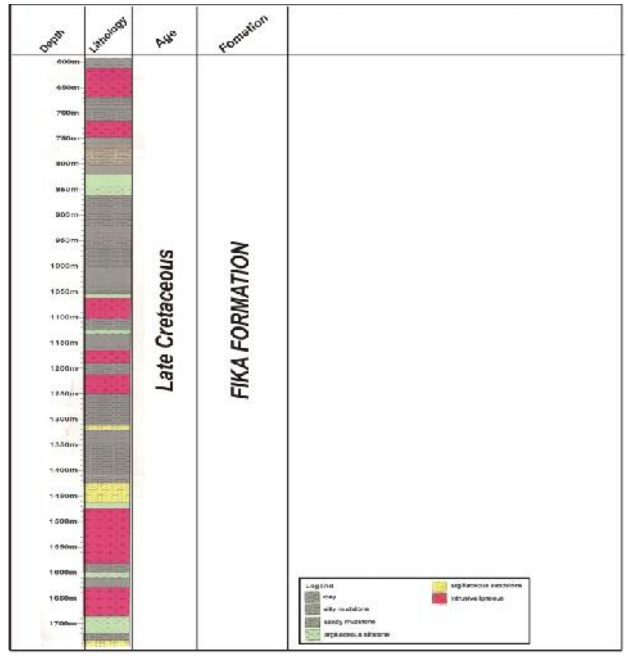
Geological background

According to Fairhead (1986), Chad (Borno) Basin belongs to the genetically and physically related systems of faults and rifts termed the West and Central African Rift System (WCARS). The System's origin is attributed to the breakup of Gondwanaland and the opening of the South Atlantic and Indian Ocean. The Benue – Chad axial trough is believed to be the third and failed arm of a triple junction rift system that preceded the opening of the South Atlantic during the early Cretaceous and the subsequent separation of the African and South American continents (Carter *et al*., 1963; Wright, 1968; Burke *et al*., 1972; Olade, 1975; Avbovbo *et al.,* 1986; Fairhead & Binks, 1991; Genik, 1992). The tectonic framework and evolution of the basin is divided into four phases:

Phase 1 – Pan African crustal consolidation (750 – 550 Ma),
Phase 2 – Early rift stage (130 – 95 Ma),
Phase 3 – Late rift stage (98 – 75 Ma), and
Phase 4 – Post rift stage (66 – 0 Ma).

The stratigraphic units represented in Borno Basin range in age from Albian to Recent (Adegoke *et al*., 1978; Avbovbo, 1980; Petters, 1981; Whiteman, 1982; Okosun, 1992, 1995). Deposition took place under varying conditions with each deposit representing one complete cycle of transgression and regression. It has been divided into six units based on the nature of sedimentary deposits within the depression. The divisions are Bima, Gongila,

Fig.2. Lithostratigraphic succession in Kemar-1 well



Fika, Gombe, Kerri-Kerri and Chad Formations. Structural features of the basin are mainly products of structural and tectonic events during Late Cretaceous times that shaped the basin. Odusina *et al*. (1983) pointed out that the geologic evolution of both the Borno Basin and the Upper Benue Trough are related. He identified four main structures, based on seismic line analysis, which are Intrusive features of either igneous or sedimentary origin, Mound structure growth faults and stratigraphic traps, Graben structures and growth faults, and Onlap sequences. Avbovbo *et al*. (1986) also identified two major structural styles based on seismic line. They are fold-related structures with low fold frequency and fault-related structures. The latter involve the basement and the resulting horsts and grabens with preponderance of high angle normal faults and paucity of reverse faults, indicating dominance of tensional movement.

Materials and methods

One hundred and eighty one drill cutting samples, provided by the Nigerian Geological Survey Agency (NGSA), selected between 600 and 1745 m interval of the Kemar-1 well were used for this study.

Lithostratigraphic analysis

A stereoscopic binocular microscope was used to describe the textural parameters of the samples. The lithofacies are mainly made up of predominantly grey to dark grey shale, sandy mudstone and silty mudstone. An intrusion of igneous lithology within the studied intervals with intercalations of argillaceous sandstone and argillaceous siltstone also occurs. Fig.2 shows a Lithostratigraphic log for the studied interval.

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Fig.3. Palynological distribution chart

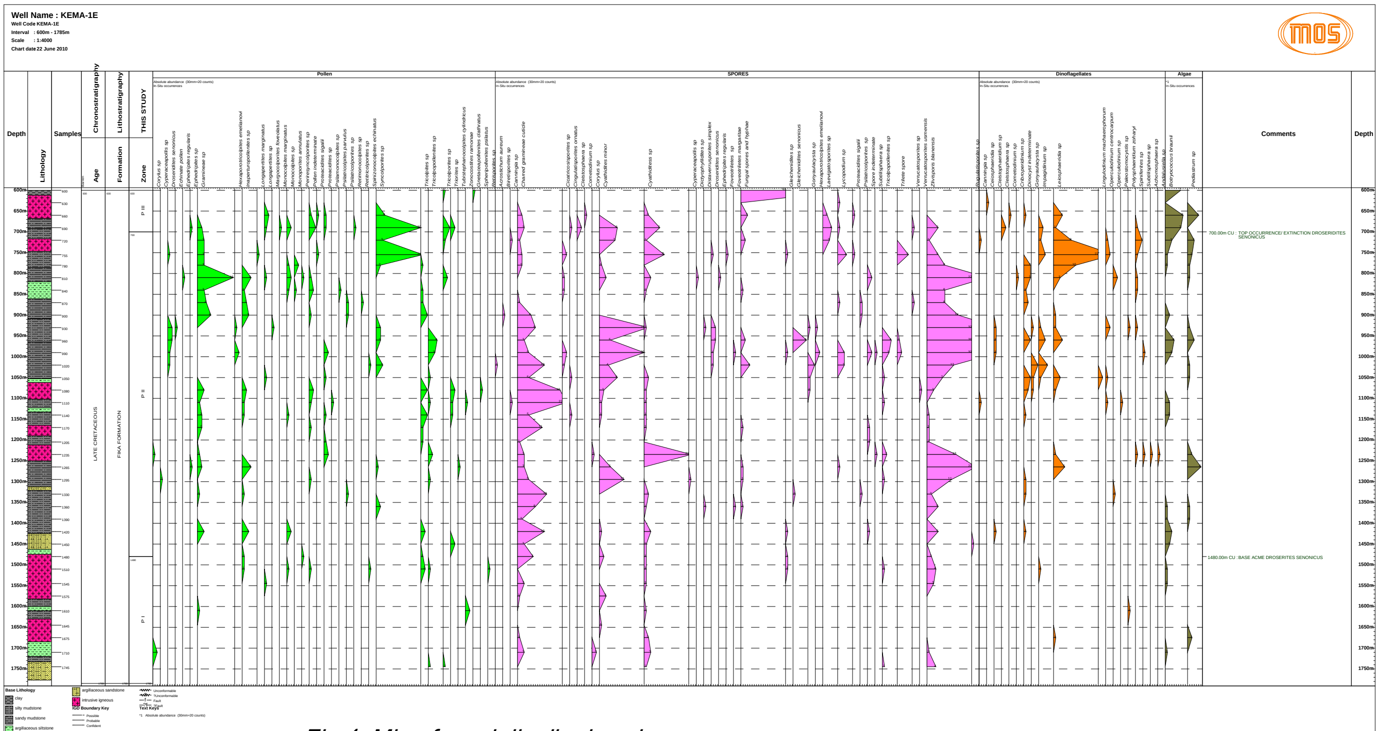
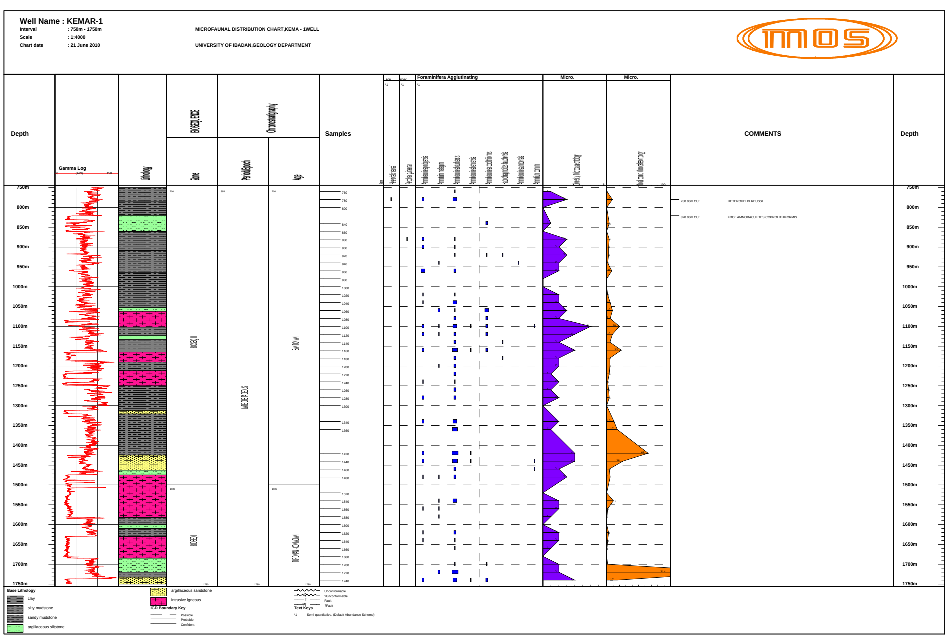


Fig.4. Microfaunal distribution chart



Palynological analysis

Thirty-eight ditch cutting samples composited at an interval of 30m, were analyzed for the palynomorph content, using International Standard for Palynological Analysis procedures (Brown, 1960; Staplin *et al.*, 1960; Faegri *et al.*, 1989; Moore *et al.*, 1991). These consisted essentially of treating the samples with 50% hydrochloric acid (HCl), concentrated hydrofluoric acid (HF), concentrated nitric acid (HNO_3) and 5% potassium hydroxide (KOH). The residues were washed in alcohol to remove the water content and mounted on slides (Traverse, 1988). The palynomorphs were analysed and identified with a high-power microscope. The well yielded a fairly rich and well preserved assemblage of pollen, spores, dinoflagellate cysts and freshwater algae. The identified microfloral taxa are presented in a distribution chart (Fig.3). Palynomorph abundance and species diversity and important biodatums made biozonation possible, while age determinations relied largely on index pollen and spores found.

Foraminiferal analysis

The studied samples were composited at 20m intervals to make the total of 45 samples, which were analyzed for foraminifera. They were soaked with kerosene and detergent solution, washed and oven-dried. Foraminifera and other accessory microfauna were picked from the washed samples employing a binocular microscope at X140 magnification (Petters, 1982; Fayose, 1970). The foraminifera were identified following classification of Bolli and Saunders (1985) and Leoblich and Tappan (1988). Few but diverse assemblages of planktic and benthic foraminifera were recovered from the samples, which are presented in a microfaunal

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Fig.5. Palynomorphs Zones recognized in Kemar-1 well

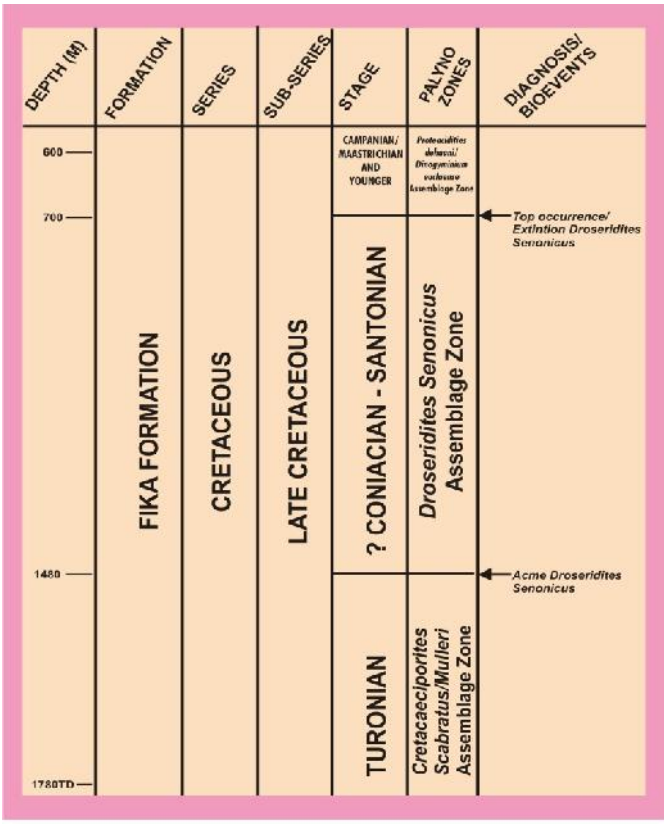
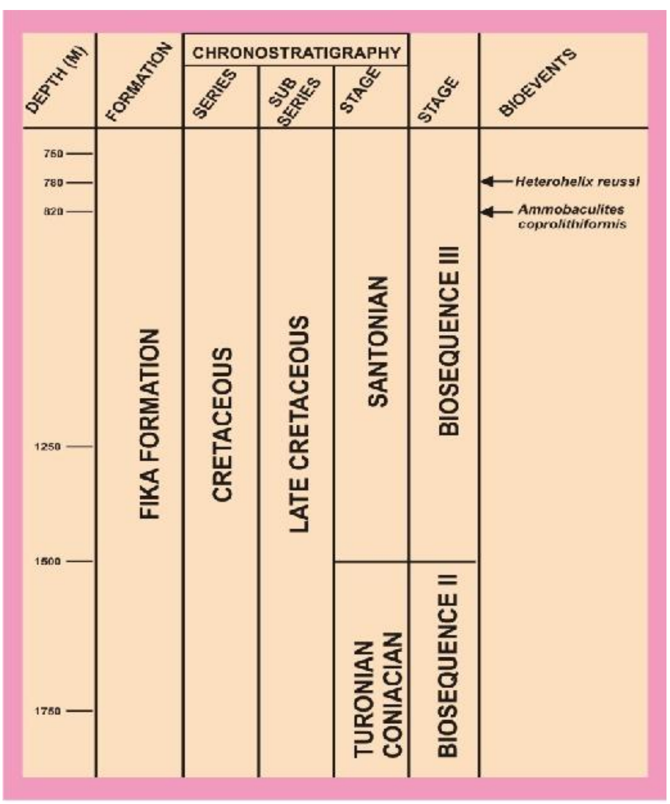


Fig.6.Biosequences recognized in Kemar-1 well



distribution chart (Fig.4). Age and biosequences were then deciphered from the important bio-events.

Results and discussion

The well yielded moderately rich and well preserved pollen, spores, dinoflagellate cysts and freshwater algae assemblages. From these, 89 palynomorphs species were recovered. The microfloral assemblage is dominated by land-derived forms such as *Droseridites senonicus, Ephedripites* sp., *Monocolpites* sp., *Glecheniidites senonicus, Tricolporopollenites* sp., *Zlivisporis blanensis* and *Cyathidites minor*. Three Assemblage Zones defined by Jardiné & Magloire (1965); Jan du Chêne *et al*. (1978); Müller *et al*. (1987); Lawal & Moullade (1986); Salard-Cheboldaeff (1990); Jan du Chêne (2000) were established for the investigated interval based on the first and last appearances of diagnostic marker species. The upper part of the well section correlates with the *Proteacidites dehaani/Dinogymnium euclaense* Assemblage Zone erected by Lawal and Moullade (1986), followed by *Droseridites senonicus* Assemblage Zone while the basal sequence correlates with the *Cretacaeiporites scabratus/mulleri* Assemblage Zone of Müller *et al*. (1987).

In establishing the foraminiferal biostratigraphy of Kemar-1 well, 45 ditch cutting samples were analysed. They yielded moderately abundant and diversified microfossils throughout the well, which enhanced the zonation. Two biosequences were established for the studied interval (740-1745m) within the well based on the peak and the bioevents. The palynozones and the biosequences recognized are presented graphically in Fig. 5 and 6 respectively and briefly discussed below:

Palynological biozonation of Kemar-1 well

Cretacaeiporites scabratus/mulleri Assemblage Zone (P I)

Stratigraphic Interval: 1480 – 1780m

Formation: Fika Formation

Age: Turonian (90.4Ma)

Description: This is the oldest Assemblage Zone recognized in Kemar-1 well. The top of the Zone is marked by the peak occurrence of *Droseridites senonicus* at 1480m (Lawal and Moullade, 1986). The base of the Zone was not penetrated at the last sample analysed (1780m). In this assemblage zone occur *Trocolporopollenites* sp., *Cyathidites minor* and *Monosulcites* sp. Few dinoflagellate cysts e.g., *Cleistosphaerium* sp., *Exochosphaeridium* sp., and *Subtilisphaera* sp. and freshwater algae, *Botryococcus braunii* were also recorded.

Droseridites senonicus Assemblage Zone (P II)

Stratigraphic Interval: 700 – 1480m

Formation: Fika Formation

Age: (?) Coniacian-Santonian (86.6 – 83.0Ma)

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Description: *Droseridites senonicus* is a key marker for this Zone because of its abundant and consistent occurrence within, and sudden extinction at the top of the Zone. The upper boundary of the Assemblage Zone is therefore defined by the top occurrence / disappearance of *Droseridites senonicus* at 700m, while the lower boundary at 1480m is marked by the base acme of the same species (Lawal & Moullade, 1986). Other markers, particularly the dinoflagellate cyst, *Oligosphaeridium pulcherrimum* and the pollen *Hexaporotricolpites emelianovi* whose tops should mark the base of the Santonian were not encountered within the interval. Thus the delineation of the Coniacian/Santonian boundary could not be undertaken. The Santonian period in this well is marked by an abrupt increase in the abundance and diversity of the microflora content. The commonest forms are *Monocolpopollenites sphaeroidites*, *Proteacidites sigalii*, *Tricolporopollenites* sp., *Droseridites senonicus, Monosulcites* sp., *Ephedripites* sp., *Zlivisporis blanensis, Cyathidites minor, Gleicheniidites senonicus, Distaverrusporites simplex, Foveotriletes margaritae* and dinoflagellate cysts such as *Cribroperidinium sp., Spiniferites ramosus, Cleistosphaeridium* sp., *Florentinia* sp., *Subtilissphaera pirnaensis* and *Gonyaulacysta* sp. The peak abundance of *Tricolporopollenites* sp., *Tricolporite* sp. and *Zlivisporis blanensis* were recorded between 800 and 1480m.

Proteacidites dehaani/Dinogymnium euclaense Assemblage Zone (P III)
Stratigraphic Interval: 600 – 700m
Formation: Fika Formation
Age: (?) Campanian and younger

Description: This is the youngest palynozone recognized in the well section. The top of the zone was not established at the first sample analysed (600m). The base is marked by the top occurrence/extinction of *Droseridites senonicus* at 700m. The zonal microflora is numerically poor with very rare marker species. Some of the palynomorphs assemblages recorded in the biozone include *Graminidites* sp., *Monocolpites* sp. and *Aletesporites* sp. The spot occurrences of Campanian-Maastrichtian dinoflagellates cysts such as *Cyathidites* sp., *Dinogymnium* sp., *Chenopodipollis* sp., *Cyperaceaepollis* sp., and the absence of *Droseridites senonicus* (a typical Coniacian-Santonian marker) suggest that this zone is not older than Campanian.

Foraminiferal Biozonation

Biosequence II
Stratigraphic Interval: 1500 – 1750m
Formation: Fika Formation
Age: Turonian to Coniacian (90.4 – 86.6Ma)

Description: This Biosequence falls largely within the Coastal Deltaic to Shallow Inner Neritic Fika Formation. Its top is marked at 1500m, while the base was not encountered at the last sample analysed (1750m). The bottom part is fairly rich in foraminifera e.g., *Ammobaculites benuensis, A. pindigensis, Ammotium nkalagum,* and *A. bornum.*

Biosequence III
Stratigraphic Interval: 750-1500m
Formation: Fika Formation
Age: Santonian (83.0Ma)

Description: The bottom of this Biosequence is fairly rich in foraminifera and is marked at 1500m. Its top is characterized by sudden occurrence of *Heterohelix reussi* recorded at 780m. Another important bioevent recorded is the First Downhole Occurrences (FDO) of *Ammobaculites coprolithiformis* at 820m. Some of the dominant foraminifera within this Zone are *Heterohelix reussi, Reophax guineana, Ammotium bornum, A. nkalagum, Ammobaculites pindigensis, A. bauchensis, A. amabensis, A. coprolithiformis,* and *Haplophragmoides bauchensis*.

Age

On the basis of the foraminiferal and microfloral assemblages, the age of the fossiliferous interval of the studied section of Kemar-1 well ranges from Early Turonian to Santonian.

Unconformities

Three unconformities were observed within the studied section of Kemar-1 well at 790m, 1300m and 1700m. The unconformities are marked by noticeable faunal discontinuities, associated paleowater depth reduction and abrupt shift in the environment of deposition.

Paleoenvironmental reconstruction

Paleoenvironmental indicators are marker species which give reliable and accurate information about past environments. When these indicators are efficiently utilized, many of the hindrances encountered in paleoenvironmental synthesis can be avoided. The paleoenvironmental reconstruction of the sequences penetrated by Kemar-1 well was based on the qualitative evaluation of the bathymetric ranges of carefully chosen environmentally sensitive foraminifera (Adegoke *et al*., 1976; Murray, 1991; Gebhardt, 1997). These are diverse and well preserved arenaceous foraminifera indicating shallow marine environment and which include *Ammobaculites bauchensis, A. coprolithiformis, A. pindigensis, A. benuensis, Ammotium nkalagum, A. bornum* and *Haplophragmoides bauchensis*. According to Gebhardt (1997), the known ecology of *Ammobaculites bauchensis*, *A. benuensis, A. pindigensis and A. coprolithiformis* is normal marine to brackish shelf. While *Ammobaculites bauchensis, A. benuensis* and *A. coprolithiformis* can tolerate reduced oxygen contents, *Ammobaculites pindigensis* on the other hand has very little or no tolerance against oxygen deficiency (Gebhardt, 1998; 2006). *Ammobaculites coprolithiformis* has also been found to occur in sediments interpreted as marsh and estuarine deposits, probably deeper portions of

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estuaries (Wightman 1990). *Haplophragmoides bauchensis* is typical of inner shelf and normal marine and tolerates reduced oxygen contents (Gebhardt, 1997). The environment of deposition of the studied section of the well was therefore interpreted to be generally shallow. It ranged from Coastal Deltaic through Fluviomarine to Shallow Inner Neritic (Adegoke *et al*., 1976). Details of the paleoenvironmental interpretations are presented below:

Interval: 1780-1720 m

Discussion: The interval consists of fairly thick sand/silt beds alternating with delta plain shale. Its fauna consists of few *Ammobaculites bauchensis, A. coprolithiformis,* and *A. pindigensis*. A single dinoflagellate cyst was recorded along with poor records of land-derived sporomorphs. This signifies a Fluviomarine environment at the lower part deepening to Shallow Inner Neritic towards the upper part.

Interval: 1720-1472 m

Discussion: This interval is predominantly delta plain sand alternating with shallow marine shales. An upward coarsening regressive sand alternating with thin greenish shales occur. Rare *Ammobaculites pindigensis, A. bauchensis* and *Ammotium nkalagum* were recorded together with pollen and spores such as *Cyathidites minor, Zlivisporis blanensis, Glecheniidites* spp*., Triorites* sp*., Araucariacites australis, Tricolporopollenites* spp*.,* and fairly rich dinoflagellate cyst occurrence. The interval can be interpreted to have been deposited in Coastal Deltaic environment at the lower part, while it varied between Coastal Deltaic and Fluviomarine environments at the upper part.

Interval: 1472-1044 m

Discussion: Marginal marine to Lagoonal shale deposits with prograding interval within the marginal marine environment composed of sand/silt beds alternating with dark grey shales make up this depth interval. *Ammotium bornum, Ammobaculites pindigensis, A. coprolithiformis, A. bauchensis* and *A. benuensis* are common to abundant. Dinoflagellate cysts e.g., *Spiniferites ramosus, Dinogymnium euclaense, Leptodinium* spp*., Cribroperidinium* spp*., Cleistosphaeridium* sp*.,* and *Gonyaulacysta* sp. are abundant while *Botryococcus braunii* and *Pediastrum* sp*.* are rare. This indicates a Fluviomarine environment with an occasional Shallow Inner Neritic influence at the lower part, while the environment fluctuated between Coastal Deltaic and Fluviomarine with an occasional Shallow Inner Neritic influence at the upper part.

Interval: 1044-910 m

Discussion: The strata are Lower Subaqueous Delta deposits consisting of thin bedded sand/silt horizons alternating with delta plain shale and rare occurrence of *Ammobaculites pindigensis, A. bauchensis,* and *A. coprolithiformis.* The interval yielded abundant land-derived sporomorphs dominated by *Gleicheniidites senonicus, Cyathidites minor, Zlivisporis blanensis, Tricolpites* sp*., Tricolporopollenites* sp*.,* and *Triorites* sp. Dinoflagellate cysts and algae also occur fairly abundantly. An environment that varied between Coastal Deltaic and fluviomarine is inferred for the interval.

Interval: 910-762 m

Discussion: Upper Subaqueous Delta deposits with moderately thick sand/silt beds alternating with delta plain shale constitute this interval. Rare *Ammobaculites bauchensis, A. coprolithiformis, A. pindigensis,* and *Haplophragmoides bauchensis* occur. It is typified by abundant sporomorphs occurrence dominated by *Tricolporopollenites* sp*., Cyathidites minor, Zlivisporis blanensis, Gleicheniidites senonicus, Droseridites senonicus, Tricolpites* sp*.,* and *Rugulatisporites caperatus* and fair and poor dinoflagellate cyst and records respectively. A Coastal Deltaic/ Fluviomarine environment is inferred (Frederiksen, 1985).

Interval: 762-668 m

Discussion: This interval consists of floodplain and overbank deposits, which include thin bedded silty sands alternating with shales. It has rare *Ammotium nkalagum, Ammobaculites bauchensis,* and *A. benuensis.* It has drastically reduced land-derived sporomorphs and dinoflagellate cysts with spot occurrences of fresh water algae. It was deposited in a Coastal Deltaic environment with occasional fluviomarine influence (Adegoke *et al.,* 1976; Murray 1991).

Interval: 668-600 m

Discussion: Alluvial fan to Flood plain deposits make up this interval. Its strata are pebbly, very coarse grained and poorly sorted fanglomerate sandstones. The clay constitutes the flood plain deposits. It is barren of foraminifera except for the lower part that yielded rare *Ammobaculites* spp., *A. pindigensis,* and *Ammotium nkalagum.* It also has a very poor record of sporomorphs.

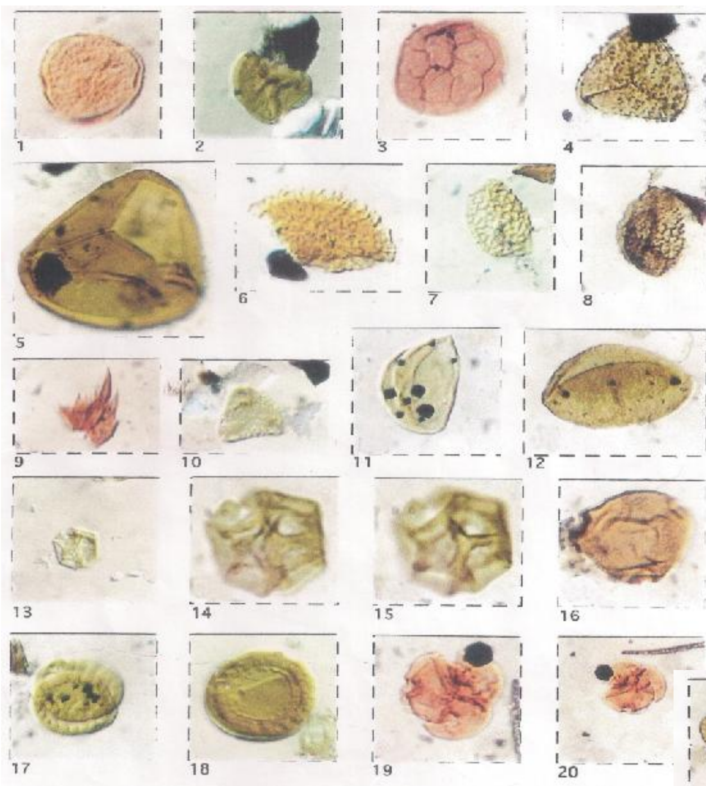
Conclusion

Biostratigraphy is a valuable tool in oil and gas exploration when it is integrated with other geological and geophysical data sets, such as outcrops, seismic lines or well logs. This paper constitutes a significant contribution to the understanding of the biostratigraphy of Borno Basin, which is currently the focus of intensive hydrocarbon exploration activities. This study has employed microfaunal and microfloral assemblages for the stratigraphic differentiation of the strata penetrated by Kemar-1 well in Borno Basin. Attempts have also been made to date the strata and to deduce their depositional environments. Three palynological zones and two foraminiferal biosequences whose age range between Early Turonian to Early Campanian were established for the studied interval, which is Fika 'Shale' Formation. The environment of deposition is also largely Shallow Inner Neritic.

Fig.7. Palynomorphs recognized in Kemar-1 well:

1. *Lygodium reticulatiformis* Jardiné & Magloire, 1965
2. Smooth trilete sinuose
3. *Zlivisporis blanensis* Boltenhagen, 1967
4. Smooth trilete verrucose sp. (spore indeterminate) Lawal, 1982
5. Large smooth trilete
6. *Gabonisporis vigourouxi* Boltenhagen, 1967

Fig.7.Palynomorphs recognized in Kemar-1 well



7. *Retimonocolpites* sp. Lawal, 1982
8. *Retimonocolpites* sp. Lawal, 1982
9. Scolecodont
10. *Tricolpites* sp. Jardiné & Magloire, 1965
11. *Longapertites microfoveolatus* Adegoke *et al*., 1978
12. *Longapertites chlonovae* Boltenhagen, 1978
13. *Cretacaeiporites polygonalis* Jardiné & Magloire, 1965 ; Herngreen, 1973
14. *Cretacaeiporites polygonalis* Jardiné & Magloire, 1965 ; Herngreen, 1973
15. *Cretacaeiporites polygonalis* Jardiné & Magloire, 1965 ; Herngreen, 1973
16. *Triporites* sp.
17. *Tubistephanocolpites cylindricus* Salami, 1984
18. *Tubistephanocolpites cylindricus* Salami, 1984
19. Ericaceae
20. Ericaceae

Fig.8. Palynomorphs recognized in Kemar-1 well:

1. *Foveotriletes margaritae* (*Filtrotriletes nigeriensis*) GHM,1968 (Van Hoeken-Klinkenberg, 1964)
2. *Cingulatisporites ornatus* Van Hoeken-Klinkenberg, 1964
3. *Rugulatisporites caperatus* Van Hoeken-Klinkenberg, 1964
4. *Osmundacidites* spp.
5. *Droseridites* sp. (could be a single grain of a tetrad of *Droseridites senonicus*)
6. *Droseridites* sp. (could be a single grain of a tetrad of *Droseridites senonicus*)
7. *Droseridites* sp. (could be a single grain of a tetrad of *Droseridites senonicus*)
8. *Droseridites* sp. (could be a single grain of a tetrad of *Droseridites senonicus*)
9. *Rhoidipites "scabratus"*
10. *Rhoidipites "scabratus*"
11. *Psilatricolporites* sp.
12. *Psilatricolporites sp.*
13. *Tricolpites* sp. Jardiné & Magloire,1965; Lawal, 1982
14. *Tricolpites* sp. Herngreen, 1973
15. *Tricolpites* sp. Herngreen, 1973
16. *Syncolporites* spp.
17. *Syncolporites* spp.
18. *Syncolporites* spp.
19. *Tubistephanocolpites cylindricus* Salami, 1984
20. *Ephedripites zaklinskaiae* Azema & Boltenhagen, 1974

Fig.8. Palynomorphs recognized in Kemar-1 well

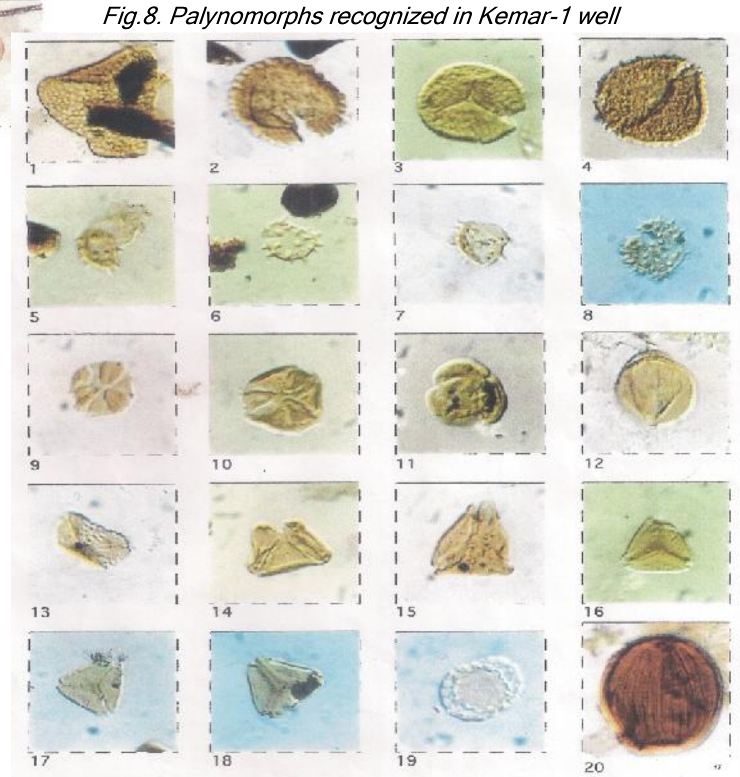


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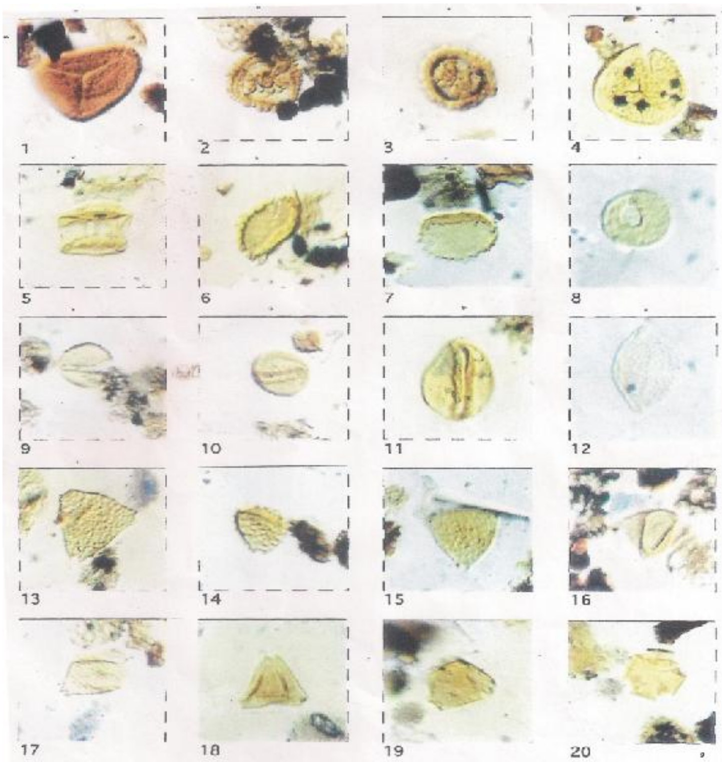
Fig.9. Palynomorphs recognized in Kemar-1 well:

1. *Foveotriletes margaritae* (*Filtrotriletes nigeriensis*) Van Hoeken-Klinkenberg, 1964

Fig. 9. Palynomorphs recognized in Kemar-1 well

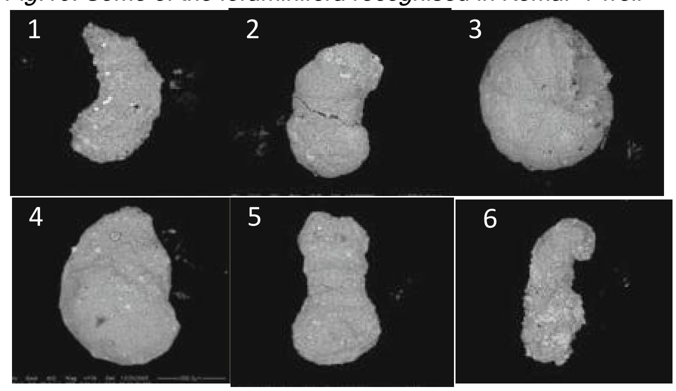


2. *Cingulatisporites ornatus* Van Hoeken-Klinkenberg, 1964
3. *Cingulatisporites ornatus* Van Hoeken-Klinkenberg, 1964
4. *Lygodium reticulatiformis* Jardiné & Magloire, 1965
5. *Tubistephanocolpites cylindricus* Salami, 1984
6. *Tubistephanocolpites cylindricus* Salami, 1984
7. *Tubistephanocolpites cylindricus* Salami, 1984
8. *Graminidites* sp. Jardiné & Magloire, 1965
9. *Monocolpopollenites sphaeroidites* Jardiné & Magloire, 1965
10. *Monocolpopollenites sphaeroidites* Jardiné & Magloire, 1965
11. *Monocolpites marginatus* Van der Hammen, 1954
12. *Auriculiidites reticulatus* Elsik, 1965
13. *Proteacidites sigalii* Boltenhagen, 1978
14. *Echitriporites trianguliformis* Van Hoeken-Klinkenberg, 1964
15. *Echitriporites trianguliformis* Van Hoeken-Klinkenberg, 1964
16. *Proteacidites sigalii* Boltenhagen, 1978
17. *Proteacidites sigalii* Boltenhagen, 1978
18. *Proteacidites sigalii* Boltenhagen, 1978
19. *Proteacidites sigalii* Boltenhagen, 1978
20. *Proteacidites sigalii* Boltenhagen, 1978

Fig.10. Some of the foraminifera recognised in Kemar-1 well:

1. *Ammobaculites benuensis* Petters, 1979
2. *Ammobaculites benuensis* Petter, 1979
3. *Haplophragmoides bauchensis* Petters, 1979
4. *Haplophragmoides bauchensis* Petters, 1979
5. *Ammobaculites coprolithiformis* Schwager, 1887
6. *Ammobaculites sp.* Petters, 1979

Fig.10. Some of the foraminifera recognised in Kemar-1 well



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