High Resolution Palynological Studies Of Upper Cretaceous Succession Of Mushe-1 Well, Central Chad Basin, Nigeria

Oloto, I.N. Yikarebogha,Y.

Abstract: These The Late Cretaceous succession penetrated by Mushe-1well in the Central Chad Basin, North East Nigeria was investigated for its palynological content. This investigation produced biostratigraphically significant Pollen, Spore and dinoflagellate cyst. The studied interval penetrated a sequence of clay, sandstone, shale, shally sandstone, sandy shale and sandstone, occuriing at different intervals in all the wells. Based on the stratigraphic distribution of the palynomorphs from the Mbeji-1 –well. Twelve informal assemblage palynozones and six dinoflagellate assemblage biozones spanning the Upper Cretaceous were identified in the Chad Basin, Nigeria. The zones are: Assemblage Zones I-IV (Cenomanian); Assemblage Zone V (Turonian); Assemblage Zone VI,VII,VIII, and IX (Coniacian-Santonian); and Assemblage Zones X,XI, XII, and XIII (Campanian-Maastrichtian) for the Pollen/Spore biozones.. The age determinations are based on the known stratigraphic ranges of pollen, spores and dinoflagellate and their relative stratigraphic positions. Data from the studied well revealed that generally in the basin, there is relatively higher frequency of the land derived pollen and spores compared to marine palynomorph abundance, which suggests a paralic condition of continental to shallow marine environment. The shallow marginal marine environment is further supported by the presence high diversity of dinoflagellate species and foram test linings at some depths which are indicative of marine paleoenvironment i.e. neritic environment.

Index Terms: Palynology, Chad Basin,, Nigeria, Cretaceous, Mushe -1 Well

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1 INTRODUCTION

High Resolution Palynology was carried out on Murshe-1 Well, This is a well drilled by the Nigerian National Petroleum Corporation (NNPC) in the Nigerian sector of the Chad Basin as exploratory well and this wells were drilled to a total depth of 3928metres,.The wells were selected for this work based on their depth of penetration, distribution along the structural Sub Basin i.e. Maiduguri in the South, Gubio in the West and Lake Chad in the North and along the basin deposition fault controlled axis. Sampling was done at 10-20 metres interval and ditch cutting samples were heavily relied upon for the analysis as there were no logs and core data available, coupled with the lack of outcrop exposure in the area.

1.1 Location of the study area.

The study area is located within latitudes 13^0N and 12^0N and longitudes 14^0E and 13^0E, north of Maiduguri near Gajigana where Murshe-1 Well, out of the twenty three wells was drilled.

1.3 Geology of the study area

This work relied on the stratigraphic scheme of the recent workers (Okosun, 1995; Hamza et al, 2002) as it is more accurate and corresponds with the lithologic description of the various wells in this study. The Stratigraphy of the Study area is as follows

1.1 Bima Formation

This unit forms the basal sequence of sediments in the Chad Basin. It is of late Albian to early Turonian age, with thickness of between 100m to over 3000m of poorly sorted and thickly bedded feldsparthic sandstone, unconformably overlying the Precambrian crystalline basement (Barber, 1965).

1.2 Gongila Formation

This formation is a transition between the continental Bima Sandstone that underlies it and the marine Fika Shale, which overlies it (Matheis, 1976). It is of Turonian age and shows a maximum thickness of 500m (Matheis, 1976). The formation is mainly composed of intercalation of sand, shale and limestone. The base of the sequence is defined by the first appearance of marine limestone above the Bima Sandstone (Carter et al., 1963). The basal limestone is about 3m thick and consists of non-fossiliferous and shelly variety as well as Ammonites of Lower Turonian age (Reyment; 1956, 1965, Carter, 1963).

1.3 Fika Shale

Overlying the Gongila Formation is the marine Fika Shale. The Fika Shale is late Turonian to Senonian in age and it is composed of blue-black shale, occasionally gypsiferous with thin limestone intercalations (Carter et al., 1963).

1.4 Gombe Formation

This unit forms an almost continuous and generally north trending belt some 250km long and 20km wide. It is a sequence of estuarine and deltaic sedimentation consisting of sandstones, shale, siltstone and ironstone (Carter et al., 1963). The sequence is best developed in the southwestern portion of the basin where it attains a thickness of about 350m (Matheis, 1976). The Gombe Formation represents the final Cretaceous sedimentation in the Chad Basin. The type section is in Kware stream about 3km south of Gombe.

1.5 Kerri-kerri Formation

The Kerri-Kerri Formation is composed of continental sequence, which dips northeast beneath the Chad Formation and lies unconformably on the folded Cretaceous sedimentations. They contain alternating layers of clayey grit, grit and sandstone with well developed cross-bedding indicating lacustrine and deltaic environments respectively (Carter et al., 1963).

1.6 Chad Formation

This formation is a variable sequence that includes all Quaternary sediments of lacustrine origin underlying the surface deposit over a vast area in the Chad Basin (Matheis, 1976). The Chad Formation unconformably overlies the Fika Shale in some parts of the basin due to non-wide spread occurrence of both the Gombe Sandstone and Kerri-Kerri Formation which are mainly restricted to the southwest part of the basin (Matheis, 1976).

1.7 Aim and objective of the study

The aim of the present study is to establish the sedimentological and floral characteristics of the formations penetrated by Murshe-1, Chad Basin, Nigeria. These characteristics when established will be used in predicting the age, depositional characteristics and paleoenvironmental trends of the formation.

2.0 MATERIAL AND METHODS

A total of one hundred and seventy ditch cuttings samples from 500ft – 3920ft depth intervals of Murshe-1 well were collected and sampled (Fig.1). From each depth-interval, about 5gm was weighed, thoroughly washed/cleaned. The pre-treatment of the samples with various Acid combinations include removal of unwanted carbonate material by washing with 10ml diluted hydrochloric acid as well as further treating the residue with 40% hydrofluoric acid and boiling hydrochloric acid to dissolve all silicates and silicofluoride gel respectively. The ultrasonic centrifuge machine further separated out the dissolved material from the organic matter residue for 2minutes. Subsequently, three drops of safarin'o dye solution dropped into the residue to stain the dinocyst and left for few minutes to allow for proper mixing and then pipette into a cover slip glass slide on top of the hot plate until dryness and was used for palynological microscopic study. The Slide were properly labelled and observed under palynological microscope through which snapshot was taken. (**See Plate 1 and 2)** for the photomicrograph of the palynomorphs.

3.0 PRESENTATION OF RESULT

3.1 Lithostratigraphic Description.

The lithologic description of the relevant sequence in these wells is based on physical inspection of the ditch cuttings from top to base and it compared favourably with the stratigraphic units outlined by Barber (1965) and modified by Matheis (1976) in their work on the Chad Basin. The lithologic sequence of the studied interval covered a depth range of 19m – 3928m, having a total thickness of 3900m **See** Fig. 1. The upper 250m within the interval of 19m – 260m consists of yellow to grey, non calcareous clay, passing into a 40m thick interval (260m-300m) of yellow to grey, clayey, non calcareous sandstone. Between the interval of 320m – 440m, a 120m thick yellow to grey, gritty, non calcareous sandy clay was encountered. The interval 460mm – 600m is composed of 140m thick light yellow, gritty, highly calcareous clayey sandstone passing into a wholly gray to brown, gritty, non calcareous clay sequence which is 40m thick within the interval of 600m – 640m. The basal unit is composed of 620m thick brown to grey, calcareous shally siltstone spanning the interval 3300m -3920m. Within this interval, there exist some units of brown to grey, calcareous silty shale at within intervals 3420m, 3480m – 3500m, 3640m, 3740m – 3780m and 3920m. From the foregoing, the gross lithologic sequence from top to base can be divided into three major lithologic types viz: clay/clayey sand unit, shale unit, sandstone-shale hybrid interval.

3.2 Palynological Result

The palynomorphs assemblage encountered in the study is composed of Pollen, Spores and dinoflagellate. The results of the palynological analyses of the wells shown on plate 1 & 2 below. The percentage occurrence of pollen is 40.4%, spores 32.8%, Interval 19m is composed of 100% pollen palynomorphs with only two forms encountered. Interval 61m – 120m is devoid of any palynomorphs i.e. is barren, while interval 140m – 180m is composed of 33.0% to 100% pollen palynomophs and 67.0% algae in depth 140m. Interval 200m is barren. Within interval 224m – 241m, pollen constitute 11.0% to 14.0% of the palynomorphs and spore palynomorphs constitute 86.0% to 100% of the forms, while the interval is devoid of other palynomorphs.

4.0 DISCUSSION OF RESULT

4.1 Biozonation- Pollen and spores biozone

On the basis of First Appearance Datum (FAD) or Last Downhole Occurrences (LDO) of three or more diagnostic species of palynomorphs forms; pollen/spore and dinoflagellate assemblage zones were defined and ages assigned to these zones. The biozones for each well are described below

(a) Biozone I- *Triorites tenuiexinus* (3780m-3928m)
The base of this zone is the base of the well. The species encountered in this zone are *Auraucaiacites australis, Graminiidites annulatus and Triorites tenuiexinus.* The top of this zone is defined by the last downhole occurrence of *Incertae sedis, Cyathidites sp and Ephedripites costaliferous.*

(b) Biozone II- *Ephedripites costaliferous* (3740m-3780m)
The base of this zone is the same as the top of zone I. The top of the zone is characterized by the first appearance datum of *Triorites africaensis, Tricolporopollenites megadolium, Tricolpites clarensis and Cretacaeiporites scabratus.* The species in the zone are *Cyathidites sp, Ephedripites costaliferous, Incertae sedis and Zliviporis blanensis.*

(c) Biozone III- *Triorites africaensis* (2900m-3740m)
The base of this zone is the same as the top of zone II. The top event is characterized by the last downhole occurrence of *Distaverrusporites simplex, Dictyophylidites harrasii, Syncolporites subtilis and Gleicheniidites senonicus.* Forms in the zone are *Triorites africaensis, Tricolporopollenites megadolium, Tricolpites clarensis, Cretacaeiporites scabratus, Monosulcites scaber, Monocolpites medius, Inaperturopollenites cf. undulatus, Psilatriletes radiatus, Cyathidites monor, Aquilapollenites minimus, Cretacaeiporites polygonalis, Ephedripites multicostatus, Gleicheniidites sp, Cingulatisporites ornatus, Cyathidites australis, Verrucatosporites favus, Monocolpopollenites sphaeroides and Alnipollenites verus.*

(d) Biozone IV- *Distaverrusporites simplex* (2700m-2900m)
The base of this zone is the same as the top of zone III. The top is defined by the last downhole occurrence of *Tubistephanocolpites cylindricus, Proteacidites longispinosus, droseridites senonicus and Ephedripites ambiguus.* The species in the zone include *Distaverrusporites simplex, Dictyophylidites harrasii, Syncolporites subtilis, Gleicheniidites senonicus, Laevigatosporites catanejensis, Monocolpites marginatus, Afropollis jardinus, Deltoidospora africana and Rugulatisporites caperatus.*

(e) Biozone V- *Tubistephanocolpites cylindricus* (2400m-2700m)
The base of the zone is the same as the top of zone IV. The top is defined by the last downhole occurrence of *Echitricolporites trianguliformis, Rugulatisporites sp and Verrucatosporites obscurilaesuratus.* Species encountered in this zone include *Tubistephanocolpites cylindricus, Proteacidites longispinosus, droseridites senonicus, Ephedripites ambiguus, Rugulatisporites ornatus, Tricolporate sp and Leptolepidites major*

(f) Biozone VI- *Echitricolporites trianguliformis* (2280m-2400m)
The base of this zone is the same as the top of zone V. The top is characterisd by the last downhole occurrence of *Polypodiaceoisporites fossulatus, Tricolporites sp and Foraminisporis dailyi.* Species in this zone include *Echitricolporites trianguliformis, Rugulatisporites sp, Verrucatosporites obscurilaesuratus, Longapertites reticulatus, Foveotriletes margaritae and Proteacidites sigalli.*

(h) Biozone VII- *Polypodiaceoisporites fossulatus* (2200m-2280m)
The base of this zone is the same as the top of zone VI. The event marking the top of the zone are the last downhole occurrence of *Psilamonocolpites magnum, Psilatricolpites okeziei, Concavissimisporites punctatus, and Psilatriporites sp.* Forms in the zone include *Polypodiaceoisporites fossulatus, Tricolporites sp, Foraminisporis dailyi, Steevesipollenites multillineatus, Cicatricosisporites dorogensis, Longapertites multicostatus and Retimonocolpites pluribaculatus.*

(i) Biozone VIII- *Psilamonocolpites magnum* (19m-2200m)
The base of this zone is the same as the top of zone VII. While the top represents the top of the studied interval. The species recorded within this zone include *Psilamonocolpites magnum, Psilatricolpites okeziei, Concavissimisporites punctatus, Psilatriporites sp, Psilatricolporites pachydermatus, Inaperturopollenites australis, Erecipites sp, Lycopodiumsporites fastiginoides, Longapertites chlonovae, Deltoidospora halii, Longapertites marginatus and Gemmazonocolpites cingulatus.*

4.2 Age Characterisation-

Pollen and spore biozone The erected biozones are compared with the palynoforal zonation schemes defined by Lawal and Moullade (1986), Salard-Cheboldaeff (1990), Eisawi and Schrank (2008) and Abubakar et. al (2011). (Figs.10, 11, 12 and 13 for Murshe-1,

(i) Assemblage zones I, II and III of Murshe-1 Well all falls within the Cenomanian age. The occurrence of *Triorites tenuiexinus, Classopollis obialosensis, Ephedripites costaliferous, Ephedripites ambiguus, Ephedripites multicostatus, Triorites africaensis* and the other forms constituting the biozones have been reported in Cenomanian sediments by Salard-Cheboldaeff (1990). These palynozones based on the stratigraphic positions and the series of last downhole occurrence of key species corresponds to the *Triorites africaensis* zone of Lawal and Moullade (1986) and Abubakar et al (2011) which is aged Cenomanian.

(ii) Palynomorph assemblage zone IV of Murshe-1 Well all fall within the Turonian age. The occurrence of *Monocolpopollenites sphaeroidites, Distaverrusporites simplex, Retimonocolpites pluribaculatus, Tricolporites sp, Triporites iverseni, Periretisyncolpites giganteus, Monoporites annulatus, Distaverrusporites simplex, Exesipollenites tumulus* and *Droseridites senonicus* have been reported in Turonian sediments by Salard-Cheboldaeff (1990), Lawal and Moullade (1986) and Abubakar et al (2011). These palynozones based on the stratigraphic positions and the series of last downhole occurrence of key species corresponds to the *Cretacaeiporites scabratus* zone of Lawal and Moullade (1986) and Abubakar et al (2011) which is aged Turonian.

(iii) Assemblage zones V and VII of Murshe-1 well all fall within the Conacian-Santonian age. The occurrence of *Classopollis brasiliensis, Polypodiaceoisporites fossulatus, Echitricolporites trianguliformis, Tubistephanocolpites cylindricus, Deltoidospora africana, Tricolporopollenites megadolium, Proteacidites sigalli, Retimonocolpites obaensis* and *Tubistephanocolpites cylindricus* have been reported in the Coniacian-Santonian sediments by Salard-Cheboldaeff (1990), Lawal and Moullade (1986), Eisawi and Schrank (2008) and Abubakar et al (2011). These palynozones based on the stratigraphic positions and the series of last downhole occurrence of key species corresponds to the *Droseridites senonicus* zone of Lawal and Moullade (1986) and Abubakar et al (2011) which is aged Coniacian-Santonian.

(iv) Palynomorph assemblage zones VIII and IX of Murshe-1 well all fall within the Campanian-Masstrichtian age. The occurrence of *Auriculiidites reticulatus, Praedapollis africanus, Lycopodiacidites caperatus, Echitricolporites manstellae, Spinizonocolpites echinatus, Ephedripites montanaensis, Rugulatisporites caperatus, Polypodiaceoisporites fossulatus, Psilamonocolpites magnum, Tricolpites tienabaensis, Translutencipollenites reticulatus, Syncolpites corrugatus, Ephedripites zeklinskaiae, Rhoidipites scabratus* and *Graminidites annulatus* have been reported by in the Campanian-Maastrichtian by Salard-Cheboldaeff (1990), Lawal and Moullade (1986), Eisawi and Schrank (2008) and Abubakar et. al. (2011). These palynozones based on the stratigraphic positions and the series of last downhole occurrence of key species corresponds to the *Proteacidites dehaani* zone of Lawal and Moullade (1986) and Abubakar et al (2011) and zones I, II and III of Eisawi and Schrank (2008) which is aged Campanian-Maastrichtian.

4.3 Paleoenvironmental interpretation

The distribution of any particular fossil assemblage in any stratigraphic section may be controlled either by palaeoecological factors or as a result of evolution (Hamza et al., 2002). Any change in fossil assemblage that corresponds with a change in lithology is probably due to the environmental tolerance of the fossil species rather than to evolution. Some fossils serve as environmental indicators and are used to interprete ancient environments of deposition of the sediments. Also, the distribution of both body fossils and trace fossils depends on the environmental conditions that existed and the time organisms lived, died, or were buried.the application of palynological data to paleoenvironmental reconstruction has been attempted by several authors

(Battern, 1973, 1982; Van Bergen et al., 1990; Vadja-santivanez, 1998). In this study, the relative abundance of terrestrially derived pollen and spore and marine derived dinoflagellates and foram test linings are used to interprete the depositional environments of the studied wells. The pollen and spores decrease with distance from the shore (Schrank, 1984). The relatively higher frequency of the land derived pollen and spores compared to marine microplankton abundance (Table 18, fig.20), suggests a paralic condition of continental to shallow marine environment.. The upper part of the well i.e. from 19m to 1160m shows an overall continental depositional environment as indicated by the very high percentage of terrestrially derived palynomorphs. The middle part of the well i.e. 1160m to 2000m shows an overall near shore marine environment of deposition as indicated by the increase in the percentage of marine microfaunal. The lower part of the well from 2000m to 3920m shows a sequence of deposition of both continental and marine influence as indicated by the overall high percentage of continental palynomorphs with intermittent incursion of near shore to open marine influence as seen in the percentages of these forms. From the biostratigraphic result, over 300 species of Pollen, Spores and dinoflagellate were encountered, and this yielded over 53,000 individual forms.The accessory microflora encountered are Fungal Spore, Pediastrum, Radiolaria, Foraminifera test lining and diatoms. Based on the stratigraphic distribution of the palynomorphs from the Mushe-1 well, twenty two informal assemblage palynozones spanning the Upper Cretaceous were identified in the Chad Basin, Nigeria. The zones are: Assemblage Zones I-VII (Cenomanian); Assemblage Zones VIII-XIV (Turonian); Assemblage Zone XV (Coniacian-Santonian); and Assemblage Zones XVI-XXII (Campanian-Maastrichtian) for the Pollen/Spore biozones. While for the the usage of the pollen/spore against marine microflora plot served as an aid in the delineation of depositional environment. From the plot, the palynofloral (pollen and spore) constituent of 0.0% - 35.0% reflects open marine; 35.0% to 60.0% reflects near shore marine environment; while a minimum of 80.0% to a maximum of 100% reflects continental conditions (i.e. Fresh water to brackish water).

5.0 CONCLUSION

Data from the studied wells revealed that generally in the basin, there is relatively higher frequency of the land derived pollen and spores compared to marine palynomorph abundance, which suggests a paralic condition of continental to shallow marine environment. The shallow marginal marine environment is further supported by the presence high diversity of dinoflagellate species and foram test linings at some depths which are indicative of marine paleoenvironment i.e. neritic environment. The upper part of the studied intervals showed an overall continental depositional environment as indicated by the very high percentage of terrestrially derived palynomorphs. The middle part of the studied intervals showed an overall near shore marine environment of deposition as indicated by the increase in the percentage of marine microflora. The lower part of the studied interval revealed a sequence of deposition of both continental and marine influence as indicated by the overall high percentage of continental palynomorphs with intermittent incursion of near shore to open marine influence as seen in the percentages of these forms.

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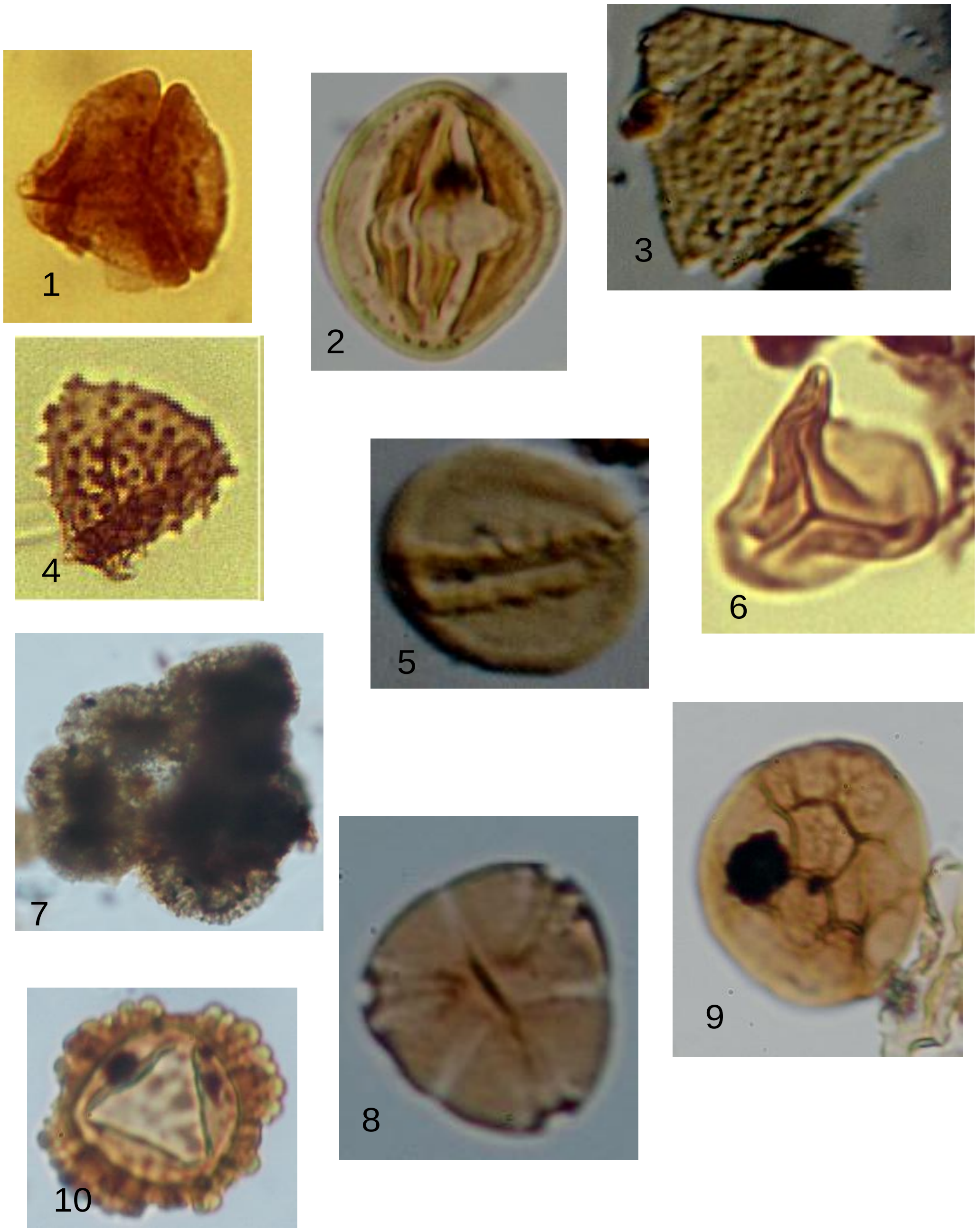
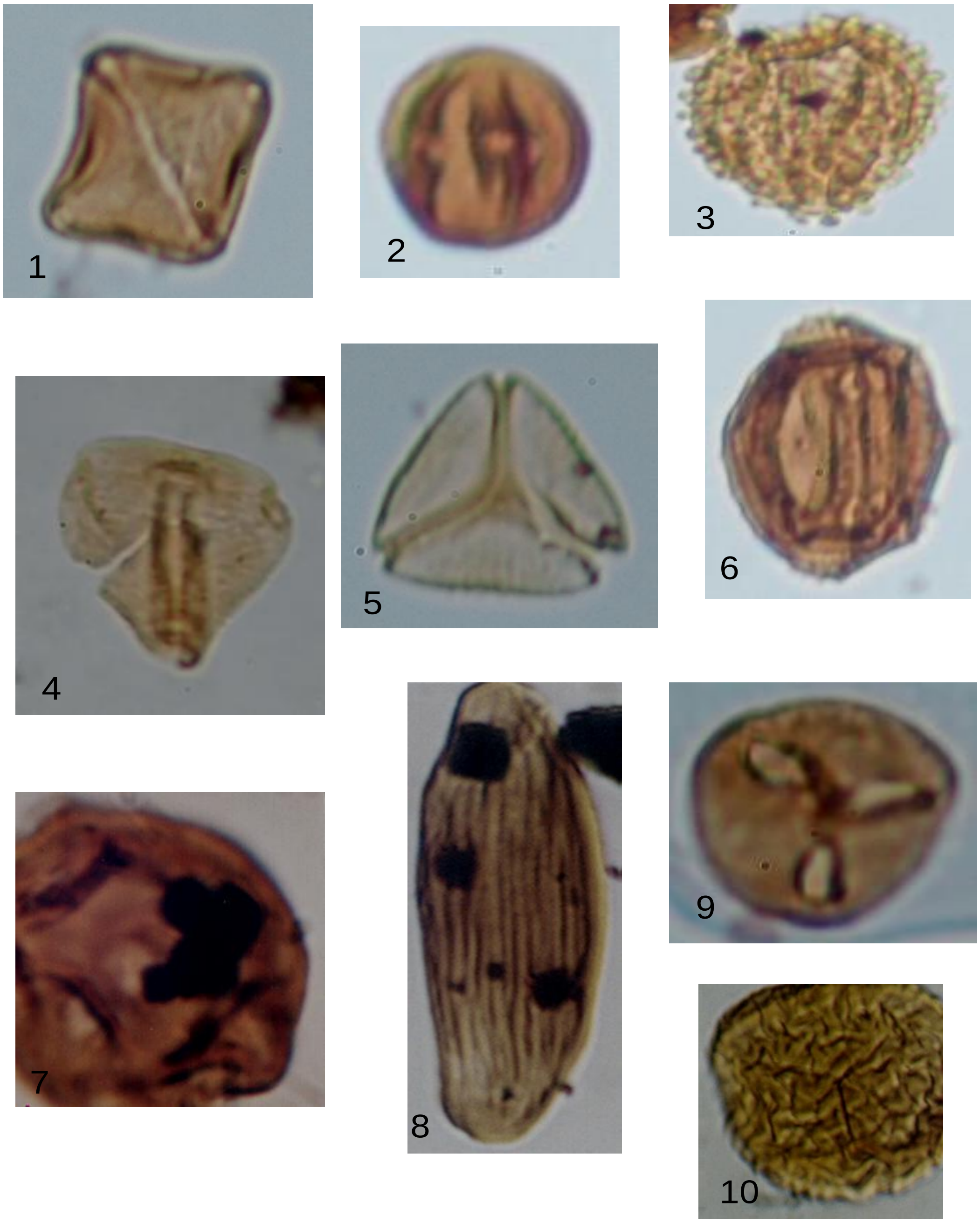
PLATE 1



1. *Syncolporites marginatus* ***2****. Psilatricolporites pachydermatus* ***3*** *Proteacidites sigalii* ***4****. Echitricolporites trianguliformis,* ***5*** *Monocolpopollenites sphaeroidites* ***6****. Cyathidites australis* ***7****. Botryococcus sp.* ***8.*** *Hexacolpotriporites sp.* ***9****. Zlivisporis blanensis* ***10*** *Cingulatisporites ornatus*

PLATE 2



1. *Aquilapollenites minimus* ***2****. Psilatricolporites pachydermatus* ***3****. Hexpollenites chmurae,* ***4*** *Triorites africaensis* ***5****. Syncolporites sowumiae* ***6*** *Hexaporotricolpites emelianovi* ***7*** *Cretacaeiporites muelleri,.* ***8.*** *Ephedripites multicostatus* ***9*** *Constantinisporis jacquei* ***10****. Rugulatisporites caperatus*

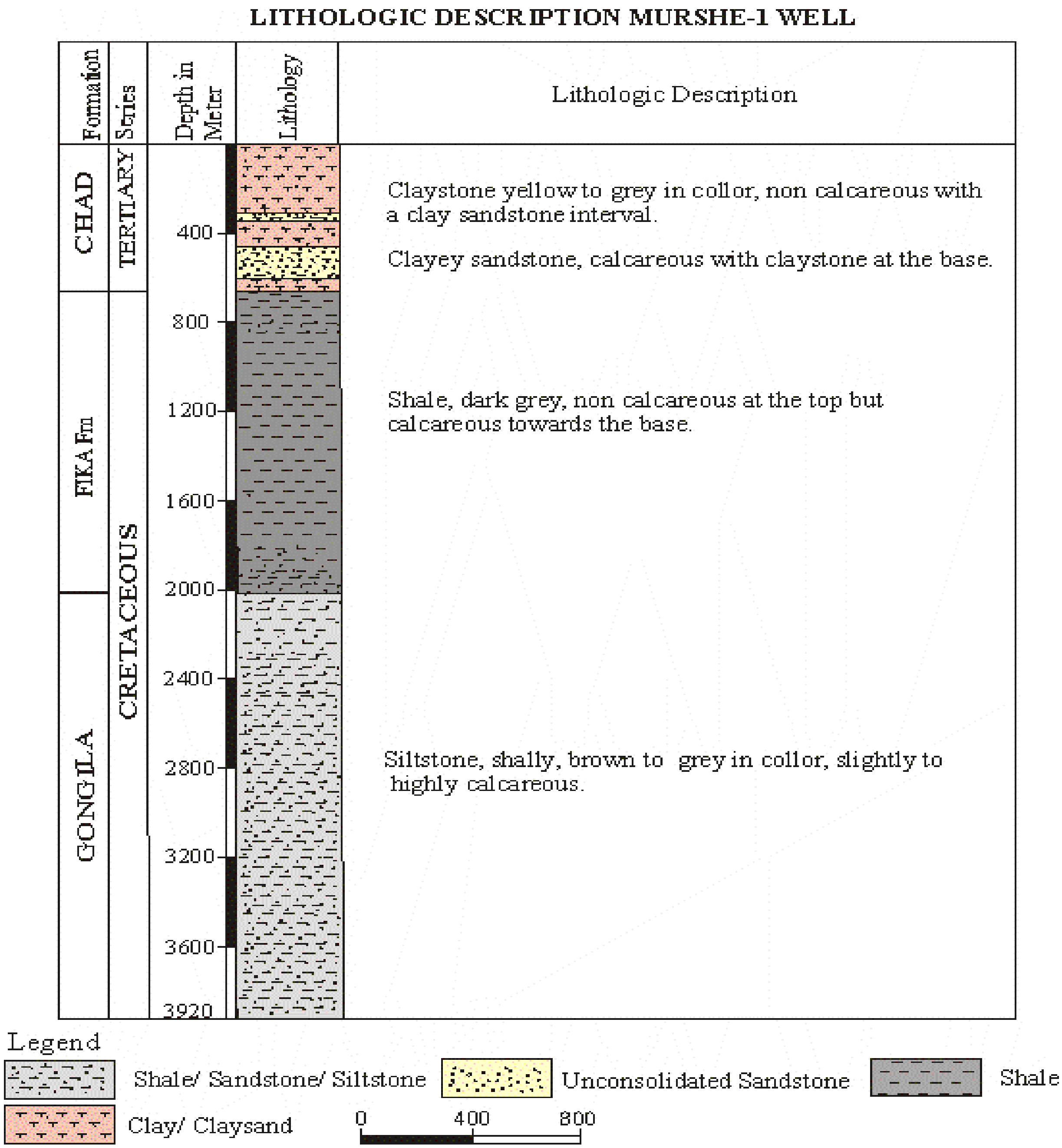


Figure1. Lithologic Description of Murshe-1 well