Biostratigraphy Studies Of X-1 Well, Chad Basin, Nigeria

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Abstract: These i The biostratigraphic study of the Cretaceous sediments penetrated by X-1 well, Chad Basin was carried out. A total of 112 ditch cutting samples were analyzed and these yielded eight genera and seventeen species of both arenaceous benthonic and planktonic microfossils. Sixteen Pollen species, 11 spore species and 15 Dinoflagellate species making up 14 genera, 8 genera and 14 genera, respectively for the microflora. The accessory microflora encountered are fungal spore, pediastrum, radiolarian, foraminifera test lining, spike and gastropod tooth. Biostratigraphiic analysis established albian-Cenomanian age for the studied interval on the basis of the First Downhole Occurrence (FDO) of index Heterohelix (Heterohelix moremani) and Electarao bearing microfossils (Elaterosporites protensus, Elaterosporites verrucatus and Elaterocoplites castelaini). The depositional environments and paleobathymetric ranges of the studied well samples were determined and interpreted with the use of the microfaunal, palynoflora assemblages and other accessories such as glauconite, foramnifera test lining and fungal spore which reflects a transition from a marginal marine to a shallow marine (inner neritic-middle neritic) environment within the continental shelf. Two maximum flooding surfaces (MFS) and one sequence boundary (SB) were identified from maximum and minimum faunal abundance and diversity peaks, respectively. The strata in the study are divided into transgressive systems tracts (TST) and Highstand Systems Tracts (HST).

Index Terms: Biostratigraphy, Chad Basin, Foraminifera, Dinoflagellate, Cretaceous.

1 INTRODUCTION

X-1 well is an exploration well drilled by the Nigerian National Petroleum Corporation in the Nigerian sector of the Chad Basin. The well was drilled to a depth of 3250 metres, but the interval sampled and analyzed in this study is 2525m metres to 3250 metres. Sampling was done at 5 metres interval and ditch cutting samples were used for the analysis.

1.1 Location of the study area

The well (X-1) lies within latitudes 13^0N and 12^0N and longitudes 14^0E and 13^0E. it is located north of Maiduguri near Gajigama.

1.2 Aim and Objective

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

2.0. MATERIALS AND METHODS

Biostratigraphic analysis was carried out on 112 ditch cutting samples which was obtained from X-1 well, Chad .Samples were collected at 30ft interval with a total thickness of 650ft. A total of 25 samples with depth range 12930-13650 ft were analyzed,the steps of analysis is as follows:

2.1 Lithostratigraphic Analysis

Sedimentologic analysis was carried out on the samples by visual inspection. Physical characteristics such as colour, texture, hardness, fissility, rock type etc were noted. Chemical tests to determine the presence of calcareous materials was also carried out using 10% dilute Hcl.

2.2 Biostratigraphic Studies

Samples for each depth were pulverized and 10g weighed into enamel container. The samples were mixed with water and treated with 2g Sodium bicarbonate (Na_2CO_3) and brought to boil at about 200◦C for some minutes. Samples were turned into plastic containers and allowed to cool. Cooled samples were washed using a set of sieves Set of sieves 90, 75 & 53µm respectively in a jet of water. Residues from each sieve was collected and dried. The dried samples were examined using Zeiss paleontological microscope at varying magnifications and the fossils were picked and morphological examinations were then carried out on species with aid nomenclature. Species were also counted and recorded.

3.0 PRESENTATION OF RESULT

3.1 Lithostratigraphic Description.

The lithologic description of the relevant sequence in this well 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 tier work on the Chad Basin. The lithologic sequence of the studied interval covered a depth range of 2520m – 3250m, having a total thickness of 730m. The upper 2.5m within the interval of 2525m – 2550m consists of black, fissile, calcareous shale passing into a 29m thick interval of gray, subfissile, calcareous sandy shale. Between the interval 2570m – 2600m, a 30m thick black, fissile, calcareous shale was encountered. The interval 2600mm-2615m is composed of a 15m thick grey calcareous shaly sandstone passing into a wholly sandstone sequence which is 10m thick within the interval of 2615m – 2625m. The interval between 2625m – 2770m consist of 145m thick of grey, calcareous shaly sandstone passing into a 15m thick grey, fissile, calcareous shale unit within the interval 2770m – 2785m. between intervals 2785m – 2840m, a 55m thick grey, calcareous shaly sandstone was encountered. The interval 2840m – 28880 consists of a 40m thick grey, subfissile, calcareous shandy shale passing into a 10m thick grey, calcareous shaly sandstone within the interval 2880m – 2890m. The interval between 2890 – 2990m consists of a 100m thick sandstone unit passing into an 80m thick shale sandstone unit within the interval 2990m – 3070m. between the intervals 3070m – 3140m a 70m thick, grey fissile, calcareous shale was encountered, passing into a 90m thick grey, calcareous shaly sandstone unit, within the interval 3140m – 3230m. The basal unit is composed wholly of a 15m thick sandsone unit within the interval 3230m – 3245m. From the foregoing, the total lithologic sequence from top to base can be divided into three

major lithologic types viz: shale unit and a sandstone-shale hybrid interval.

3.2 Biostratigraphic Analysis

The generic and family names of the foraminifera conform to the classification of Loeblich and Tappan (1964) with some modifications of Petters (1983) and Caron (1989).See Plate 1 for pictures of the different forms of Foraminifera) The foraminiferal assemblages comprise 17 species (diversity) and 8 genera. Four species, namely, Heterohelix globulosa, Heterohelix moremani and Heteroheliz sp constitute 11.8%, 16.8%, 11.5% and 2.8% respectively, making up 44.2% of the toal mcrofauna encountered. The benthonic forms make up 44.2% of the total microfauna encountered. The benthonic forms make up the remaining 13 species and they include Haplophragmoides sp (34.4%), Haplophragmoides bauchensis (91%), Haplophragmoides pindigensis (1.6%). Ammobaculites coprolithiformis (1.57%), Ammobaculites sp (0.4%), Ammobaculites bauchensis (0.9%), Ammobacultites benuensis (1.97%), Reophax sp (0.7%), Miliammina pindigensis (0.3%), Bolivina (0.10%). Together, they constitute 55.8% of the entire mcrofauna population. The abundant species are Haplophragmoides sp, Heterohelix globulosa, Heterohelix moremani, Heterohelix reussi and Happlophragmoides bauchensis in that order. The distribution of the fauna encountered in the formation in a sample-by-sample basis is few to abundant i.e. from 1 to greater than 20 forms. The top unit between intervals 2525m – 250m is dominated by both benthonic and planktonic foraminifera. This assemblage is composed of the following benthonic forms; Ammobaculites benuensis (Peters, 197f), Ammobacultes coprolithiformis (Scwager, 1868), Haplophragmoides sp, Bolivina sp, ostracod, Haplophragmoides bauchensis (Petters, 1979f) and the planktonic forms are Heterohelix globulosa (Ehrenberg, 1840), Heterohelix sp. The bentics are 42.1% of the assemblage varying from 33.3% to 46. 9% of the total assemblage varying from 53.1% to 66.7% per sample. Within the interval 2550m – 2570m, there occurred 391.% benthic forms and 60.9% planktic forms. The benthic forms vary from 14.3% at he top to 54.8% at the base, while the planktic forms is 85.7% at the interval 2550m – 2555m decreasing to 45.2% at the interval 2565m – 2570. The microfauna encountered in this interval are Ammobaculites sp, Haplophragmoides sp, Ammobaculties coprolithiformis (Scwager, 1868), Ammobaculites bauchensis (Petters, 1979), Reophax sp and Ostracod constitute the benthonic microfauna, while Heterohelix reussi (Ehrenberg, 1840), Heterohelix sp constitute the planktonic microfauna. The next interval 2570m – 2600m is made up of 84.4% benthonic microfauna and 15.6% planktonic microfauna. The benthonic mcrofauna are Haplophragmoides sp, Ammobaculites bauchensis (Petters, 1979f), Ammobaculties benuensis (Petters, 1979f), and Ostracod the percentage occurrence range from 33.3% to 80% per sample. The planktonic microfauna are Heterohelix reussi (Cushman, 1948) and Heterohelix globulosa (Ehrenberg, 1840), with occurrence ranging from 20% to 66.7%. The interval 2600m – 2615m is composed of 71.4% of benthics and 28.6% of planktics. The planktics and benthiics are 50% each in the interval 2600m – 2605m, with the benthics increasing to 80%, while the planktics decrease to 20% in the interval 2610m – 2615m. the encountered benthics are Haplophragmoides pindigensis (Petters, 1979f), and Haplophjragmoides so. The planktonics are Heterohelix moremani (Cushman, 1948). The palynomorphs encountered in the well with their percentage occurrence are Psilastephanoporites sp (0.2%), Elaterocolpites castelaini (Jardine and Maglore, 1965; 93.0%), Spiniizonocolpites echinatus (Muller, 1968; 0.6%). Psilastephanoporites tesseroporus (0.2%), Elateroplicites africaensis (Hergreen, 1973; 0.8%), Psilamonocolpites sp (0.8%), Auriculdites reticulates (Elsik, 1964; 1.0%), Classopols sp (0.2%), Galeacornea stoveri (0.2%), Classopolliis obialosensis (0.6%), Gleincheniidites senonicus (Ross, 1949; 0.2%), Longapertites sp (0.2%) for the pollen mcroflora. Cyathdites minor Couper, 1968; 2.0%), Verrucatosporites sp (15.6%), Reticulatisporites jardinus (Brenner, 1968; 22.2%), Rugulatisporites sp (0.6%), Faveotriletes sp (0.3%), Leptolepidites major (0.9%), Elaterosporites protensus (Jardine, 1967; 14,0%), Elaterosporites klaszi (jardine and Magloire, 1967; 36.6^), Elaterosporites verrucatus (Jardine and Magloire; 1967; 0.9%), Laevigosporites sp (4.6%) and Elaterosporites cf: protensus (Jardiine, 1967; 2.6%) are the spore microflora. The Dinoflagellate palynomorphs encountered are Diphyes colligerum (Deflandre and Cookson, 1955; 1.2%), Dinogymniumdigothus ver. Crassus (1.2%), Spiniferites sp (5.8%), Muderongia cf simplex (1.2%), Lejeunecysta hyaline (Gerlach, 1961; 1.2%). Hystrichospharidium sp (5.8%), Gardoodinium sp (9.3%), Palacecystricochophora infusorioides (2.3%) subtilisphaera senegalensis (3.5%), Palaeoperidinium pyrophorum (1.2%), Chatanglella niiga (2.3%), Diinochenodinium hombiforms (2.3%), Senegalinium biicavatum (60.4%) and Gonyaulacysta sp (1.2%). The other palynomorphs are fungal spore (5.1%), Pediastrum (6.3%), Radiolaria (26.6%), Foram test lining (59.5%). Spikes (1.3%) and Gastropod (toot) (1.3%). The palynomorph assemblages are sporadic in occurrence and vary from few in some depths to common in others while depth 2830m – 2835m has the highest number of species (13), while depths 2655m – 2660m and 2870m – 2875m, have the highest number of individual, i.e. depth 2655m – 2660m has 181 forms with Elaterosporites klaszi accounting for 41. Depth 2870m – 2875m has just two species, but 101 individuals with Elaterocoplptes accounting for 100. Majority of the depths contain as few as one to three forms i.e. intervals 2540m – 2550m, 2620m – 2625m and 2630m – 2635m contain only a single form, intervals 255m – 2560m, 2565m – 2570m and 2640m – 2645 contain two forms, depths 2590 – 2595m, 2960m – 2965 and 2980m – 2985m contain three forms each.

4.0 DISCUSSION AND INTERPRETATION

4.1 Age Determination

On the basis of extinction levels or first downhole occurrences (FDO) of index species of planktonics and palynomorphs forms, age determination of the studied interval was made. The first downhole occurrence of the planktonic index foraminifera Heterohelix moremani (Cushman, 1948) Albian – Cenomanian in age (fig 7) occurred at depth interval of 2600m – 2605m, marking the top of the Cenomanian at tthat level. The foraminiferal association is dominated by Haplophragmoides sp, Haplophragmoides bauchensis (Petters, 1979f), and Ammobaculites benuensiis (Petters, 1979f). this interval is within the Anomalnma Plmmeral – Trochammina wckendeni and the lower part of the Planulina beadnelli-Ammoastuta nigeriana zones established by Petters (1982). The suite of benthonic foraminifera assemblage in this

interval include Ammbaculites bauchensis (Petters, 1979f), and Ammobaculites coprolithiformis (Schwager, 1868). The first Downhole Occurrence of the palynomorph Elaterocolpites castelaini (Jardine and Magloire, 1965) at 2620m – 2625m mark the top of the Cenomanian at that level. The studied interval corresponds to Herngreen (1973) pollen zone 11, which is Albian-Cenomanian in age. This zone is characterized by the presence of Elaterosporites klaszi (Jardinie and Magloire, 1967), Elaterosporites verrucatus (Jardine and Magloire, 1967) and Elaterocolpites castelaini (Jardine and Magloire, 1965). The first downhole occurrence (FDO) of the palynomorphs n this study are Elaterosporites protensus; 2655m – 2660m, Elaterosporites klaszi; 2655m – 2660m, Elaterosporites verrucatus; 2735m – 2740m and Elaterocolpites castelaini; 2620m – 2625.

4.2 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 interpret ancient environments of deposition of the sediments.

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. In micropalaeontology, foraminifera are mostly marine organisms; hence their occurrence in rocks is a direct indication of the marine environment. Thurman (1985) subdivided the marine environment as shown in fig 8. Marine microfossils are known to be associated with each subdivision of the marine environment. Microfossils thus recognized in samples indicates the environment of deposition of the sample to be that to which they are associated with. Studies of modern ecology have provided at least five distinct criteria for the reconstruction of marine palaeoenviornments (Bandy and Arnal, 1960). This techniques of planktonic/benthonic ratio has been used by many workers to determine water depth in marine environment. In this study, the foraminferal planktonic/benthonic (P/B) ratio in samples from the studied well range from 0 – 100% (fig 9). An interpretation of this ratio using modern analogies (e.g Gibson, 1989; Gebherdt, 1977; Obaje et al, 2000) points to changes in water depth between marginal marine to middle neritic i.e. shallow marine environment. Based on the P/B ratio, the following environments were inferred; marginal marine for intervals 2525m – 2590m, 2620m – 2645m, 2660m – 2690, 2710m – 2725m, 3020m – 3130m – 3175m 3210m – 3230m and the middle neritic environment for intervals 2690m – 271m and 3160m – 3175m. The planktonic foraminifera encountered in this study belong to the non-keeled morphogroup of heterohelicids. The non-keeked planktonic foraminifera such as the heterohelcids are believed to be shallow water dwellers (petters, 1983; Jarvis et al., 1988). Heterohelicids are the first to colonize new seaways and the last survivors, being able to withstand harsh conditions such as shallow and anoxic waters (Gebherdt, 1997; Obaje et al., 2002). The association of low diversity arenaceous benthonic i.e. Haplophragmoides species, Ammobaculiites species and Reophax species with Heterohelix, is indicative of marginal marine conditions that suggest a shelf to shoreface environment of deposition (Hamza et al., 2002) The application of palynological data to paleoenvironmental reconstruction have 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 diinoflagellates and foram test linings are used to interprete the depositional environments of the studied interval. The pollen and spores decrease with distance from the shore (Schrank, 1984). The palynofloral constituent of 0% - 35% reflects open marine; minimum of 35% to maximum of 60% reflects nearshore marine environment; while pollen and spore represented by a minimum of 80% to a maximum of 100% reflects continental conditions (i.e. fresh water to Brackish water) as indicated by the relatively higher frequency of the land derived pollen and spores compared to marine mcroplankton abundance (figs 10a-c). this suggests a paralic condition in a shallow marine environment. The shallow marginal marine enviironmetn is further supported by the high diversityof terrestrially derived palynomorphs such as Elaterocolpites castelaini, Elaterosporites klaszi, Elaterosporites protensus and Galeacornea and low value of Classopollis.

5.0 CONCLUSION

X-1 well located in OPL 422, Chad Basin was studied for its sedimentological and biostratigraphic (micropaleontological and palynological) contents, from which paleoenvironmetnal and sequence stratigraphic analyses were made. The studied initerval penetrated a sequence of shale, sandstone, shaly sandstone and sandy shale, covering a total depth of 730m (252m – 3250m). From the biostratigraphic result, a total of eight genera and seventeen species of both planktonic and benthonic foramiinifers were encountered and a total of 16 pollen species, 11 spores species and 15 Dinoflagellate speces making up 14 genera, 8 genera and 14 genera respecitively for the microflora. The accessory microflora encountered are fungal spore, pediastrum, radiolarian, foraminifera test lining, spike and Gastropod (tooth). The arenaceous benthonic foraminifers encountered include Ammobaculites species, Reophax species and Bolivina species, while the planktonic foraminifera encountered is the heterohelicids. Biostratigraphic analysis established Albian-Cenomanian age for the studied interval on the bass of the first Downhole Occurrence (FDO) of the planktonic heterohelix specie; Heterohelix moremani (Cushman, 1948) and the presence of index palynomorphs species, Elaterosporites protensus (jardine, 1978), Elaterosporites verrucatus (Jardine and Magloire, 1967) and Elaterocolptes castelainii (Jardone and Magloire, 1967). The combined usage of the pollen/spore against marine microflora plot and the planktonic/benthonic (P/B) ratio plot served as an aid in the delineation of depositional environment. A marginal marine environment was inferred for depths 2525m – 2590m with more palynmorphs than microfauna. The palynomorphs constitute between 60% to 100% of the microfossil count. Depths 2590m to 2620m reflects an inner neritic environment with the microfauna dominating the fossil count and the benthonics constituting between 80% to 100% of the total microfauna count. A marginal marine environment is inferred for depth 2620m to 2630, containing about 80% to 100% palynomorphs. Depths 2630m – 2660m, 2925m – 2945m, 3020m – 3135m and 3202m – 3250m, all reflect an inner neritic environment containing between 60% to 100% benthic foraminifera, with

few palynomorphs and planktonic microfauna. A middle neritic environment was inferred for depth intervals of 2675m – 2705m and 3150m – 3165m. these intervals contains 60% to 100% marine microplanktonic fauna. The overall environment of deposition inferred for the study interval range from marginal marine to middle neritic (shallow marine). The presence of the non-keeled planktonic heterohelix which are shallower water dwellers in association with simple chambered benthonic foraminifera assemblages is a further confirmation of the inferred depositional environment.

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PLATE 1

Plate 1: Showing different forms of foraminifera encountered in the course of the research work