AGE AND PALEOECOLOGY OF THE NEW NETIM FORMATION CALABAR FLANK, SOUTH EASTERN NIGERIA

BY

EDOHO D. BASSEY & NSE U. ESSIEN*

DEPARTMENT OF GEOLOGY, UNIVERSITY OF CALABAR, NIGERIA.

ABSTRACT

Diverse benthic and planktic Foraminiferal assemblages of Cretaceous age occur within the shales that intercalates the New Netim Marl in the Calabar Flank, South Eastern Nigeria. This formation forms marl ridges across the Calabar Flank from Ikot Nyong (Northeast) to Mbebu village (southwest) . Fifteen fresh samples were collected from the highly fissile shales that intercalate the marl units (fig 1). They were subjected to foraminiferal (micropaleontological) and palynological analysis to determine the age and study the paleoecology of the New Netim Formation. Foraminiferal analysis reveals the occurrence of the following index benthic forms: *Ammobaculites jessensis, Ammobaculites benuensis* and *Haplophragmodies bauchensis.* Also, the planktic foraminiferal species identified include: *Whiteinella inornata, Whiteinella baltica* and *Heterohelix reussi.* These foraminiferal assemblages point to a Turonian – Coniacian age for the New Netim Formation. Palynomorphs recovered from the palynological analysis are generally long-ranging microspores. However, the occurrence of Mid – Upper Cretaceous *Trifossapollenites sp.* and Cicatricosisporites sp. indicates a Turonian – Coniacian age for the marl unit under investigation. The above foraminiferal and palynological assemblages suggest a Turonian- Coniacian age for the New Netim Formation and a shallow inner- neritic paleo- bathymetric environment for the carbonate build-up..

Keywords: Age, Foraminifera, Palynomorphs, Paleoecology, New Netim Formation.

INTRODUCTION

The New Netim Formation consisting dominantly of marlstones intercalated with highly fissile shale units (Fig.1) is a new stratigraphic entity erected by Petters *et al*, 1995. This carbonate build - up was deposited in the Calabar Flank, Southeastern Nigeria. This work, which focuses on the determination of the age and paleoecology of the New Netim Formation involved extensive field mapping exercise along its depositional strike, a distance of 163 km. During the course of the field work, this formation was sampled at various locations where it outcrops, notably at lkot Nyong, Mfamosing and Mbebu (Fig.2). Altogether, four stratigraphic sections were studied out, samples collected from the interbeded thin fossilliferous shale beds, ranging from 0.001m to 0.08m in thickness were subjected to foraminiferal and Palynological analysis. This result of this study is intended to be used to collaborate the result of previous studies (Nyong, 1995, Perch-Nielson and Petters, 1981).

FIG 1: Nodular-marl and shale intercalation in the New Netim Marl

Corresponding Author: nseessien@yahoo.com

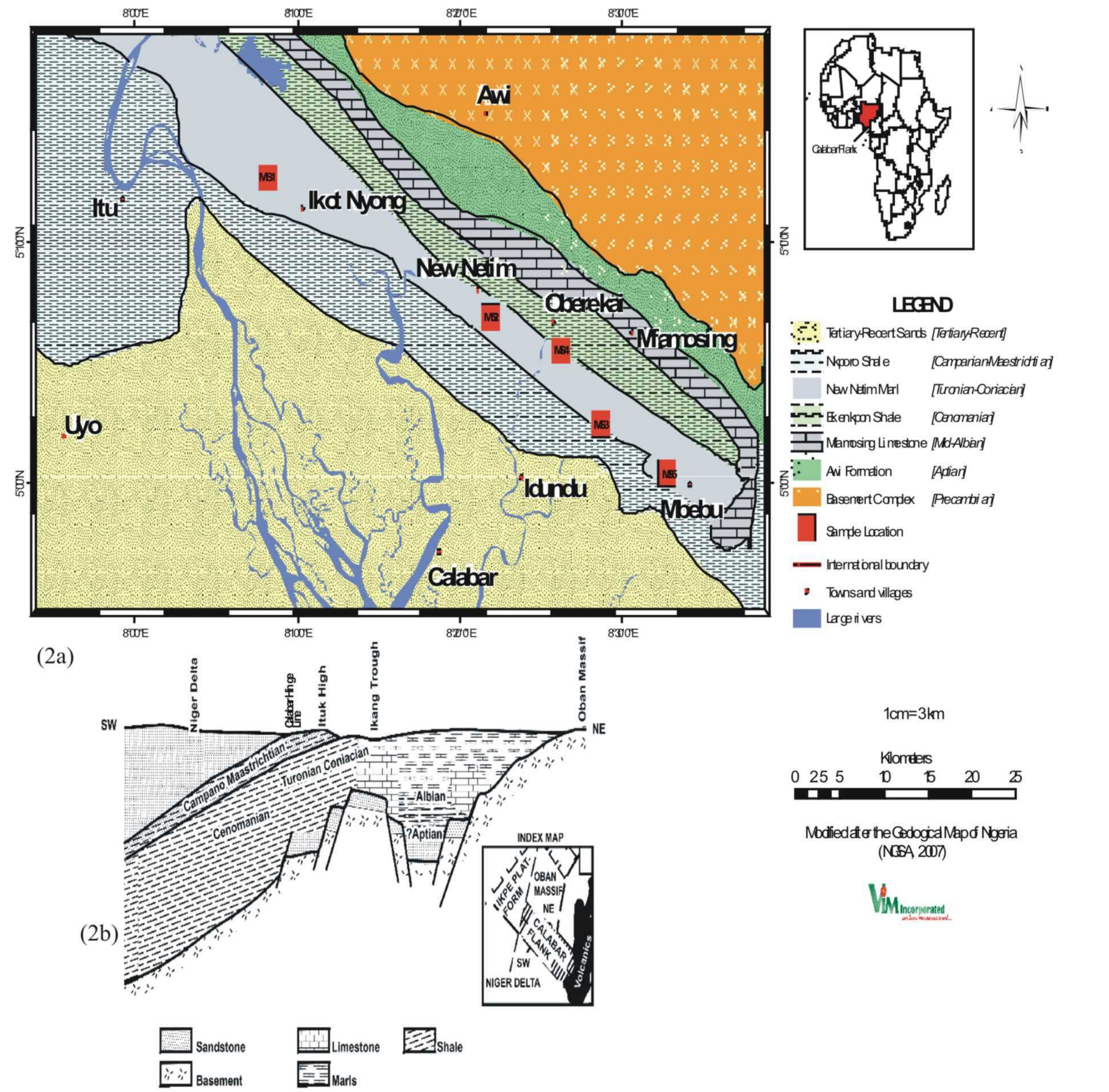


FIG. 2: Geological map of the Calabar Flank showing sample locations. Inset (2b): Structural elements and conceptual subsurface distribution of Cretaceous sediments in the Calabar Flank (Modified from the Geological Map of Nigeria, NGSA, 2007)

GEOLOGIC SETTING OF THE CALABAR FLANK

The Calabar Flank as described by Murat (1972) is an epeirogenic sedimentary basin of Southeastern Nigeria, which is bounded on the north and south by the Oban massif and Niger delta respectively. In the east, the flank is bounded by the Cameroon volcanic line and by the Ikpe platform in the west (Fig.2b). Sedimentation in the flank started during Early Cretaceous (probably Aptian) with the initial deposition of fluvio- deltaic cross-bedded sandstone of the Awi Formation. This unit overlies the Precambrian Basement complex of the Oban massif (Adeleye and Fayose, 1978). The Awi Formation is directly overlain by carbonate platform of the Mfamosing Limestone of Mid – Albian age. During the Cenomanian and Early Turonian, subsidence of the faulted blocks (horst and graben, Fig. 2b) allowed widespread deposition of shales with minor marl intercalations which belongs to the Ekenkpon Formation. Deposition of marl increased in importance in the Coniacian with continued alternate deposition of thin dark shale beds known as the New Netim Formation (Nyong 1995). Santonian and Early Campanian sediments have not been reported in the flank and represents with hiatus a period of non – deposition and / or erosion. Nkporo Shales (Late Campanian- Maastrchtian) overlies the New Netim Formation. The Cretaceous sedimentary succession in the Calabar Flank is capped by a predominantly continental sands and gravels of Late Tertiary to Recent age known as the Benin Formation (Essien et al, 2005)

LITERATURE REVIEW

The New Netim Marl has not been widely studied as the earlier deposited carbonate unit, the Mfamosing Limestone. Nyong (1995) studies on the Cretaceous sediments in the flank describe the marl sequence as showing lateral facies change from thickly bedded units with dark flaggy shale intercalations rich in burrows and ammonites to massive sections with almost mono specific assemblage of echinoid to thickly bedded/massive sections with few burrows and no body fossils. He suggested that deposition of the marl units probably occurred in a wide variety of near shore marginal marine setting. Akpan and Ntekim, (2004) studies on Cretaceous bivalves and paleoenvironment of the Calabar Flank using marl as samples and suggested that the marls were intensively bioturbated by invertebrates. Analysis by Nyong, (1995) using foraminifera and Perch – Nielson and Petters, (1981) using cocolith suggested Early Coniacian age for the marl unit.

METHODOLOGY

Micropaleontology

Samples for foraminifera studies were collected from the thin shale units that intercalates the New Netim Marl at different stratigraphic intervals. Altogether, fifteen (15) outcrop samples were collected and subjected to foraminifera analysis. Each sample was prepared in the laboratory following the standard procedures for microfossil sample preparation, particularly for foraminifera as outlined by Brasier, (1980). A binocular microscope with the magnification of 30 to 100 times was used in studying the different forms.

Palynology

The fifteen (15) outcrop samples were also analyzed for palynomorphs. Samples preparation was by the usual maceration techniques for acid insoluble microfossils using 40% Hydrofluoric acid (HF) (for silica and silicates), 40% concentrated Nitric acid (HNO_3) (for oxidation of humic matter) and 1% Potassium hydroxide (KOH) (for acid neutralization and dissolution of humic matter). Concentration was by sieving using 200 and 400 mesh nylon screens and pipetting the organic residue from a watch glass. Slides of temporary strew mounts using Apathy's medium was made for each of the samples. Optical microscopes were use for studying the palynomorphs.

RESULT AND DISCUSSION

Foraminiferal occurrence and age determination

A total of eighteen (18) species comprising nine (9) planktics and nine (9) benthics (Plates 1 and 2) were recovered from the analysed samples. The Foraminiferal range charts for the planktonic and benthonic foraminifera are as shown in Figs 3 and 4 respectively. The result shows the dominance of long and short ranging taxa. Diversified Cretaceous benthic and planktic foraminiferal assemblages were identified in the shale intercalations. At Ikot Nyong (location MS_1 - Fig. 2) along Calabar - Itu highway (km 34), samples $Sh_{A\ 1\text{-}4}$ show a wide occurrence of planktic foraminifera assemblage (Fig 5). Age interpretation was therefore based on the diagnostic planktic assemblage identified and recorded in the samples. The predominant assemblages include: *Hedbegerella holmdelensis, Hedbegerella planispiral, Hedbegerella delrioensis, Heterohelix moremami, Heterohelix ressui, Whiteinella inornata and Whiteinella baltica. Heterohelix ressui* and *Whiteinella inornata* points to the Turonian-Coniacian age (Boli *et al*, 1989). Samples belonging to outcrop section Sh $_{B1-4}$ (location MS_4 – Fig. 2) at Mfamosing (Fig.6) belong to the Turonian-Coniacian age because of the single occurrence of *Heterohelix reussi.* Arenaceous benthic foraminiferal assemblage occur in the entire interval sampled in the marl outcrop in Sh $_{C\ 1-4}$ at Mbebu (location MS_5 - Fig. 2) -Fig.7. Benthic forms with very minor occurrence of planktic foraminifera (*hedbegerella delrioensis*) were also recorded. The benthic foraminifera noted here are *Ammobaculites jessensis, Ammobaculites sp, Ammobaculites suberetaceus, Ammobaculites coprolithiformis, Ammobaculites amabensis, Ammobaculites benuensis, Ammotium borunm, Haplophragmodies sp.* and *Haplophragmodies bauchensis. Ammobaculites jessensis and Haplophragmoides bauchensis* points to the Turonian-Coniacian age (Petters, 1982). Outcrop samples belonging to section Sh $_{D\ 1-3}$ (location MS_3 - Fig. 2) at Mfamosing (Fig. 8) were very poor in foraminiferal recovery. However, very rare occurrence of *Ammobaculites jessensis* which points to the Turonian - Coniacian age for the anlysed samples were recorded (Petters, 1982).

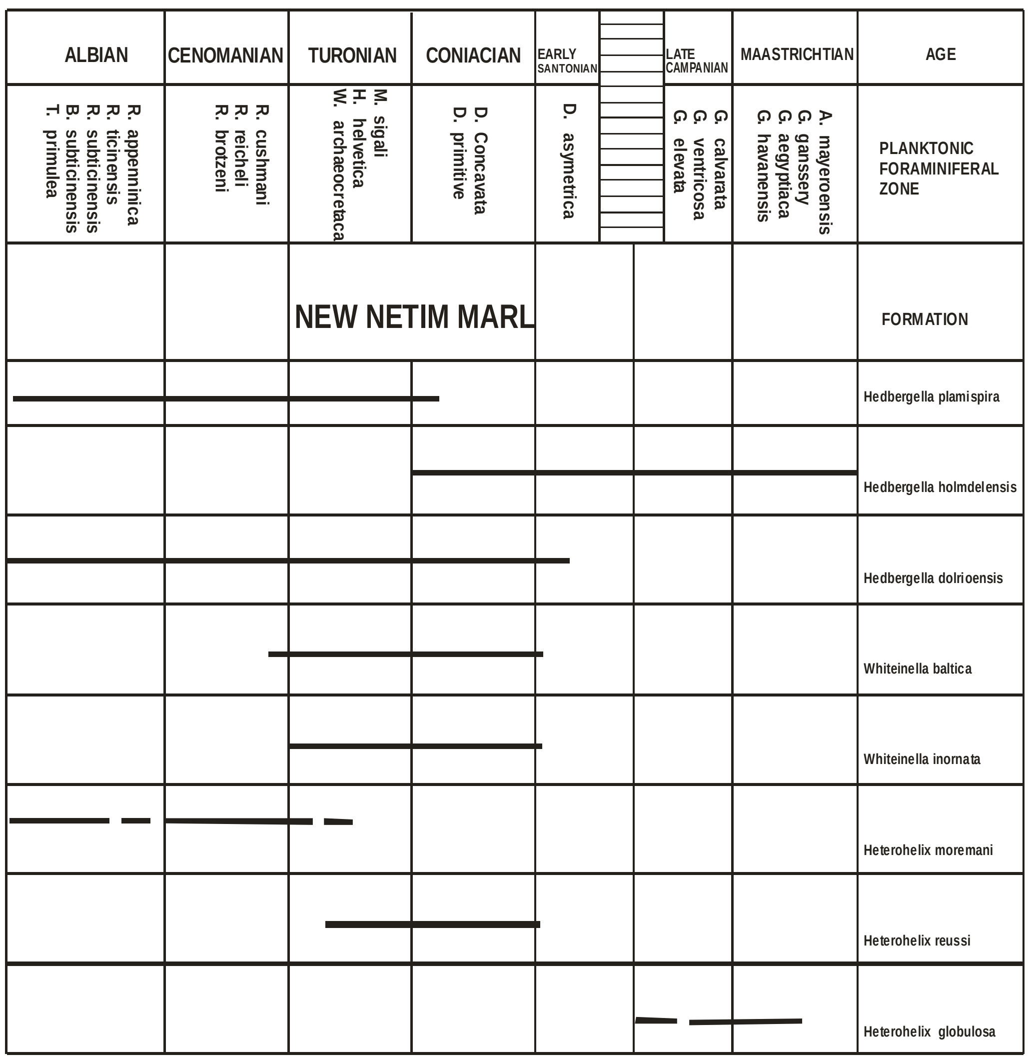


FIG. 3: Planktonic foraminiferal range chart

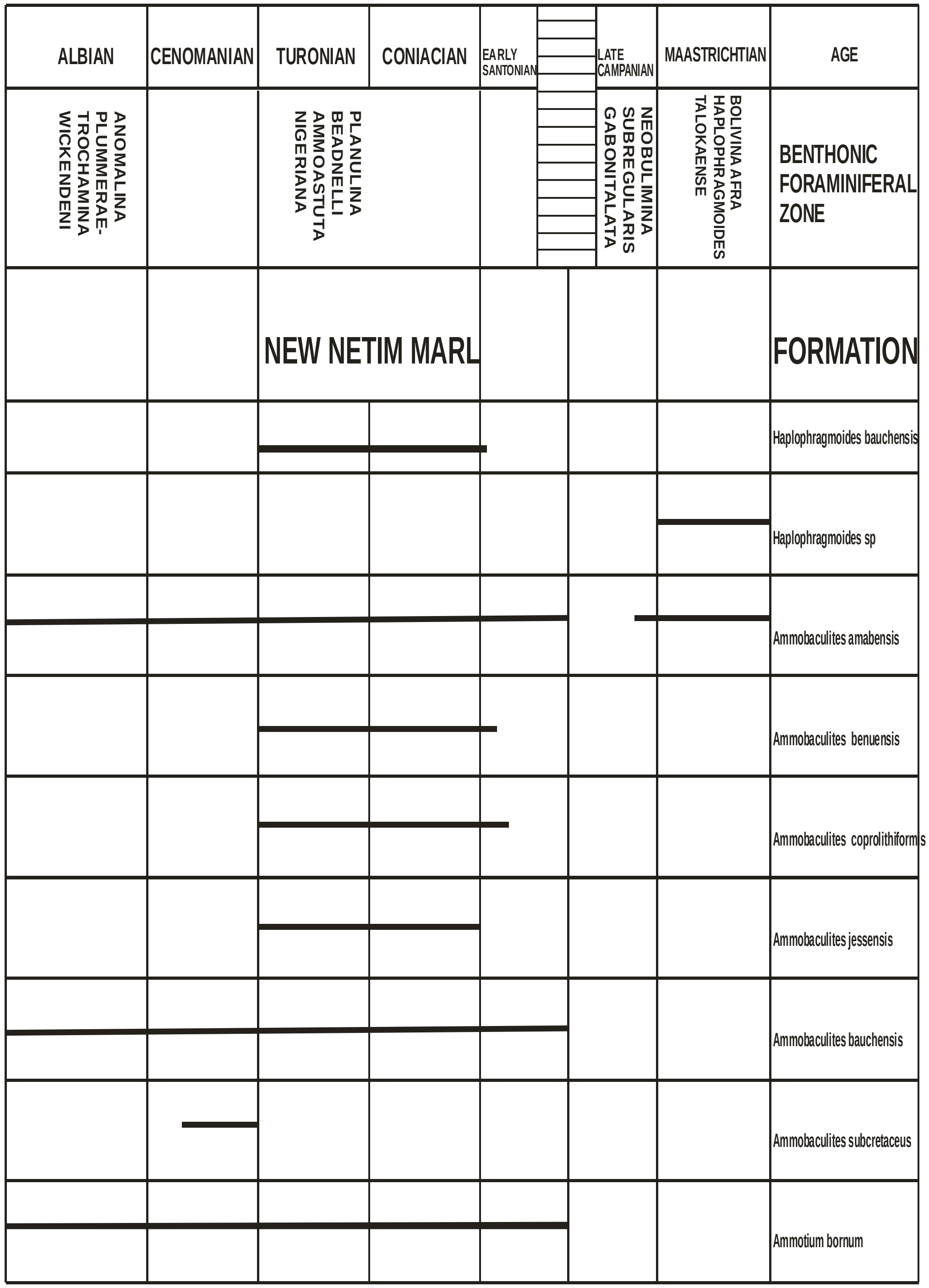
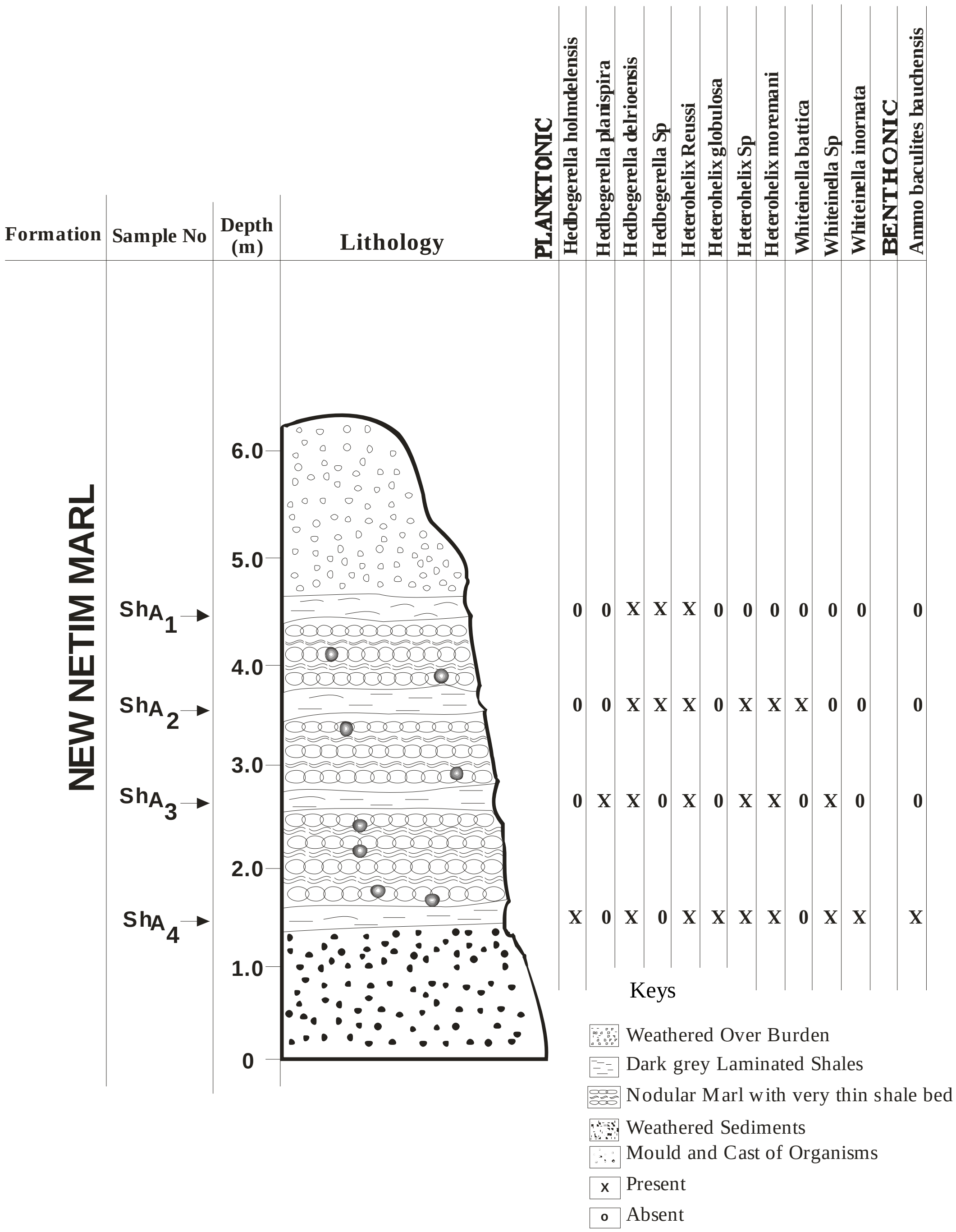


FIG. 4: Benthonic foraminiferal range chart



FIG, 5: Foraminiferal distribution in the interbedded shales within the New Netim Marl outcrop (Sh $_{A\ 1\text{-}4}$) at Ikot Nyong (location MS_1)

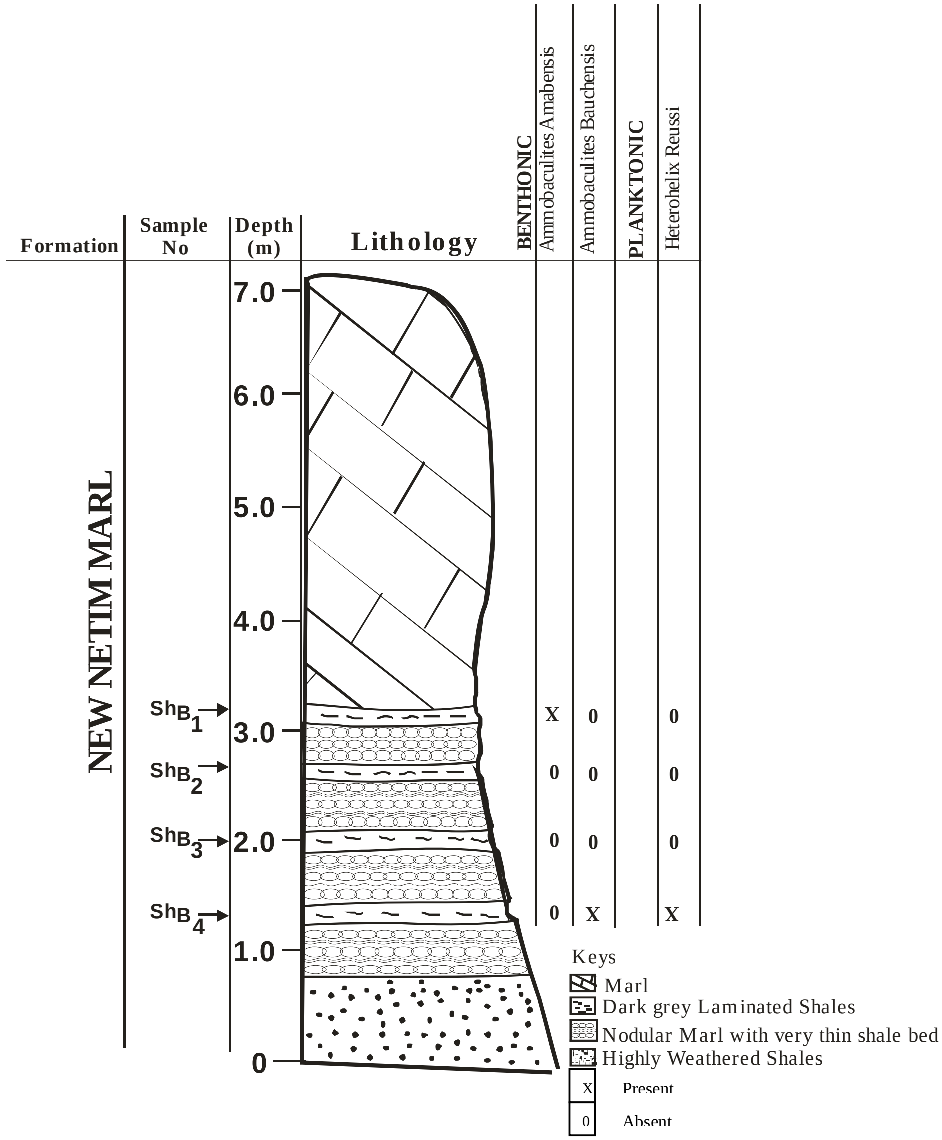


FIG. 6: Foraminiferal distribution in the interbedded shales within the New Netim Marl outcrop (Sh $_{B1-4}$) at Mfamosing (location MS$_4$

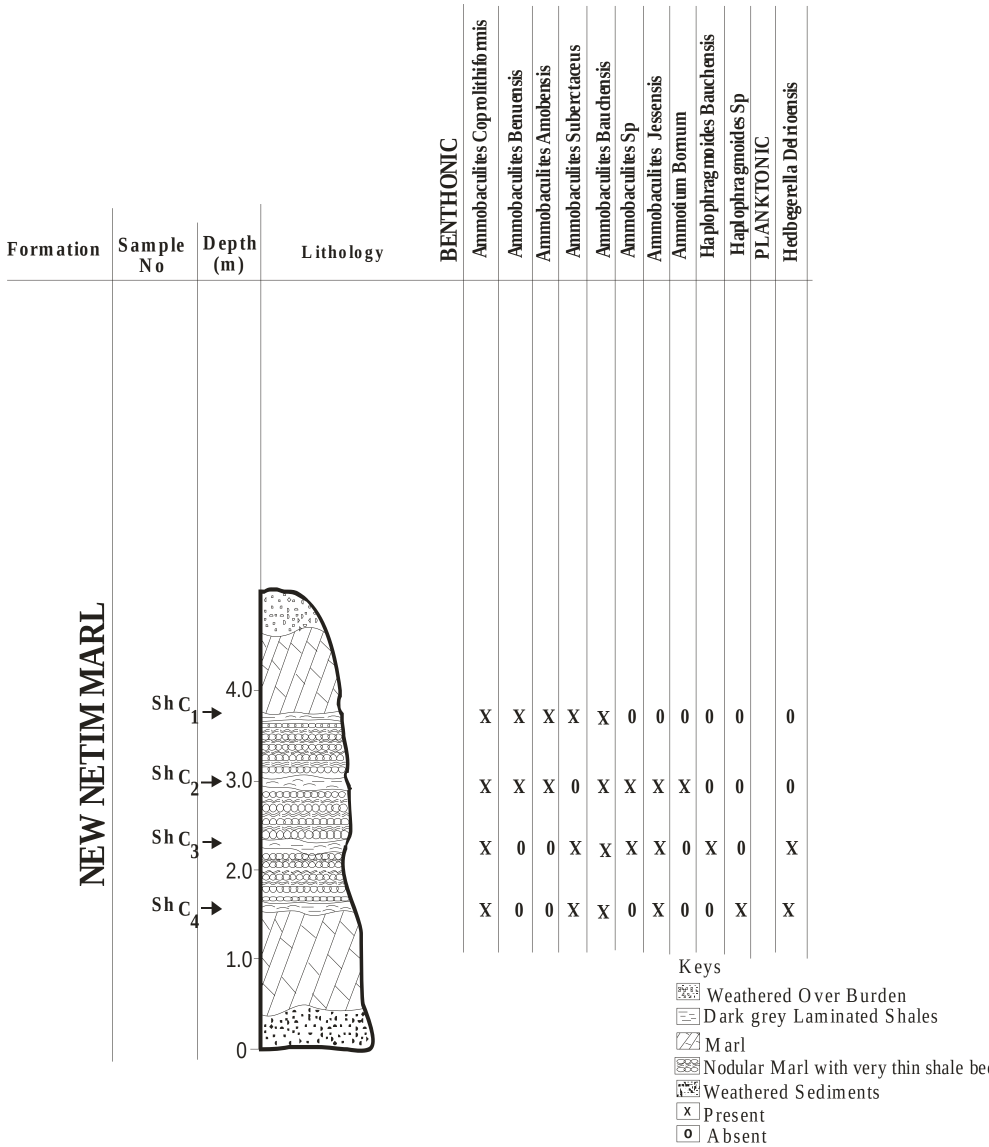


FIG. 7: Foraminiferal distribution in the interbedded shales within the New Netim Marl section

(Sh $_{C\,1\text{-}4}$) at Mbebu (location MS_5)

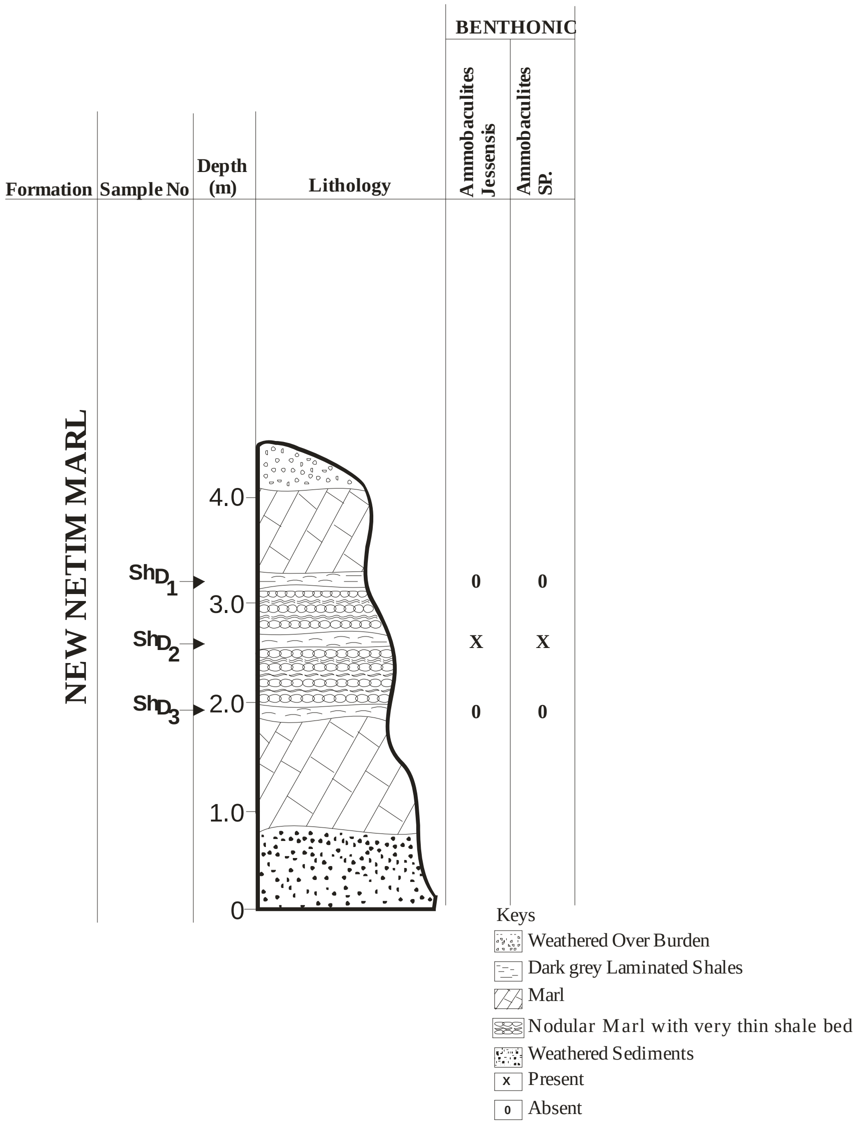


FIG. 8: Foraminiferal distribution in the interbedded shales within the New Netim Marl outcrop (Sh $_{D\ 1\text{-}3}$) at Mfamosing (location MS_3)

Palynomorph occurrence and age determination

Results obtained from palynormophs in this study is not very impressive (Plate 3). Range chart for Palynomorphs in the analyzed samples is as shown in Fig.9. Samples belonging to outcrop section Sh_A 1-4 yielded only few palynomorphs namely *Ephedripites, sp., Ephedripites procerus, Cicatricosisporites sp., Steevesipollenites gigantus,* and *Trifossapollenites sp.* All these forms range from Albian – Cenomanian, with exception of *Trifossapollenites sp.* and *Cicatricosisporites sp*. which is of Upper - Mid Cretaceous age (Fig 9). In samples Sh_B 1-4 at Mfamosing (Fig11), palynomorphs recorded for Sh_B 1 were only *Steevesipollenites giganteus* and *Steevesipollenites sp* of Albian – Turonian age. *Ephedripites procerus* was found only in Sh_B2 while Sh_B3 and 4 were barren of pollen and spores. Samples Sh_C1-4 from Mbebu (Fig 12) recorded abundant palynomorphs ranging from Albian –Turonian in age. The identified species were: *Classopollis* *jardinel, Cicatricosisporites sp., Ephedripites procerus, Steevesipollenites giganteus, Ephedripites sp.* and *Gemmatriletes clavatus.* Sample Sh_D 1 from Mfamosing (Fig. 13) had only two palynomorphs namely *Ephedripites procerus* and *Steevesipollenites giganteus* ranging from Albian – Turonian. Sh_D2 and 3 from the same location were barren, with only abundant foram lining.

Generally, most of the palynomorphs identified are of Early Cretaceous age: *Classopollis jardinel and Gemmatriletes clavatus. Ephedripites procerus, Ephedripites sp.,* and *Steevesipollenites giganteus* forms are long-ranging species. *Trifossapollenites sp.* and *Cicatricosisporites sp*. occur in Upper to Mid Cretaceous and point to a Turonian-Coniacian age for the New Netim Marl. According to Jan Du Chene *et al* (1978), *Trifossapollenites sp.* has been found in Upper Cretaceous in Canada and Mid Cretaceous in Peru and *Cicatricosisporites sp.* has also been found in Accra (Upper Cretaceous). From the above result, abundance and diversity of Turonian-Coniacian palynomorphs remained low in the New Netim Marl. However, the association of *Trifossapollenites sp.* and *Cicatricosisporites sp.* suggests a Turonian – Coniacian age for the New Netim Marl (Jan Du Chene et al, 1978) .

Studies similar to that carried out in this investigation were conducted by Harold and Frerich (1997) in Mexcala Formation which is part of the southern arm of the Laramide fold-thrust belt of Mexico. It forms a comparative evaluation for this study. In their evaluation, a total of 15 planktic foraminiferal species from 35 productive shale samples demonstrate that the Mexcala is assignable to the Coniacian to Santonian Age *Dicarhella concavata* biozone. Thus, local Laramide onset occurred during Coniacian time (88 Ma).

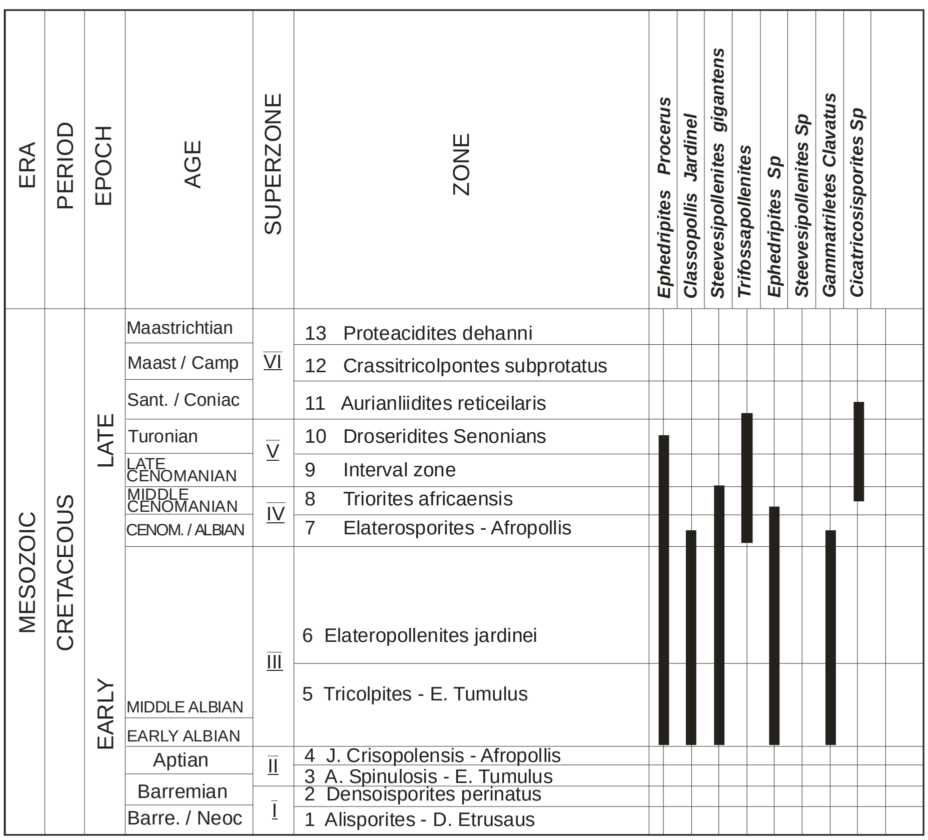


FIG. 9: Range Chart for Palynomorphs

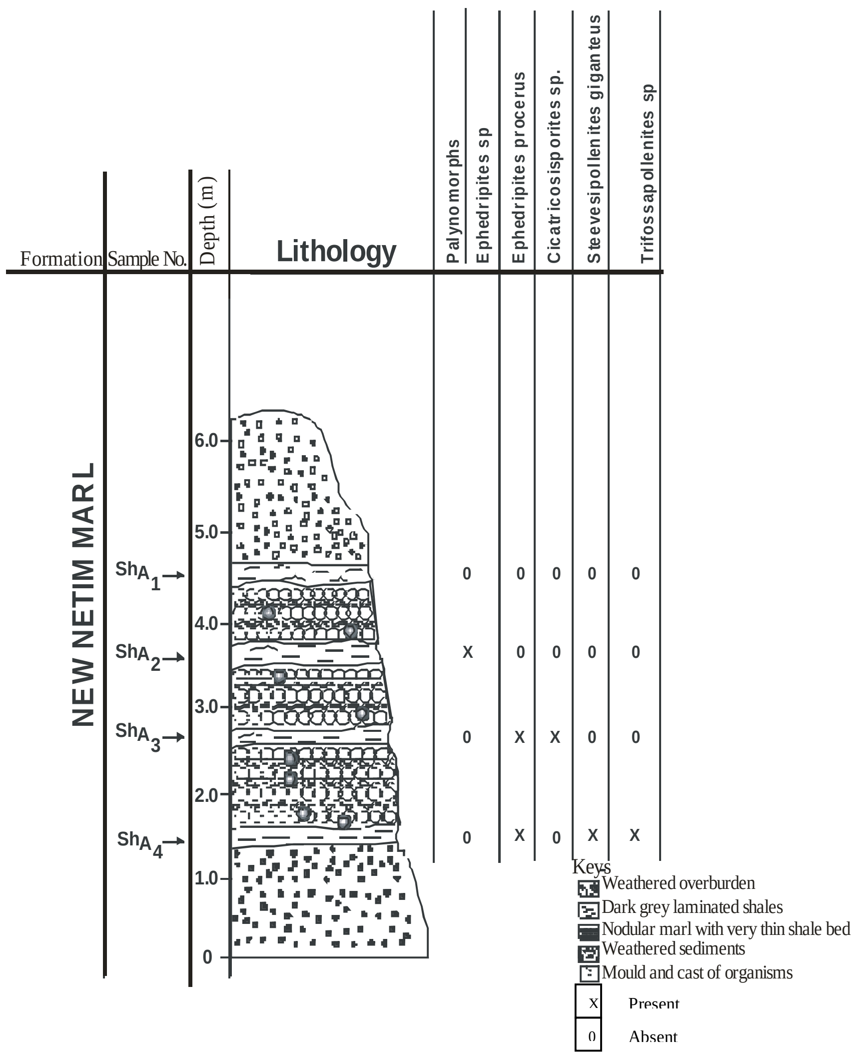


FIG. 10: Palynomorph distribution in interbedded shales of New Netim Marl outcrop Section (Sh $_{A1-4}$) at Ikot Nyong (Location MS_1)

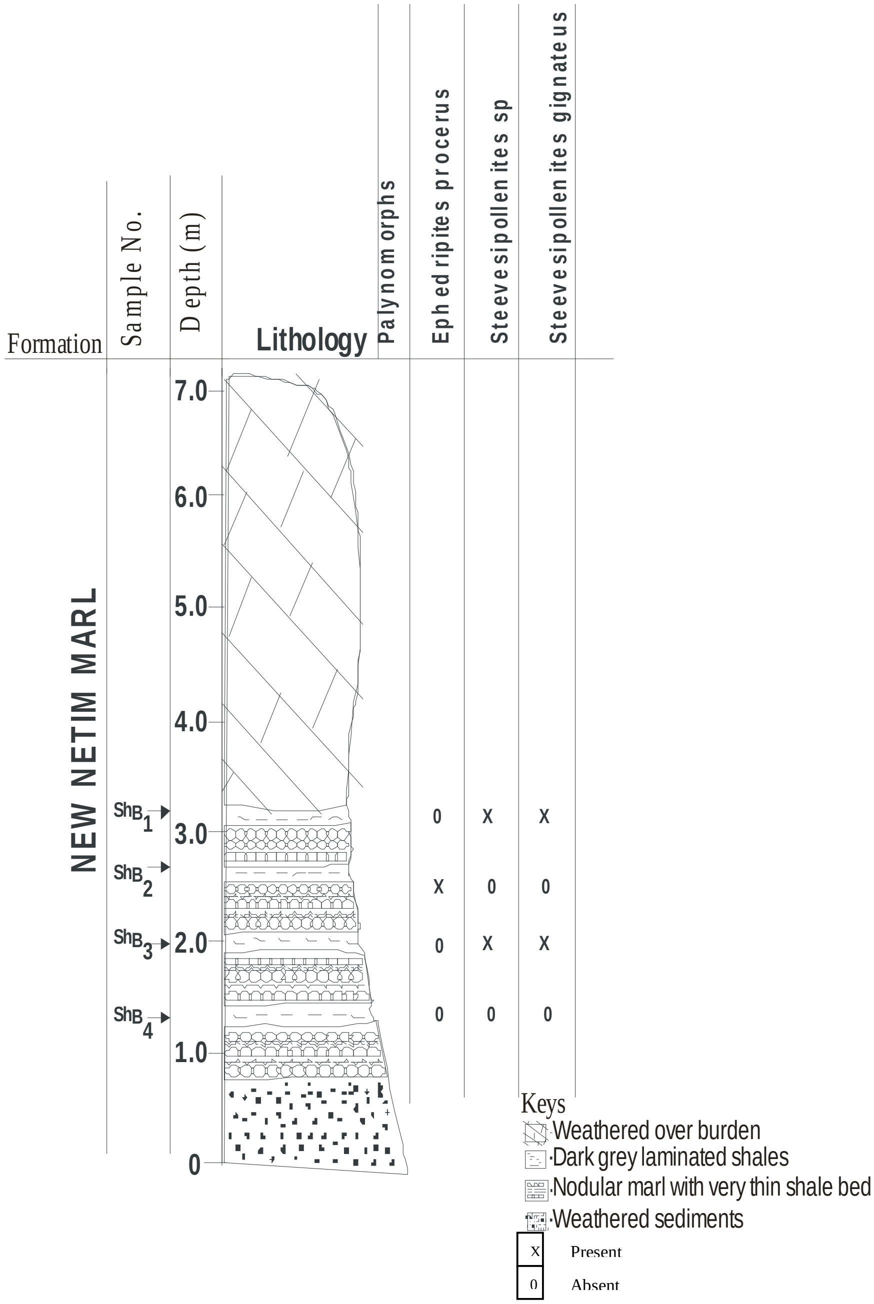


FIG. 11: Palynomorphs distribution in the interbedded shales within the New Netim Marl outcrop (Sh $_{B1-4}$) at Mfamosing (location MS_4)

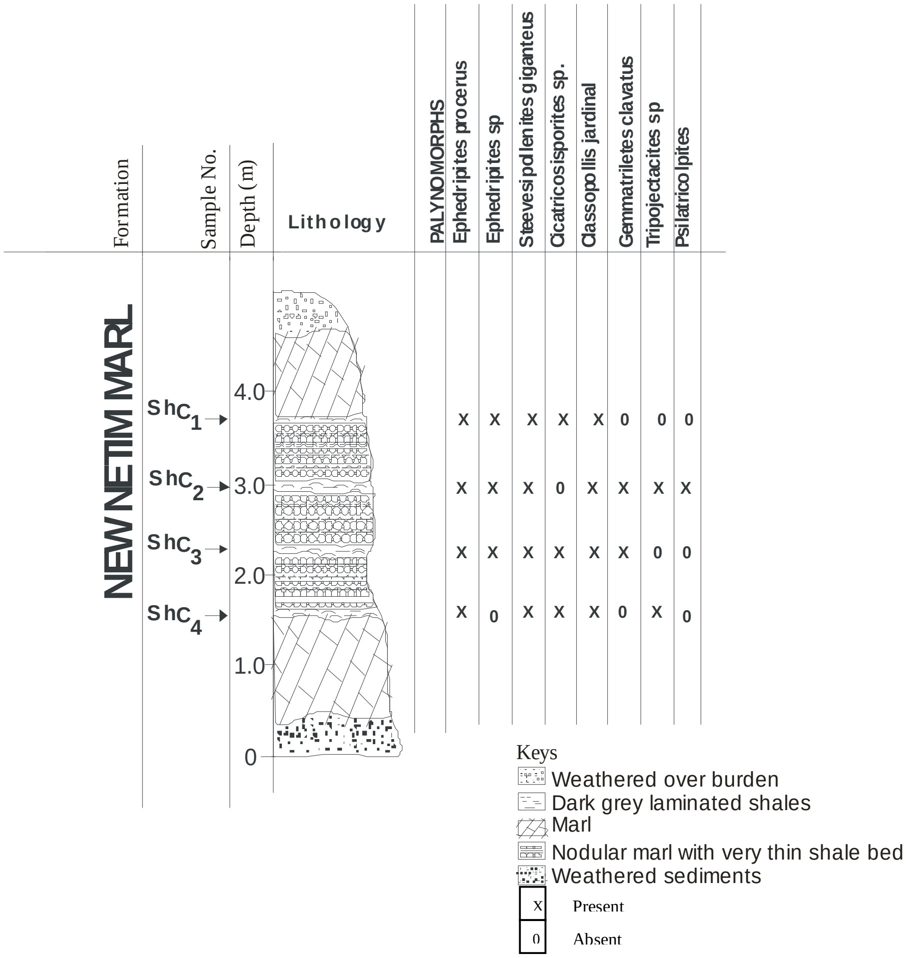


FIG. 12: Palynomorph distribution in interbedded shales of New Netim Marl outcrop Section (Sh_{c1-4}) at Mbebu (Location MS_5**)**

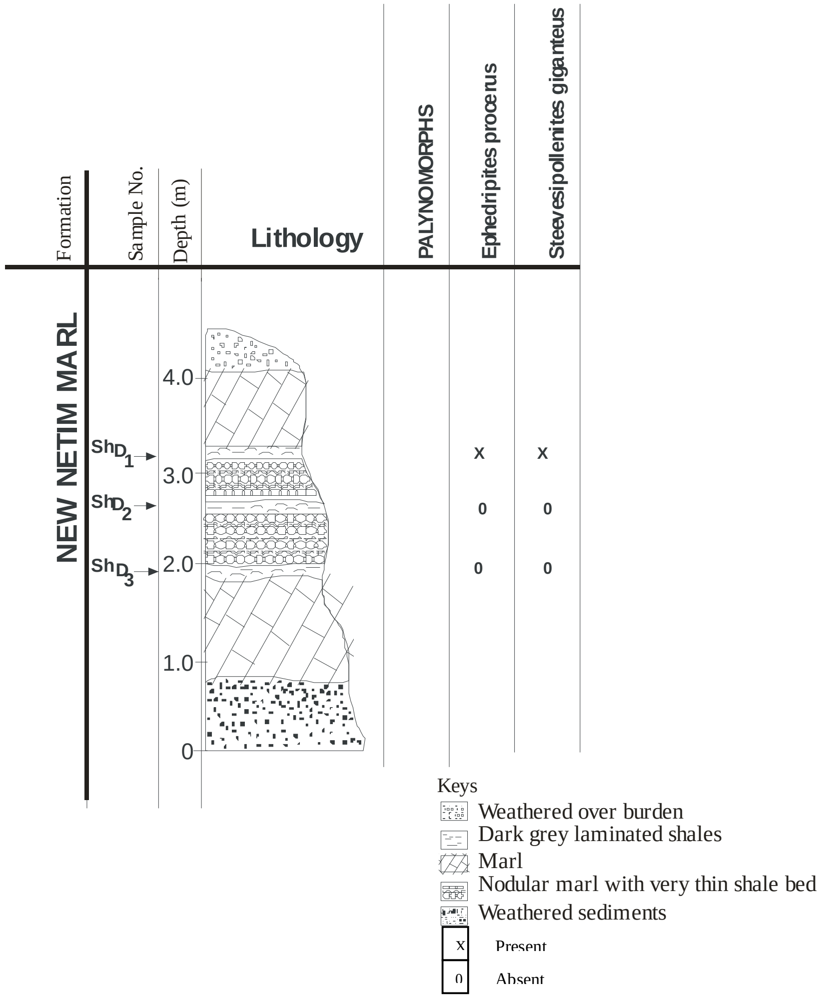


FIG. 13: Palynomorphs distribution in the interbedded shales within the New Netim Marl outcrop (Sh $_{D1\text{-}3}$) at Mfamosing (location MS_3)

PALEOECOLOGY

The poor occurrence of benthic foraminifera in Sh_A 1-4 (Ikot Nyong- Fig 5) is suggestive of an anaerobic bottom conditions at those intervals, which was unfavourable for the development of benthonic communities (Petters 1982). Abundant of planktonic forms (Fig.3) in outcrop sections dominated by *Heterohelix* and *Hedbegerella* with only a few keeled forms signifies flooding of the region during this period by a sea that was characterized by shallow water depth and restricted ecological circulations. Petters (1980) and Eicher and Worstell (1970) had noted that the *Heterohelicids* and the simple globigerine-shaped *Hedbergellids* dominated Cretaceous shallow water environments, as they constitute the first planktonic species to colonize new seaways and also the last to disappear. Based on these considerations, a middle-outer neritic (prodelta) paleo-water setting environment of deposition is suggested for location Sh_A 1-4 (Ikot Nyong) outcrop section.

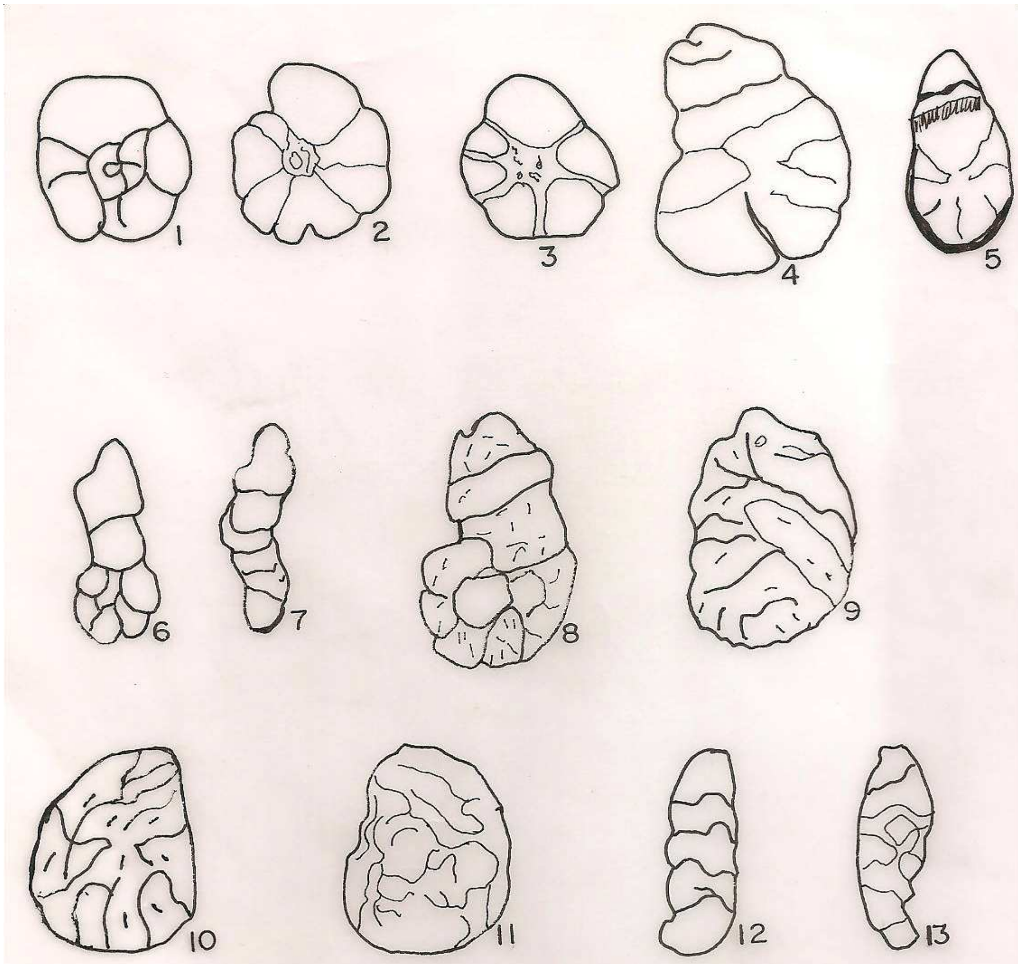
An entirely arenaceous benthic foraminiferal assemblage occur at sampled intervals $Sh_{C\ 1\text{-}4}$ (Mbebu – Fig 7). Diversed arenaceous taxa with very minor occurrence of planktic foraminifera, represented by *Hedbegerella delrioensis* was observed. Foraminfera, particularly the benthics are among the most sensitive group of organisms that could respond to even slight changes in their environmental conditions. According to Brasier (1980), high – diversity foraminiferid assemblages strongly suggest a wide range of available food resources. The predominance of this similar benthic assemblage in Sh_C 1-4 (Mbebu) is indicative that the sediments were deposited within the middle (prodelta) neritic paleo – water depth.

Similar foraminiferal assemblage occurs in Sh_B1 – 4 (Fig. 6)and Sh_D 1 – 3 (Fig. 8) at Mfamosing village. Samples were generally very poor in foraminiferal recovery. However, abundant and diversified species of Ostracoda (*Brachycythere cf. sapucariensis*) were observed to dominate the sections. Their abundant cannot be ignored in the paleo - ecological studies of a sedimentary formation and its depositional environment. These organisms have adapted to various niches as the ocean water surface, sea floor, freshwater ponds and even humid forest soils. They are however known to be shallow marine benthos, where they may be less than the foraminifera amongst the fossil microfauna. Ostracods are particularly useful for the biozonation of marine strata on a local or regional scale. It is second to none as indicators of ancient shorelines, salinities and relative sea floor depths (Brasier, 1980). Ostracods today are predominantly benthic or pelagic throughout their life history. Deduction from the analysis of Sh_B1 – 4 and Sh_D 1 – 3 (Mfamosing), whose foraminiferal association is characterized by low planktic/benthic ratios and abundance of ostracods, shows that the sediments (New Netim Marl) were deposited within a shallow - inner neritic setting.

CONCLUSION

Foraminiferal analysis reveals the occurrence of benthic and planktic index forms. These forms are *Ammobaculites jessensis, Ammobaculites benuensis, Haplophragmodies bauchensis, Whiteinella inornata, Whiteinella baltica* and *Heterohelix ressui*. The above fossil assemblage points to a Turonian – Coniacian age for the New Netim Formation. Palynological analysis of the shale samples shows that all the recovered palynomorphs were long ranging palynofloral assemblage, mostly from Albian – Turonian. Of note, is the occurrence of the Mid – Upper Cretaceous *Trifossapollenites sp.* and *Cicatricosisporites sp*. which points to a Turonian – Coniacian age for the rocks under investigation. The Turonian – Coniacian age deduced in this study for the New Netim Formation is in conformity with earlier Coniacian age by Perch-Nielsen and Petters,

(1981) based on cocolith. Also, the paleoecological study indicates a shallow - inner to middle-outer neritic (prodelta) paleo-water depositional environment for the New Netim Formation.



EXPLANATION OF PLATE 1: Benthic Foraminifera (Redrawn from Petters, 1982)

1 – 2: Haplophragmoides bauchensis. (Petters, 1979) umbilical view, side view.

3: Haplophragmoides sp. seen only in ShC_4 Loc. MS_5.

4: Ammobaculites bauchensis (Petters, 1979) × 120. Spiral view.

5: Ammobaculites benuensis (Petters, 1979) × 120.

6 – 7: Ammobaculites coprolithiformis (Schwager, 1868). × 96,

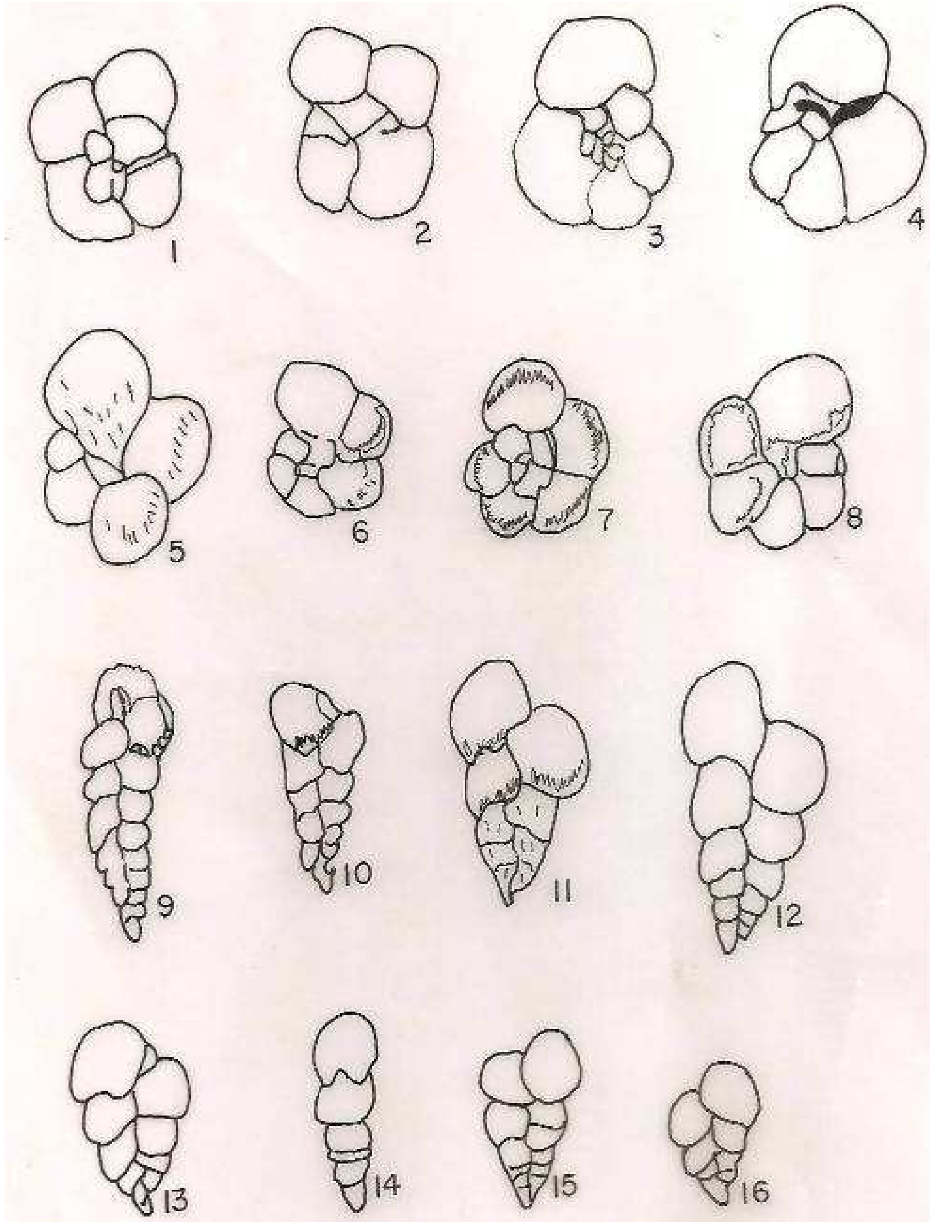
8: Ammobaculites subcretaceus (Cushman & Alenxander, 1930) × 120.

9: Ammobaculites amabensis (Petters, 1979) × 101.

10: Ammobaculites jessensis (Petters, 1979) × 71.

11: Ammobaculites sp. × 58.

12-13: Ammotium Bornum × 58.



EXPLANATION OF PLATE 2 :Planktonic foraminifera (Redrawn from Bolli et al, 1989)

1 – 2: Whiteinella baltica (Douglas & Rankin, 1969) × 60. Spiral view, 2, umbilical view.

3 – 4: Whiteinella inornata (Bolli, 1957) × 60 Spiral view, 4, umbilical view.

5: Hedbergella delrioensis (Carsey, 1926) × 96. Umbilical view.

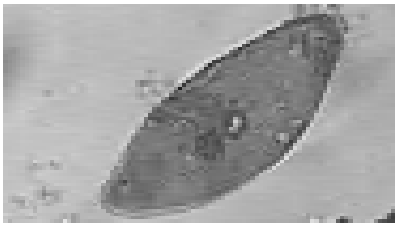
6: Hedbergella holmdelensis (Oysson, 1964) × 96. Umbilical view,

7 – 8: Hedbergella Planispira (Tappan, 1940) × 120. 7, spiral view, 8, umbilical view.

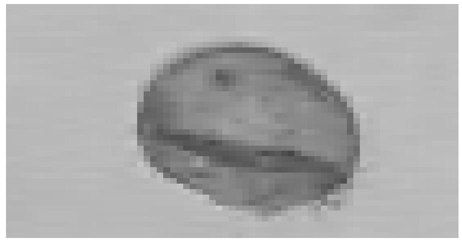
9-10: Heterohelix moremani (Cushman, 1938) × 160. Side views.

11- 12: Heterohelix reussi (Cushman 1938) × 160. Side views.

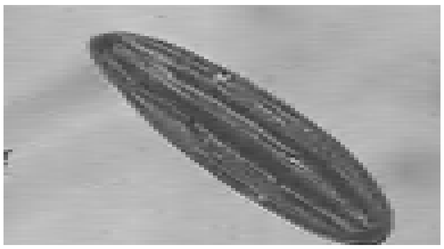
13 - 16 Heterohelix globulosa (Ehrenberg, 1840) × 180. side views, 14, edge view.



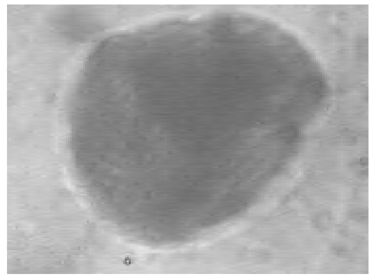
1



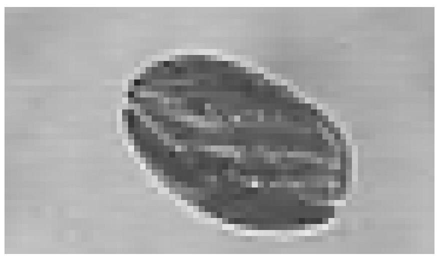
2



3



4



5

EXPLANATION OF PLATE 3 (Edited after Jan Du Chene et al, 1978).

1: Steevesipollenites giganteus

2: Classopollis jardinel.

3: Ephedripites procerus.

4: Cicatricosisporites sp.

5: Steevesipollenites sp.

REFERENCES

Adeleye, D. R. & Fayose, F. A. (1978). Stratigraphy of the type section of Awi formation, Odukpani area, Southern Nigeria. *Journal of Mining Geology, 15*: 33 – 57.

Akpan, E. B. & Ntekim, E. E. (2004). Cretaceous bivalves and palaeoenvironments of the Calabar Flank, S. E. Nigeria. *Global Journal of Geological Sciences, 2(1):* 15 – 36

Boli, H. M.; Saunders, J. B. & Perch-Nielsen, K. (1989). *Plankton Stratigraphy*. Cambridge: University Press.

Brasier, M. D. (1980). *Microfossils*. London: George Allen and Unwin.

Cushman, J. A. (1911). Monograph of the foraminifera of the North Pacific Ocean. *Astrorhizidae and Lituolidae United States Natural Museum Bulletin, 71(1):* 1 – 134.

Eicher, D. L. & Worstell, P. (1970). Cenomanian and Turonian foraminifera from the Great plains, United States. *Micropaleontology*, *16*: 269 – 324.

Essien, N. U.; Ukpabio, E. J.; Nyong, E. E. & Ibe, K. A. (2005). Preliminary organic geochemical appraisal of cretaceous rock units in the Calabar Flank, Southeastern Nigeria. *Journal of Mining and Geology, 41(2):* 185 – 191.

Jan Du Chene, B. E.; De Khasz, I. & Archibong, E. E. (1978). Biostratigraphic study of the borehole. Ojo-1, Nigeria, with special emphasis on the Cretaceous microflora. *Revue de Micropaléontologic*. *21(3)*: 123 – 138.

Lang, H. R. & Frerich, W. E. (1997). New planktic foraminifera data document Coniacian age (88ma) for Laramide orogeny onset and paleooceanography in Southern Mexico . *Jet propulsion laboratory technical report server, United States (1- 16)*

Lipps, J. H. (1979). Ecology and paleoecology of planktonic foraminifera. In: J. H. Lipps, W. H. Berger, M. A. Buzas, R. D. Douglas and C. A. Ross (Eds.), *Foraminiferal Ecology and paleoecology* (62 – 104). Houston: SEPM.

Murat, R. C. (1972). Stratigraphy and paleogeography of the Cretaceous and Lower Tertiary in Southern Nigeria. In: T. J. Dessuavagie (Ed.), *African Geology (*251 – 266). Ibadan: University Press.

Nyong, E. E. & Ramanathan, R. M. (1985). A record of oxygen deficient paleoenvironments in the Cretaceous of the Calabar Flank, South East Nigeria. *Journal of African Earth Sciences, 3(4)*: 455 – 460.

Nyong, E. E. (1995). Cretaceous sediments in the Calabar Flank in Geological excursion guidebook. *Proceedings of the 31st Annual Conference of the Nigerian Mining and Geosciences Society,* (14 – 23). *Calabar:* March 12 – 16.

Perch-Nielsen, K. & Petters, S. W. (1981). Cretaceous and Eocene microfossil ages, from the Southern Benue Trough, Nigeria. *Journal of Archeological Sciences, Geneva, 34* (2): 211 – 218.

Petters, S. W. (1980). Biostratigraphy of the Upper foraminifera of the Benue Trough, Nigeria. *Journal of Foraminiferal Research*, *10(3)*: 191 – 204.

Petters, S. W. (1982). Central West African Cretaceous – Tertiary benthic foraminifera and stratigraphy. *Paleontologica*, *179*: 1 – 104.

Petters, S. W., Nyong, E. E., Akpan, E. B. & Essien, N. U. (1995). Lithostratigraphic revision of the Calabar Flank, South East Nigeria: *Proceedings of the 31st Annual Conference of the Nigerian Mining and Geosciences Society, Calabar*.