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# PETROGRAPHY IN RELATION TO PALAEOGEOGRAPHY OF THE LATE CRETACEOUS LIMESTONE UNITS IN OHAFIA AREA OF SOUTHEASTERN NIGERIA

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**ABSTRACT:**

Petrographic studies have been carried out on the limestone units at the base of the late Maastrichtian Nsukka formation in Ohafia area of south-eastern Nigeria. The aim is to relate petrography with palaeogeography of the limestone sequence. Field studies show that two limestone beds cover over 40 kilometres. They occur as two distinct low hills, in a shale-limestone-shale sequence. The limestones are basically made up of , spary and boisparitic matter, replacing pre-existing aragonitic skeletal matter in the marine organisms that formed the units. Skeletal grains are preserved both as agglutinated, glauconitised, pyritised and calcified fossils, a development that not only depicts the fossils as unreworked but points to the completely marine conditions that characterised their formation. The results are found to be in line with results of earlier work on the palaeogeographic reconstruction of southern Nigeria. With calcite forming well over 80 % of the total mineralogical composition of the samples studied, minor ankarite, benthic and a few planktonic foraminifera recorded, shallow to relatively nearshore palaeo-environment is thus proposed for the area. It is thus concluded that the Late Maastrichtian units in Ohafia-Obotme area of south-eastern Nigeria is another facies of the Nsukka Formation of eastern Nigeria.

KEYWORDS: NSUKKA FORMATION, GLAUCONITIC, SPARITES, MARINE.

## .0 INTRODUCTION

The Ohafia area of southeastern ligeriais is located between latitudes 5° 0'N - 5° 52'N and between longitudes 7° 5'E - 8° 00'E. The area is accessible ırough Calabar, Umuahia and Afikpo ( igs. 1 & 2) and located at the south- estern portion of the Afikpo syncline. ıe occurrence of limestones in Ohafia-Arochukwu area of Abia state has generated a lot of interest. Firstly, the southern portion of the limestone units has been grouped under Tertiary event by Ekwere et al (1994). The type locality of Nsukka Formation has coal seams but lack limestones unlike the same formation in the study area which has no coal seams but has recognisable limestone units. The

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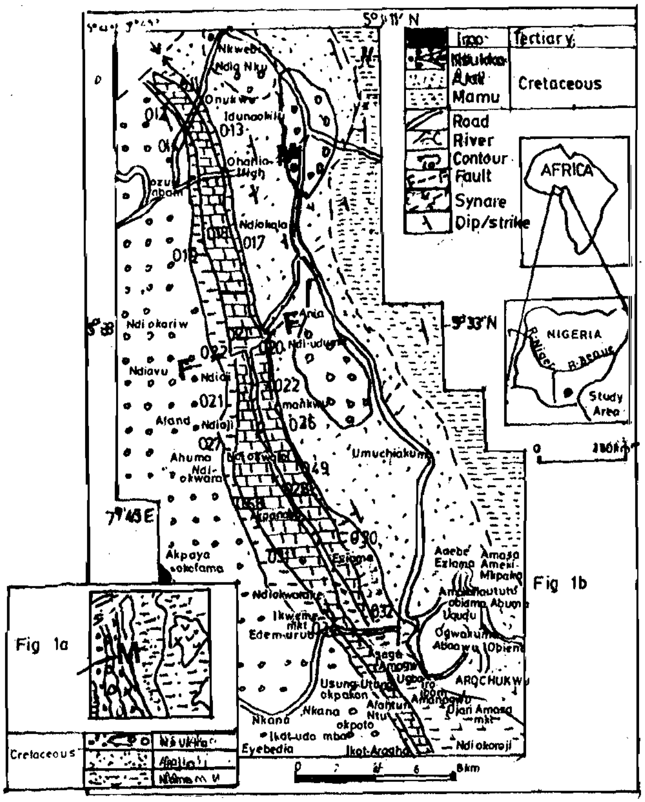



Fig · 1
Geological maps of (a) the SW end of Afigbo Syncline Nigeria ( b) Ohafia Nkana area (Abia and Akwa Ibom States Southeasten Nigeria) Showing the disposition and locations of limestone samples Note the relationship that exists between the Ohafia and the Obotme limestones with respect to Ekwere et al (1994)

Abia-Isu limestone located at the area east of the present study location is of the Nkporo Formation while the Ohafia-Eziama-Obotme unit is of the Late Maastrichtian (probably Nsukk Formation). Thus there is no field evidence to group these under one formation. The present study is aimed at a close study on the petrography and palaeoenvironment of the limestone units.

## 2.0 GEOLOGICAL SETTING:

The area is underlain by three main geological formations as follows:

(a) Mamu formation:- This is a mid-Senonian paralic sedimentary formation made up mostly of shales, silty shales, shaly to silty sandstones and very fine-grained sandstones (Kogbe,1989). The shales are conspicuously dark-coloured and are observed along stream and river valleys in the eastern and central parts of the area.

(b) Ajali formation:- The Ajali formation in the survey area is made up of loose, sub-rounded to sub-angular and quartz arenitic sandstone that is cross-bedded in most locations( Hoque and Ezepue, 1977). The sandstone is poorly to moderately sorted and belongs to the late Maastrichtian. It not only forms a major aquifer but occupies over half portion of the study area. This formation is however overlain by an iron oxide- cemented member near the acontact with the overlying younger Nsukka formation( Ibe and Adiuku-Brown,1992). Ajali Formation is purely continental (Kogbe, 1989) but Hoque and Ezepue( 1977) have described the formation as fluvio-deltaic based on petrography and grainsize studies.

(c) Nsukka formation: This formation has been described by Reyment (1965) and Kogbe (1989) as a partial paralic event, bearing the inprint of a Maastrichtian marine trangression in southeastern Nigeria. The unit is concretionary and highly ferruginised. The formation starts with a shale-limestone-shale-sequence, overlying the Ajali formation and is the same as the limestone recorded between Agbor and Auchi in western Nigeria (Reyment, 1965). The same limestone has been recorded between Owerri and Okigwe (Reyment, 1965). The three

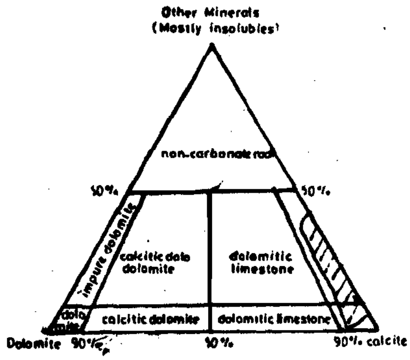



Figure 2 Mineralogical classification of the limestones from Ohafia area

▨ limestone samples from the study area

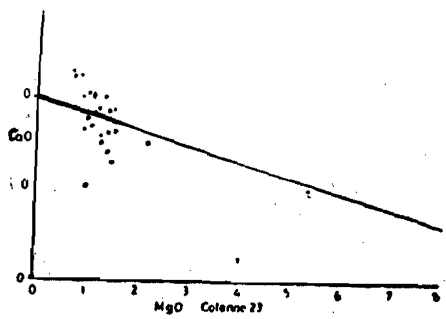
After Car and Rooney (1975)

formations are conformable and have a general west to southwest dip direction of 8° - 15° in magnitude. However dip values of over 30° are recorded in areas suspected to have been involved in some measure of tectonic activity. The disposition of these formations is shown in Fig. 3.

## 3.0 METHOD OF STUDY

### 3.1 SAMPLING

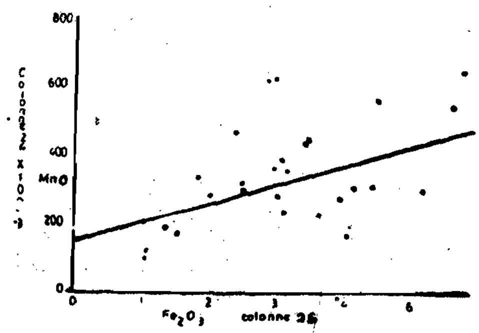
Samples of the two limestone units in the study area ( figure 3). were collected. While the upper bed trends throughout the strike of the area, the lower bed forms a crescent and tends to be sandwitched between two shale beds (Fig. 3). Between 500 and 1000g of the samples were collected along the strikes, spanning for over 40 kilometres, as shown in figure 3.




Fichier LIME 1·2

| source | Som des Carres | Degre de Liberte | moy des Carres | F Ratios | Prob>F |
|---|---|---|---|---|---|
| Modele | 193·5 | 1 | 172.5 | 220 | 0.000 |
| Erreur | 203.7 | 26 | 7.8 | | |
| Total | 376 2 | 27 | | | |

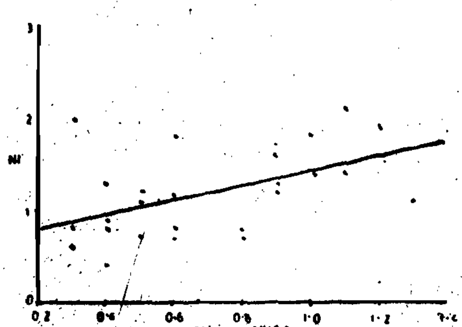
coefficient determination 0.5
Coefficient Ajuste(R^2) 0.4
Coefficient de correlation -0·7




Fichier LIME 1·2

| source | som des carres | Degre de Liberte | moy des carres | F Ratio | prob>F |
|---|---|---|---|---|---|
| Modele | 0·2 | 1 | 0 2 | ...9 | 0 001 |
| Erreur | 0·4 | 26 | 0 0 | | |
| | 0·6 | 27 | | | |

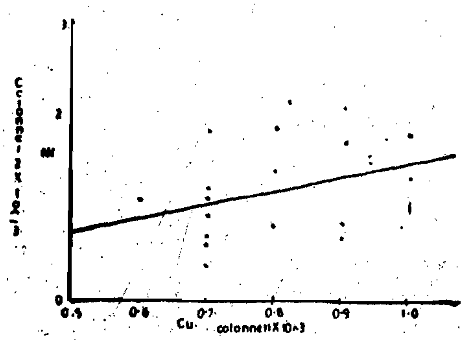
Coefficient de determination 0 3
Coefficient Ajuste (P>2) 0 3
Coefficient de correlation 0.0




Fichier LIME1·2

| source | Som des Carres | Degre de Liberte | moy des Carres | F Ration | Prob>F |
|---|---|---|---|---|---|
| Modele | 0 0 | 1 | 0 0 | 10 2 | 0 004 |
| Erreur | 0 0 | 26 | 0 0 | | |
| Total | 0 0 | 27 | | | |

Coefficient de determination R^2 0 3
Coefficient Ajuste (R^2) 0 3
Coefficient de correlation (R) 0 5




Fichier LIME 1·2

| Source | Somdes Carres | Degrede Liberte | moy des Carres | F Ratio | Prob>F |
|---|---|---|---|---|---|
| Modele | 0·0 | 1 | 0·0 | 8·5 | 0·0007 |
| Erreur | 0·0 | 76 | 0·0 | | |
| Total | 0 0 | 27 | | | |

Coefficient de determination(R^2) 0·2
Coefficient Ajuste(R^2) 0·2
Coefficient de correlation (R) 0·5

TABLE 1 RESULT OF CHEMICAL ANALYSES OF LIMESTONE SAMPLES

| | LS-17 | LS-18 | LS-19 | LS-20 | LS-21 | LS-22 | LS-023 | LS-11 | LS-12 | LS-13 | LS-14 | LS-14A | LS-15 | LS-16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SiO2* | 11.13 | 11.92 | 3.71 | 3.74 | 6.69 | 2.81 | 8.01 | 1.96 | 7.44 | 21.32 | 2.92 | 2.65 | 3.28 | 3.78 |
| TiO2 | 0.27 | 0.29 | 0.07 | 0.10 | 0.33 | 0.14 | 0.17 | 0.02 | 0.40 | 0.13 | 0.11 | 0.06 | 0.11 | 0.12 |
| Al2O3 | 1.82 | 1.79 | 1.37 | 1.02 | 2.15 | 0.93 | 2.04 | 0.79 | 1.88 | 1.64 | 0.83 | 0.90 | 0.88 | 0.94 |
| Fe2O3 | 3.61 | 3.89 | 4.47 | 8.32 | 2.98 | 2.33 | 4.40 | 1.07 | 3.69 | 1.54 | 3.04 | 1.07 | 1.98 | 2.49 |
| MnO | 0.23 | 0.28 | 0.57 | 0.49 | 0.28 | 0.47 | 0.32 | 0.12 | 0.36 | 0.17 | 0.39 | 0.10 | 0.28 | 0.30 |
| MgO | 1.41 | 1.50 | 1.24 | 7.75 | 1.47 | 1.37 | 1.28 | 0.95 | 1.06 | 1.04 | 1.10 | 0.75 | 1.03 | 1.13 |
| CaO | 43.94 | 43.19 | 48.22 | 36.93 | 46.34 | 50.11 | 45.67 | 52.46 | 46.92 | 40.45 | 50.35 | 52.34 | 50.86 | *50.32 |
| Na2O | 0.05 | 0.05 | 0.00 | -0.01 | 0.02 | 0.03 | 0.04 | 0.02 | 0.06 | 0.11 | 0.03 | 0.04 | 0.20 | 0.04 |
| K2O | 0.50 | 0.52 | 0.07 | 0.17 | 0.14 | 0.05 | 0.15 | 0.04 | 0.18 | 0.31 | 0.08 | 0.05 | 0.09 | 0.11 |
| P2O5 | 0.35 | 0.30 | 0.08 | 0.23 | 0.20 | 0.31 | 0.35 | 0.22 | 1.52 | 0.22 | 0.28 | 0.54 | 0.28 | 0.47 |
| LOI* | 35.54 | 35.41 | 40.29 | 40.42 | 38.30 | 40.74 | 36.16 | 41.88 | 35.98 | 32.45 | 40.36 | 41.06 | 40.84 | 40.19 |
| **Total** | 99.83 | 99.13 | 100.08 | 99.16 | 98.91 | 99.31 | 98.58 | 99.49 | 99.48 | 99.39 | 99.48 | 99.55 | 99.59 | 99.64 |
| | | | | | | | | | | | | | | |
| Sc** | 14.00 | 3.00 | 17.00 | 18.00 | 21.00 | 17.00 | 21.00 | 26.00 | 19.00 | 13.00 | 17.00 | 18.00 | 19.00 | 21.00 |
| V | 37.00 | 31.00 | 10.00 | 18.00 | 91.00 | 38.00 | 29.00 | 16.00 | 25.00 | 17.00 | 20.00 | 17.00 | 11.00 | 16.00 |
| Cr | 39.00 | 41.00 | 9.00 | 22.00 | 67.00 | 28.00 | 41.00 | 5.00 | 24.00 | 11.00 | 12.00 | 7.00 | 11.00 | 20.00 |
| Co | 11.00 | 9.00 | 9.00 | 13.00 | 9.00 | 4.00 | 14.00 | 4.00 | 11.00 | 4.00 | 6.00 | 3.00 | 6.00 | 5.00 |
| Ni | 15.00 | 16.00 | 13.00 | 11.00 | 17.00 | 9.00 | 18.00 | 4.00 | 21.00 | 13.00 | 8.00 | 8.00 | 7.00 | 12.00 |
| Cu | 11.00 | 11.00 | 10.00 | 7.00 | 9.00 | 7.00 | 10.00 | 7.00 | 9.00 | 5.00 | 8.00 | 8.00 | 9.00 | 7.00 |
| Zn | 61.00 | 70.00 | 25.00 | 39.00 | 45.00 | 25.00 | 122.00 | 19.00 | 53.00 | 18.00 | 37.00 | 18.00 | 35.00 | 56.00 |
| Rb | 15.00 | 14.00 | 4.00 | 7.00 | 4.00 | 3.00 | 5.00 | 2.00 | 7.00 | 7.00 | 5.00 | 2.00 | 3.00 | 5.00 |
| Sr | 873.00 | 811.00 | 373.00 | 386.00 | 798.00 | 994.00 | 890.00 | 1215.00 | 687.00 | 782.00 | 1042.00 | 1084.00 | 676.00 | 670.00 |
| Y | 12.00 | 13.00 | 9.00 | 9.00 | 8.00 | 10.00 | 20.00 | 4.00 | 30.00 | 9.00 | 7.00 | 7.00 | 8.00 | 12.00 |
| Zr | 256.00 | 276.00 | 0.00 | 42.00 | 70.00 | 17.00 | 19.00 | -30.00 | 207.00 | 120.00 | 21.00 | -17.00 | 22.00 | 42.00 |
| Nb | 6.00 | 6.00 | 3.00 | 2.00 | 6.00 | 3.00 | 3.00 | 1.00 | 6.00 | 3.00 | 1.00 | 1.00 | 2.00 | 2.00 |
| Ba | 107.00 | 122.00 | 79.00 | 44.00 | 39.00 | 13.00 | 41.00 | 11.00 | 74.00 | 109.00 | 31.00 | 23.00 | 24.00 | 55.00 |
| Pb | 2.00 | 3.00 | 4.00 | 2.00 | 6.00 | 2.00 | 5.00 | 1.00 | 4.00 | 2.00 | 2.00 | 2.00 | 3.00 | 2.00 |
| Th | 9.00 | 9.00 | 7.00 | 9.00 | 7.00 | 6.00 | 3.00 | 4.00 | 10.00 | 7.00 | 7.00 | 5.00 | 5.00 | 4.00 |
| U** | 1.00 | 1.00 | 1.00 | 0.00 | -2.00 | -1.00 | -1.00 | -2.00 | 3.00 | -4.00 | -2.00 | 0.00 | -1.00 | 0.00 |

Negative values indicate not detected while zero indicate non detectable amounts
($SiO_2$* - LOI*): All major element values and loss on ignition(LOI) are in per cent.
(Sc** - U**): All Trace element values are in parts per million (ppm) concentration

Supervising analyst: Alan Gray

## 3.2 PETROGRAPHIC DESCRIPTION OF LIMESTONE UNITS:

In hand specimen, the two units have the same colour which range from light grey to cream. Rounded clay noddules and calcitised shell fragments of gastropods and bivalves are abundant. These form conspicuous light-coloured and helical patches in all samples. A few outcrops at the base of the Formation show some ferruginisation.

Under the petrographic microscope at X100 maginfication, the units show increasing calcite and decreasing quatrz contents from north to the south of the area. This development tallies well with the field observation where rounded quartz grains (2 - 4 cm in diameter) characterise the upper unit at Ndi Uduma Ukwu unit in the northern part (plate 1). In general, the calcite and formaminifera contents of the units increase from Ndi Uduma Ukwu to areas around Obotme. Shell fragments constitute over 70 % of the structures studied. However these are entirely replaced by spary calcite (plate 2). Shell matter, essentially of gastropods, and bivalves as well as foraminifera tests are replaced by calcite. The Amankwu and Ndi Uduma Awoke units show increasing fossil content as seen in plate 3. In some foraminifera, pyrite, glauconite and quartz grains are observed. Such agglutinated forms are evidence of material borrowed from the environment and thus reflect the palaeo-environment. Modal estimates of the mineral identified under the microscope are as follows:- Calcite (81 %), Iron oxide (7 %), Glauconite (5 %), Quartz (2 - 10 %), Others (under 5 %). Because of the identical mineralogy of both the upper and lower beds, they were treated as belonging to the same deposit but separated by shale units (Fig.2). However the presence of apatite grains in both beds could not be generalised as these were only identified in the lower bed. Samples from the area south of Isiugwu village showed greater calcite content. In this location, samples were purely calcite from an inferred fault zone (Ibe, 1996). Fibrous calcite observed in some of the samples possibly indicate recrystallisation either due to dolomite or ankarite ( Plates. 4 & 5). Foraminfera of the heterohelix species was identified. So were globorotalia and the primitive forms numulites.

Table 2 - Summary of correlation coefficients for elemental and major oxide ratios from regression results

| Elemental/ Oxide Ratios | Correlation Coefficient | Elemental/Oxide Ratios | Correlation Coefficient |
|---|---|---|---|
| Ni/Cr | +0.5* | $SiO_2/CaO$ | -0.8 |
| Ni/Co | +0.5 | CaO/MgO | -0.7 |
| U/Sr | -0.2 | MnO/Ni | -0.1 |
| $Fe_2O_3/Co$ | +0.6 | MnO/CaO | -0.3* |
| Ni/CaO | -0.4 | Co/CaO | -0.8 |
| $CaO/Fe_2O_3$ | -0.3 | Ba/CaO | -0.4 |
| $MgO/Fe_2O_3$ | 0.0 | $MnO/Fe_2O_3$ | +0.6 |
| Sr/CaO | +0.2 | | |

* Negative values indicate negative correlation coefficient, while positive values indicate positive correlation coefficients. However values less than -0.3 or greater the +0.3 are deemed to be significant.

## 4.0 DISCUSSION

The presence of marine fauna, agglutination and glauconite in-fillings are

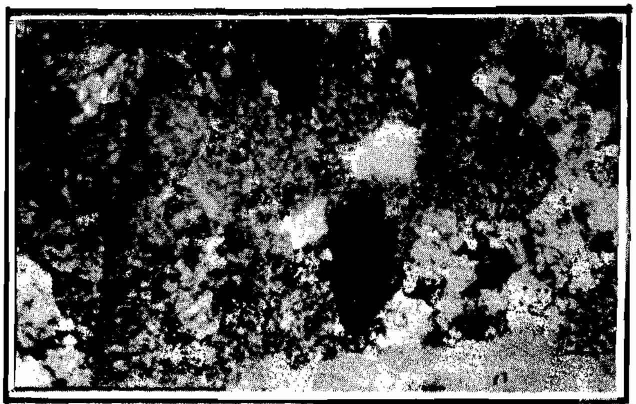


Plate 1 Showing increased quartz content in the Ndi Uduma Ukwu Limestone.

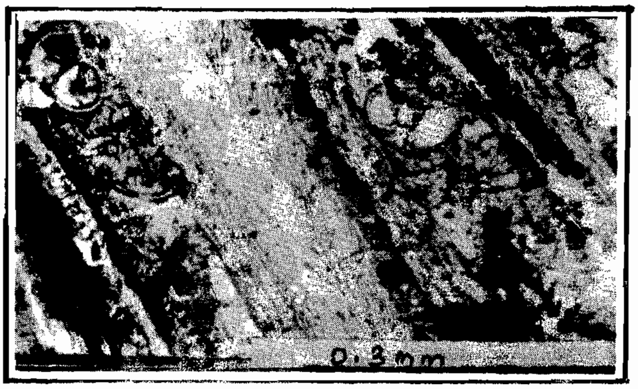



Plate 2 Spary to micritic calcite replacement of faunal remains in the limestones

Plate 3 Increasing calcified skeletal remnants at the Amankwu, Ndi Uduma Awoke and Eziama Limestone Units.

Plate 4 Evidence of recrystallisation from fibrous calcite and dolomitisation at the Isiugwu unit.

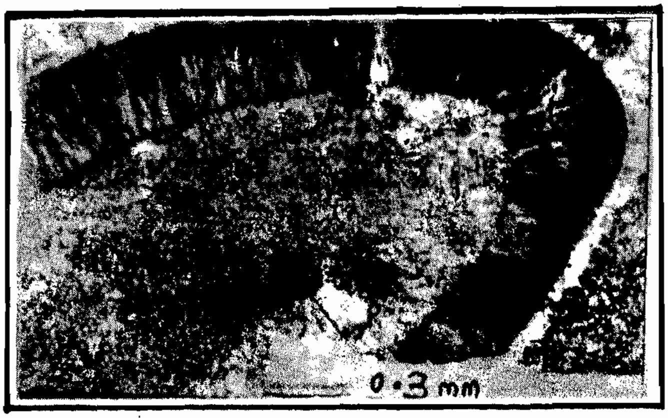



Plate 5 Further evidence of fibrous calcite crystallisation in Nid Amogu Unit.

possible indication of not only the marine nature of the fossils but the fact that the project area was under marine conditions during the late Maastrichtian. This is because glauconite forms exclusively under such conditions and is unable to withstand significant reworking. A comparison made between the results of chemical analysis of Reyment (1965) and that of Ibe (1998) shows that the limestone identified near the Awle river, between Agbor and Auchi in western Nigeria are the same. Furthermore, the Nsukka Formation between Okigwe and Owerri has limstone bed. The present units in this study represent the southerly section of the Nsukka Formation in eastern Nigeria. The presence of rugoglobigerina foraminifera in the samples is an indication of slightly deep marine conditions. Thus the late Maastrichtian in the Ohafia area bears the inprint of a marine sequence which probably continued to the Tertiary. It is possible that sections of the Obotme limestone have Tertiary signatures as Ekwere et al (1994) have pointed out but

Cretaceous-Tertiary transition an associated events. Lastly, limestones form during relatively trangressive maxima. Thus the mere presence of the limestones in Ohafia area suggest an entirely palaeo-environmental setting for the Nsukka Formation. It is then clear that the type locality previously set for Nsukka Formation needs to be re-addressed in the light of all the findings regarding the limestone in the Fomation both in parts of western and eastern Nigeria.

## 5.0 CONCLUSION:

As as a result of the preponderance of marine minerals and fossils from the limestone units of the Ohafia area of southeastern Nigeria, the abnormal Sr and Ba concentrations, Ibe (1998) has used Goldberge (1954) finding on scavenging of elements at the sea floor to draw some inferreces on the late Maastrichtian marine transgression in the Ohafia area. This is in line with Kogbe (1989 ) based purely on palaeontology. The limestone units of the Ohafia area show spary calcitic nature, where skeletal grains are wholly replaced by calcite. The presence of limestone in the Nsukka formation in this part of Nigeria is a new development since many researchers have had to lump Nsukka formation under coal measures, making it non-marine. This study shows that there was actually a late Maastrichtian Tertiary marine transgression that affected most part of southern Nigeria in general and the project area in particular. Faunal evidence confirms this.

## 6.0 ACKNOWLEDGEMENT:

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