INTERNATIONAL JOURNAL OF NATURAL AND APPLIED SCIENCES (IJNAS), VOL. 4, NOS.1& 2 (2009); P. 58 – 64. 1 TABLE, 2 FIGS, 2PLATES

Lower Tertiary foraminifera from subsurface sediments in the Calabar flank, S.E. Nigeria.

O. A. Njoh*[1], U. U. Nkeme[2] and S. W. Petters[3]

ABSTRACT

The Calabar Flank has erroneously been considered and treated as an exclusive Cretaceous sedimentary basin. A recent examination of some sections in the Uruan–1 and Ikono-1 wells respectively on the eastern edge of the basin have revealed a lower Tertiary Foraminifera assemblage which do not only characterize the lower Tertiary, but permitted the recognition of the Paleocene and Eocene ages. This foraminiferal assemblage is fairly abundant, diverse and consists of both the benthonic and planktonic forms. The planktonics are dominated by the acarininids and morozovellids and also some diagnostic forms like *Morozovella angulata* (White), *Morozovella acuta* (Toulmin), *Subbotina triloculinoides* (Plummer), *Acarinina aequa* (Cushman and Renz), *Acarinina soldadoensis-soldadoensis,* (Bronnimann), *Pseudohastigerina wilcoxensis* (Cushman and Ponton), *Planorotalites pseudomenardii* (Bolli) *Chiloguembelina wilcoxensis* (Loeblich and Tappan). The benthonics include among others, *Anomalinoides midwayensis, Eponides pseudoelevatus, Bullimina midwayensis, Bolivina africana, Hopkinsina danvillensis, Gyroidinoides sp, and Anomalinoides umboniferus.* This benthic assemblage generally correlates with the lower Tertiary. Therefore unlike thought previously the sediments studied here confirmed that the lower Tertiary interval do occur in the Calabar Flank. However, it is suggested that the sediments may be the relicts of the massive post-Cretaceous erosional episodes which were widely reported in this region.

INTRODUCTION

The Calabar Flank as a sedimentary basin is not usually associated with the Tertiary depositional events in Nigeria. Except in a few synoptic notes such as Murat (1972) in which it was recognized that, large areas east of the Niger Delta, downdip of the Abakaliki Plunge including the Calabar Flank, have shown repeated periods of erosion and or non-deposition during Middle and Upper Eocene. Reijers (1998) while considering the sequence stratigraphy of the Mfamosing Limestone Carbonates in subsurface sediments in the Calabar Flank, suggested that, some Tertiary sediments can be found in some wells in the western edge of this basin. Petters (2004), (Personal communication) affirms that although not regularly encountered, Tertiary sediments do occur particularly in the subsurface on the western flank of the basin, but attributed its gross absence to widespread post-Cretaceous erosion in this basin, during which most of the Tertiary sediments were eroded. However, no further investigation has yet been carried out on this unusually somewhat patchy occurrence of the Tertiary sediments in the Calabar Flank. Apart from the wide spread coastal plain sands, no Tertiary outcrops have been encountered in this basin, moreso, subsurface sediments are not commonly available. Cretaceous outcrop samples therefore have been the only study material used in most of the previous works carried out in the basin. These outcrops are rare, highly weathered, eroded or covered by thick overburden, vegetation or swamps that are very characteristic of this tropical region. The purpose of this work therefore is to investigate and properly date these subsurface sediments using foraminifera to confirm the suggested Tertiary age. The result will undoubtedly improve on our understanding of the depositional history of the Calabar Flank sedimentary basin.

Like the adjoining Niger Delta, the Calabar Flank is very attractive because of its geology and economic potentials. A good amount of work has been carried out and published on the various aspects of this basin, though focused principally on the Cretaceous sediments a few amongst them include; Reyment (1965, 1968), Zarboski (1983, 1985) who used ammonnites, and gastropods to establish ages for the Cretaceous sediments in the Calabar Flank. Rao and Kuraman (1988) viewed Mesozoic and Cenozoic plant life from outcrop and borehole sediments, while Akpan (1985) used trace fossils to define the paleoenvironments in some areas of the basin. More refined biostratigraphic works include those of Petters (1980, 1982, 1983), Petters et al (1995), Nyong and Ramanathan (1985), De Klasz (1978), Edet and Nyong (1993) and Ukpong et al, (2007).

*Corresponding author. Email: njoh68@yahoo
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[1] Department of Geology and Environmental Science, University of Buea, Cameroon.
[2] Chevron, Lagos ,Nigeria
[3]Department of Geology, University of Calabar, Calabar, Nigeria

The Calabar Flank is located in the Southeastern part of Nigeria. It is bordered to the north by the Precambrian Oban Massif Bassement Complex, to the south and southwest by the Calabar Hinge Line delimiting the Niger Delta, to the northwest by the Afikpo Syncline and to the east by the Rio del Rey Basin in Cameroon (Fig. 1).

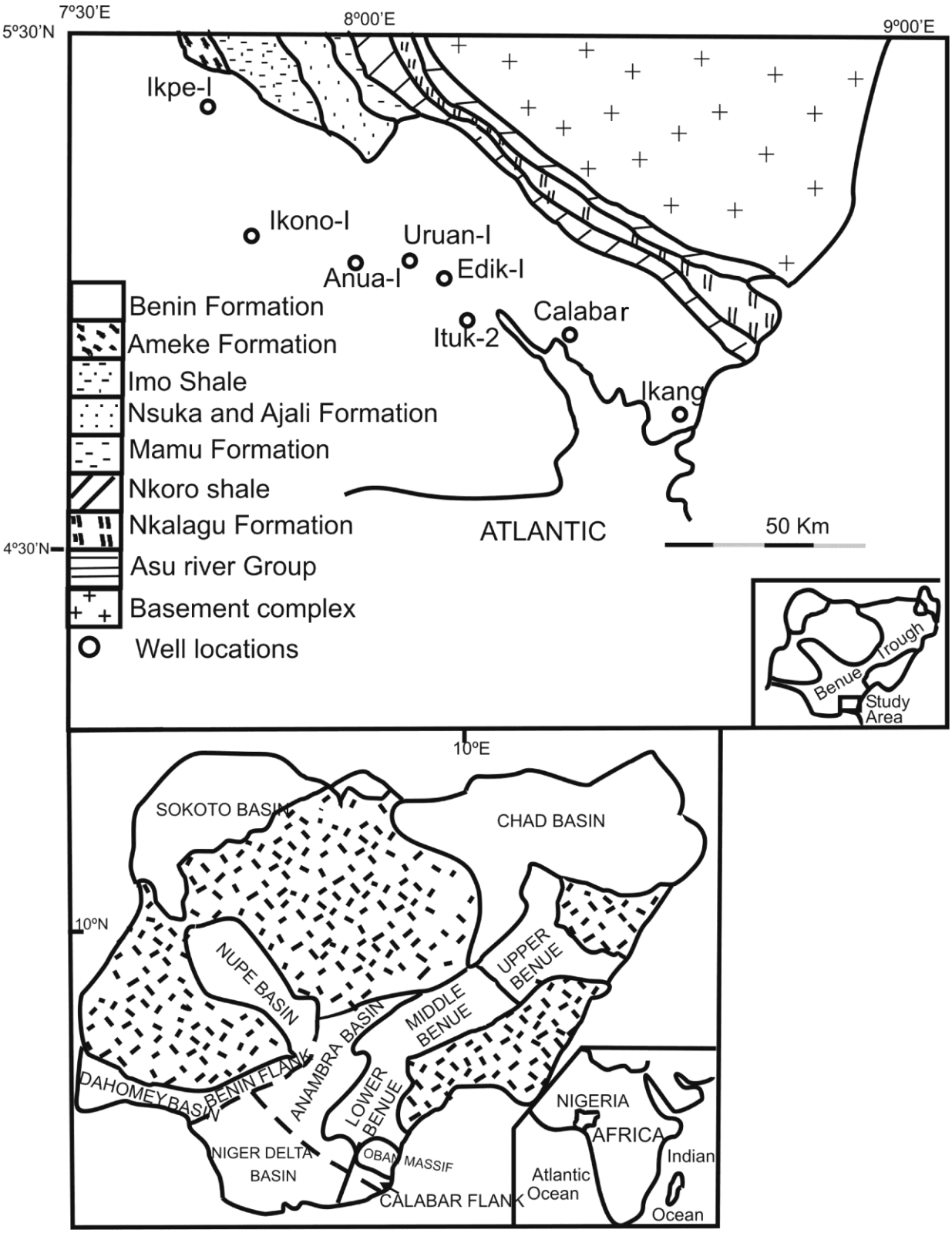

Fig. 1. Map showing geologic/samples locations in Calabar flank

Geologic framework

Edet and Nyong (1993), defined the Calabar Flank as a faulted continental marginal basin consisting of NW-SE trending crustal blocks of graben and horst structures; the Ikang Trough and Ituk High. Though previously treated simply as part of the Southeastern Benue Trough or generally as part of the Southern Nigerian

sedimentary basin, the Calabar Flank as it is now known (Murat, 1972; Petters and Reijers (1986, 1987), Reijers and Petters (1987), recognizably distinguished itself as a unique and distinct sedimentary basin. (Fig. 1)

It has been ascertain from previous works (Murat, 1972; Petters and Reijers, 1986, 1987) that the Calabar Flank being a re-entrant route, was more open to greater Cretaceous marine influence than other basin in southern Nigeria. This is evident from the absence of any major sand deposits or pseudo-deltas which usually represent regressive phases and marginal areas as are commonly encountered in other basins. Thus the lithostratigraphic development in the Calabar Flank was largely controlled by the depositional cycles concurrent with the transgressive episodes.

Sedimentation began in this basin with the deposition of the Awi Formation which is Neocomian-Aptian in age. It is composed of olive-brown sandy shales, fine grained continental micaceous sandstones and blue-grey organic-rich mudstones. It lies directly and unconformably on the Precambrian Oban Massif (Reijers and Peters, 1986, 1987). The first marine incursion deposited the Mfamosing Limestone Formation during the Upper Aptian-Albian which consists of shallow marine karstified platform carbonates (Reijers, 1998). The Ekenkpon Shale Formation (new name) of Petters *et al* (1995), formally called the Odukpani Formation, was deposited during the late Albian – Cenomanian-early Turonian age and the sediments include the thick sequence of black highly fissile shales, with minor but frequent intercalations of marl, calcareous mudstone and shell beds. The thick marl units that overlies this formation is the New Netim Marl Formation (new name) of Petters *et al* (1995), it is of Conician age. A non-deposional period or an erosional phase separates these sediments from the overlying Nkporo Shale (late Campanian-Maastrichtian age) which is characterized by dark-grey carbonaceous, friable shales with occasional thin beds of limestone and gypsum (Table. 1).

Table. 1. General Stratigraphy of the Calabar Flank

AGE	Formation
PLIOCENE	BENIN SAND FM
MIOCENE	
OLIGOCENE	
EOCENE	AMEKE FM
PALEOCENE	IMO FM
MAASTRICTIAN	NKPORO FM
CAMPANIAN	
SANTONIAN	
CONICIAN	NEW NETIM MARL FM
TURONIAN	EKENKPON SHALE FM
CENOMENIAN	
ALBIAN	MFAMOSING LIMESTONE FM
EARLY CRETACEOUS	AWI FM

The sequence above has been reconstructed mainly from the sparsely available outcrops in the Calabar Flank. However, the lithostratigraphic units examined in the Uruan-1 and Ikono-1 wells respectively, include the Paleocene Imo Shale, which consist of dark-grey and bluish-grey calcareous shale. The Eocene Ameke Formation

directly overlies the Imo Shale and include; finely laminated shales with sandstone intercalations.

MATERIALS AND METHOD

The Ditch Cutting samples were made available for this study by the NNPC/MOBIL Nigeria Chair at the University of Calabar. The samples were collected from Uruan-1 and Ikono-1 well respectively both of which are onshore wells that were drilled on the western edge of the Calabar Flank.(Fig. 1) Samples were selected at intervals of 6m and 12m. They were processed for micro-faunas, particularly for foraminifera following the standard procedures for foraminifera sample preparation outlined by Passagno (1967), Zingula (1968), and Brasier (1980).

Foraminiferal counts were made from all the samples and a total of 115 species were recovered out of which 15 species were arenaceous benthics, 71 species calcareous benthics and 29 planktics. With no Scanning Electron Microscope (SEM) available, picking and examination was down with a Wild Heerbrugg M3 binocular microscope. Identification and analysis were made based on the wealth of type collections, monographs and with the aid of recent and relevant publications. Some index species were only hand-drawn (plate 1and 2) and described. These have been preserved in carefully prepared slides and stored in the micropaleontology type collection in the department of Geology of the University of Calabar.

RESULTS AND DISCUSSION

Paleocene biostratigraphy

The following planktonic foraminifera were recovered from the Paleocene interval examined in the Uruan-1 well; *Subbotina triloculinoides, Pseudohastigerina wilcoxensis, Morozovella aequa M. angulata, Acarinina laevigata, Planorotalites pseudobulloides, P. compressa,* and *Chiloguembelina wilcoxensis.* Kogbe (1976) and Petters (1979) assigned a Paleocene age to the Ewekoro Formation based on a similar foraminiferal assemblage. Ogbe (1974) had earlier identified the same assemblage together with *Globorotalia variata* and subdivided the Paleocene of this formation into the Danian and Thanetian stages.

The foraminiferal assemblage above undoubtedly confirms a Paleocene age for the interval studied in the Uruan-1 well. However this assemblage has also permitted a fair correlation with the P4 and P3 foraminiferal biozones of Berggren (1972) and Bolli (1975). These biozones have consequently been assigned to the upper and lower sections of the interval studied as follows; at the upper section (835-945m), the following forms were recovered: *Subbotina triloculinoides, Morozovella aequa, Pseudohastingerina wilcoxensis, Acarinina laevigata* together with the long ranging *Morozovella angulata, Planorotalites compressa* and *Planorotalites pseudomenardii*. The lower section (957-1237m) yielded the following species: *Subbotina triloculinoides, Planorotalites pseudobulloides, Morozovella angulata, Morozovella aequa* and *Acarinina laevigata.*

There is a conspicuous absence of the early Paleocence marker species; *Globigerina daubjergensis, Globigerina eugubina and G.trinidadensis* thus indicating that the early paleocence was not encountered in this study.

The benthonics which make up the bulk of forms encountered in this well included, *Anomalinoides midwayensis, Lenticulina midwayensis, Bulimina midwayensis B. asperoaculeata, B.trigonalis, Epinoides pseudoelevatus, Cibicides succedens, Elphidiella africana, Loxostomum applinae, L. dendericki, Dentalina colei, Epistomella midwayensis, Pseudoglandulinana manifesta, Spiroplectamina dentata, S. spectabilis, Haplophragmoides excavata, Textularia plummerae, Uvigerina sp and Recurvoides contortus.*

The above assemblage correlates with the *Anomalinoides umboniferus-Eponides pseudoelevatus* Zone of Petters (1982). This benthonic assemblage may not be a very good age indicator as they are often long ranging and very cosmopolitan. Similar assemblages have been reported to be very regular in the Paleocene of the Midway Formation in Texas, offshore South Africa, Aquitatine Basin in France, Sirte Basin in Libya and the El Haria Shale in Tunisia (Berggren and Aubert 1975,, 1976). Petters (1979), working on the Paleocene of the Ewekoro Formation identified the following bentonic forms, *Loxostomoides applinae, Tappanina selmensis, Osangularia plummarae, Gavelinella danica, Angulogerina cuneata, Pulsiphonina prima, Nodosaria latejugata. Bulimina asperoaculeata, Anomalinoides umboriferus and Cibicides succedens.* Hence, the benthic association recovered, generally supports a Paleocene age to this interval.

Eocene biostratigrahy

The planktonic foraminifera assemblage encountered in the Ikono-1 well is fairly abundant and diverse. It is generally characterized by long ranging forms but the entire assemblage confirms the establishment of an Eocene age for the interval studied. The few index fossils however permitted the further subdivision of the Eocene into early, late-early and middle Eocene zones, but the late Eocene could not be recognized.

The planktonc species recovered included *Morozovella acuta, Subbotina pseudobulloides, M. subbotina, M. acutispira, M. marginodentata, Acarinina wilcoxensis, A. tribolusa, A. pentacamarata, Chiloguembelina midwayensis, Morozovella angulata, A. Pseudotopilensis, A. inaequispira, A. angolusa, A. soldadoensis–soldadoensis, Pseudotopilensis barbadoensis,*

Acarinina broedermani, A. bulbrooki, Planorotalites renzi Orbulinoides beckmani and Cassigerinella sp.(plate1)

Slanky (1962), Fayose (1969) and Ako *et al* (1981) described early and middle Eocene planktic foraminiferal association dominated by the acarinids from the subsurface Dahommey Embayment, Southwestern Nigeria. Petters (1981) inferred an early Eocene age for the phosphatic beds in the Dahomey Embayment based on the following planktic foraminiferal association; *Acarinina esnaemsis, A. pentacamarata, A. pseudotopilensis, A. soldadoensis, A. wilcoxensis, subbotina inaequispira* and *Pseudohastigeria wilcoxensis*. Stolk (1969) broadly subdivided the Ameke Formation into an early Eocene, *Globorotalia formusa* Zone, a late early and middle Eocene *Cassigerinella amekensis* Zone and a late Eocene *Chiloguembelina martini-cubensis* Zone.

Petters (1983) also established the *Acarinina pentacamarata* Zone in the Gulf of Guinea based on the association of *Acarinina pentacamarata, Acarinina angulosa, A. pseudotopilensis, A. inaequispira and A. fontosa.*

The lowest section of the interval investigated in this well (1037-1003m) yielded predominantly morozovellids among other forms, *Morozovella acuta(plate1), M. subbotina, M. marginodentata and Acarinina wilcoxensis.* This association correlates with the early Eocene *Morozovella subbotina* (P6) Zone of Bolli (1975) and *Globorotalia subbotina* Zone in the Niger Delta of Petters (1979).

*Acarinina pseudotopilensis, A. inaequispira. A. angulosa, and A. pe*ntacamarata were recovered from the 1003-907 depth interval and this correlates with the Late-early Eocene *Acarinina pentacamarata(plate1)* (P9) zone. The middle section (907-853m) of this section is characterized by a preponderance of the long ranging acaraninids and this has blurred the proper recognition of the middle Eocene foraminiferal age zones. However, the co-occurrence of the acaraninids including *Acarinina bullbrook* with *Planorotalites renzi* and *Orbuliniodes beckmani*, suggest the *Orbuliniodes beckmani* zone. Above the 857m depth level, the is a paucity of the planktics, while only a few of the long ranging acarininids persist together with *Acarinina bullrooki* and *Pseudohastigerina barbdoensis* therefore the middle Eocene has only been suggested for this section of the well. Upward, there is a clear absence of the planktics and coupled with an increasing sandy lithology, this upper section can be corroborated with the onset of the regressive phase that occurred generally in the southern Nigerian basins during the late Eocene period.

On the other hand, the entire benthic foraminiferal association encountered in the investigated interval of the well include; *Recurviodes contortus, Ammodiscus cf cretacea, Haplophragmoides sp., Ammobaculites nwalum, Eggerella sp., Bolivina explicata, Tritaria sp., Nonion sp., Bolivina sp., Gavelinella sp., Epistominella sangrina, Eponides cf pseudoeleventus, Hopkinsina danvillensis, Uvigerina sp, and Bolivina sp.(plate2).* This association generally suggests an Eocene age.

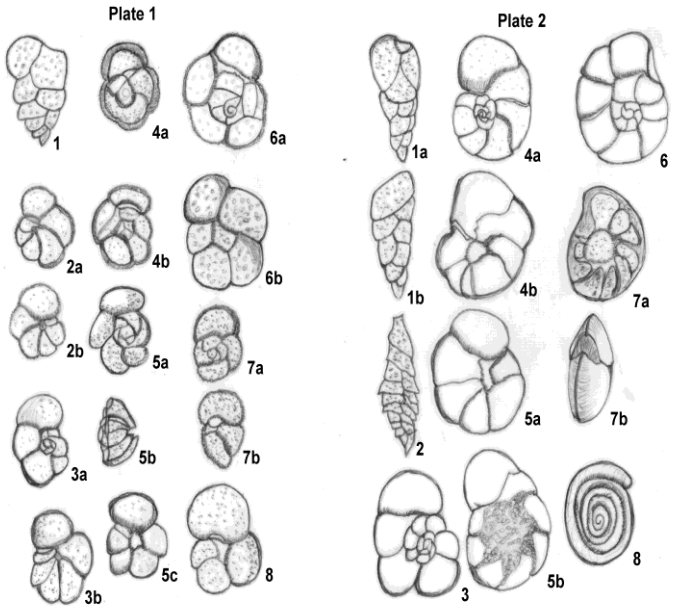

Plate 1

1 *Chiloguembelina midwayensis*; side view
2 *Planorotalites wilcoxensis;* (a) umbilical view (b) spiral view
3 *Planorotalites pseudomenardii;* (a) umbilical view (b) spiral view
4 *Morozovella acuta*; (a) umbilical view (b) spiral
5 *Morozovella angulata*; (a) Spiral view (b) side view (c) umbilical view
6 *Acarinina pentacamarata*; (a) spiral view (b) umbilical view
7 *Acarinina soldadoensis soldadoensis;* unbilical view
8 *Acarinina inaequispira;* umbilical view

Plate 2

1 *Bolivina Africana*; (a) apertural view (b) side view
2 *Hopkinsina danvilensis*, side view
3 *Eponides Africa*; side view
4 *Anomalinoides umboniferus;* (a) spiral view (b) umbilical view
5 *Gavelinella danica*; (a) umbilical view (b) spiral view
6 *Cibicides succedens*; spira lview
7 *Elphidiella africana*; (a) spiral view (b) apertural view
8 *Trochamina sp.* spiral view.

CONCLUSION

A considerable amount of research has been carried out and published on the various geological aspects on the Calabar Flank including its biostratigraphy. Most of the works have been based on surface samples collected from the various outcrop sections in the basin. Though the outcrops are very rare, small, scattered and highly weathered, they constitute the only study material available. These outcrops expose exclusively Cretaceous sediments and apart from the

common occurrence of Recent coastal plain deltaic sands, there has been no report of any Tertiary sedimentary outcrop in the Calabar Flank. Since only the Cretaceous sediments have so far been available for most previous studies, conclusions from them have portrayed this basin as exclusively Cretaceous. With reports of the widespread repeated erosional episodes during the post-Cretaceous period in this region, coupled with the in availability of subsurface sediments for studies, it was therefore easy for previous researchers to conclude that all the post-Cretaceous sediments in the Calabar Flank were eroded, or were never deposited at all.

However, the subsurface samples made available for this study from two onshore wells, Ikono-1 and Uruan-1 wells have yielded foraminiferal assemblages that have undoubtedly revealed the presence of lower Tertiary sediments in the basin. Base on these microfossils, the Paleocene and Eocene sedimentary intervals have been identified. Though located on the western edge of the basin, the occurrence of these Tertiary sediments in the subsurface, definitely calls for a wider investigation of sediments from more wells. This will help to delineate the extent of these Tertiary sediments and also will redefine the depositional and erosional history in the Calabar Flank and other Southern Nigerian sedimentary basins in general.

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