

FORAMINIFERAL BIOSTRATIGRAPHY AND PALEOENVIRONMENTAL ANALYSES OF SEDIMENTS FROM FOLU-1 BOREHOLE, IBEJU-LEKKI, LAGOS STATE, NIGERIA

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ABSTRACT

Biostratigraphic and paleoenvironmental analyses were carried out on thirty-five ditch cutting samples from interval 0.05 – 25.50 m in Folu-1 borehole, Ibeju-Lekki Local Government Area, Lagos State. The sedimentological description of the samples revealed two (2) sequences – a lower predominantly fine to medium-grained sandy sequence with a sandwiched sandy clay/mudstone unit and an upper fine to coarse grained, poorly sorted sandy sequence. The occurrence of abundant and diverse planktic foraminifera permitted the recognition of the N23 planktic zone and the assignment of Holocene (Milazzian) age to the studied section of the borehole. Sequence stratigraphic studies revealed a transgressive system tract (TST) at the lowermost 25.50 – 17.25 m section and a highstand system tract (HST) between 17.25 – 9.00 m. Maximum transgression was noticed at 17.25 m depth with the maximum clay/mudstone development and the depth of highest abundance and diversity of foraminifera. The abrupt shallowing noticed at 9.00 m depth from middle/outer neritic environment to fluvial deposition, interpreted as indicative of an unconformity, marked the sequence boundary (SB). The identification of the unconformity and the clay/mudstone unit in the borehole section provided an invaluable information for consideration in the construction and building purposes of which aim the hole was drilled.

Keywords: Biostratigraphy, Paleoenvironment, Unconformity, Sand, Clay/mudstone, Construction.

INTRODUCTION

Conventional biostratigraphy has been widely linked to oil exploration and production. However, the use of this discipline includes solving geological problems associated with engineering works and the extraction of industrial minerals through standard innovative micropaleontological techniques (Hart, 1993). Biostratigraphy is employed in solving engineering problems in a manner akin to those applied in the oil Industry through deduction of subsurface relationship on the basis of the ages of the encountered formation. Traditional applications of biostratigraphy include age determination, correlation, fault and unconformity identification and paleoenvironmental studies which are also of great relevance to engineering and construction activities. Hart (1993) identified that micropaleontology play important roles in this area in situations where (a) detailed stratigraphic knowledge is required; (b) where subsurface/borehole material is being employed and, as a result, sample size may be limited; (c)

where it is necessary to identify the presence of faults and/or repeated successions; (d) where stratigraphical knowledge is required in the area of complex facies relationships; and (e) where there is a need to identify the presence or absence of reworked or allocthonous material. The ongoing construction activities (roads, bridges and buildings) in recent years in various parts of Lagos State informed the drilling of several shallow boreholes through the Tertiary to Recent sediments in the State. Many of these boreholes are targeted at identifying competent sand layers to which piles can be erected as well as for soil tests in the construction sites. The Folu-1 borehole is one of such holes drilled to a depth of 25.50 m.

Cyclic deposition in coastal environments provides invaluable information that could lead to identification of depositional units which could serve as either source rock, seals or caprock and reservoirs through sequence stratigraphic studies. Adequate knowledge is required on the stratigraphy and paleoenvironment of the

Tertiary to Recent sediments of the Nigerian sector of the Dahomey Basin where studies and published works are very rare. Such information will complement existing published data on older ages (Cretaceous) and will be helpful in hydrocarbon exploration in the basin.

For many decades, most geological researches on the Dahomey Basin have focused on the lithostratigraphy and tectonic framework of the basin while others paid attention to the basin's hydrocarbon potential. The tectonic framework of the basin has been described by authors such as Billman (1976), Lehner and Ruitter (1977), Omatsola and Adegoke (1981), and Adediran and Adegoke (1987). Adediran and Adegoke (1987) proposed a four stage evolutionary model for the Gulf of Guinea basin (Dahomey Basin inclusive). The first stage was the deposition of thick clastic sediments mostly immature sandstones and fresh water shales in the intracratonic basin followed by the deposition of reworked sands and silts intercalated with shales of fluvial – lacustrine origin deposited within the grabens during a period of tectonic activity, erosion and sedimentation. The third stage was the deposition of a paralic sequence (in the northern basins) and evaporite deposits (in the southern basins) marking the beginning of marine incursion into the basin after the separation of South American and African plates. The fourth and final stage was the deposition of marine sediments rich in fauna and flora representing the final stage of the development of the Gulf of Guinea basins.

Researches on the stratigraphy of the basin include the works of Jones and Hockey (1964) in which they assigned the Abeokuta Formation to the mainly arenaceous strata with mudstone, silt, clay and shale interbeds that outcrop onshore in the Nigerian sector of the basin. Reyment (1965) reported the occurrence of the Nkporo shale in the subsurface of the Dahomey basin. Billman (1976), from the study of some offshore Cretaceous sequences in the Republic of Benin, erected two informal lithostratigraphic units in the basin viz; unnamed Older Folded Sediments (oldest) and unnamed Albian Sands. The remaining portion of the Cretaceous sequence was referred to as the Abeokuta Formation, Awgu shale and Nkporo shale (youngest). Omatsola and

Adegoke (1981) assigned the Cretaceous sediments to the Abeokuta Group and subdivided it into three formal formations: Ise Formation (oldest), Afowo Formation and Araromi Formation (youngest). The first two correspond to the unnamed Older Folded Sediments and the unnamed Albian Sands respectively, while the Araromi Formation was considered equivalent to the Nkporo shale of Billman (*op. cit.*). The Ise and Afowo Formations were dated Neocomian (Valanginian) and Albian-Turonian respectively by these workers. Billman (1992) divided the stratigraphy of the entire Dahomey basin into three chronostratigraphic packages – these are the pre-lower Cretaceous folded sediments, Cretaceous sediments and Tertiary sediments.

The Tertiary strata which lies conformably on top of the Araromi Formation in most parts of the basin comprises of the lens shaped, sandy, glauconitic and phosphatic limestone of the Ewekoro Formation which has been dated Upper Paleocene (Adegoke, 1977). The predominantly shaly Imo Formation lies unconformably on the Ewekoro Formation. The formation consists of fine-textured dark micromaceous shale, locally silty with glauconitic marl and conglomerate at the base. The greenish-grey variety of the shale encountered in the subsurface of most inland areas of Western Nigeria and which in the Ewekoro quarry disconformably overlies the Ewekoro Formation was named Akinbo Formation by Ogbe (1972). The formation has been dated Lower-Middle Eocene. The Oshosun Formation overlies the Akinbo Formation across a gradational boundary and is composed of green to greenish grey clays and glauconitic shales interbedded with loose sand. The formation has been assigned a Late Paleocene to Early Eocene age (Bankole *et al.* (2005). The formation is conformably overlain by the Ilaro Formation which is characterized by coarse to fine-grained sands, clays and shales with occasional thin bands of phosphate beds. This was overlain by the Coastal Plain Sands (Benin Sand Formation). The formation consists of very poorly, clayey, pebbly sands, sandy clay and rare thin lignite (Reyment, 1965). The Benin Formation was dated Upper Miocene to Recent.

Studies on the foraminiferal biostratigraphy and paleoecology of Dahomey basin include those of Reyment (1965), Adegoke (1969, 1977), Adegoke *et al.* (1970, 1980) and Nwachukwu *et al.* (1992). These studies discussed the stratigraphic occurrence and the taxonomy of foraminiferal species in the basin. Adegoke *et al.* (1971) studied the foraminifera in sediments from the Gulf of Guinea. Planktonic species recorded were tropical forms with an admixture of a few species tolerant to cold waters. Four broad bathymetric biofacies were delineated on the basis of the distribution and abundance of dominant planktic species. These species in decreasing order of abundance are *Globigerinoides ruber*, *Globigerinoides trilobus*, *Globoquadrina* sp. and *Globorotalia menardii*. Adegoke (1975) worked on the foraminifera fauna of the polyhaline lagoons of the Gulf of Guinea. He observed that the diversity and abundance of foraminifera vary markedly from lagoon to lagoon. The commonest genera seen were *Ammobaculites*, *Ammonia*, *Elphidium*, *Quinqueloculina* and *Triloculina*. The work revealed that agglutinated forms dominate the sandy nearshore water while calcareous forms are common in deep waters.

Adegoke *et al.* (1980) gave a detailed account of the sedimentology and microfauna of the Lagos lagoon and harbour. They concluded that there was rapid deposition along the eastern and southern lagoon shoreline while the western margin of the lagoon was subjected to intense winnowing and erosion accompanied by bypassing of terrigenous sediments. They also showed that the Lagos harbour and creeks are richer in microfauna than the Lagos lagoon. Adegbie and Dublin-Green (1994) studied the foraminifera in the Gulf of Guinea and concluded that the high foraminiferal population and diversity was a result of nutrient-rich sediments transported into the Gulf by rivers from the hinterland. They also concluded that warm water tolerant foraminiferal species were dominant and the presence of some cold-water planktonic species were due to the influence of cold currents such as the Canary and Benguela currents. Debenay *et al.* (2000) related the foraminiferal assemblages and distribution pattern in the paralic environment in the Gulf of Guinea to environmental stress. Three areas of increasing

environmental stress were deduced using the assemblage zones which were determined by factor analysis of nineteen most frequent species.

This study is aimed at establishing the stratigraphic succession of the Tertiary sequence penetrated by the Folu-1 borehole as well as interpret the paleoenvironment of deposition of the encountered sequences.

MATERIALS AND METHODS

A total of thirty-five ditch cutting samples from interval 0.05 – 25.50 meters obtained from the Folu-1 borehole located at the proposed site of the Folu Bridge in Ibeju-Lekki Local Government Area of Lagos were used for the study. The coordinates of the borehole are Latitude 6° 25' 36.60" N and Longitude 4° 11' 15.37" E (Fig. 1). The area is located in the Eastern part of the Dahomey basin, south western Nigeria. Sampling was done at an interval of 0.75 metres. Drilling mud was washed off the samples through a 63 micron sieve for the purpose of lithological description. The washed samples were described using a binocular microscope. Textural parameters documented include shape, size, roundness, degree of sorting as well as presence or absence of index accessory minerals. Twenty-five grammes of each sample were processed for their foraminiferal and other microfaunal content using the standard preparation techniques. Each of the weighed samples was soaked in a mixture of water and liquid soap for twenty four (24) hours to allow for the disaggregation of the samples and de-flocculation of any clay material present therein. The samples were then washed gently over a 63 micron sieve under a jet of water. The washing continued until all the clay materials present in the sample were removed. The residue was then transferred carefully into an aluminium plate and dried in an oven at a temperature of about 60°C for about thirty minutes. The dried residues were sieved into the coarse, medium and fine fractions. These were labeled and properly packaged and sealed in nylon envelopes. The foraminifera and accessory microfauna were carefully picked from the residue with the aid of a picking needle and tray under a stereo-binocular microscope and transferred into a labeled cellule. The picked foraminifera were identified to species

level using relevant foraminifera literatures and publications including Cushman (1948), Loeblich and Tappan (1964) and, Bolli and Saunders (1985). Recorded taxa were inputted into the StrataBugs software to generate the stratigraphic distribution

chart.

A tentative sequence stratigraphic framework was made for the hole section by integrating the sedimentology and biostratigraphy data.

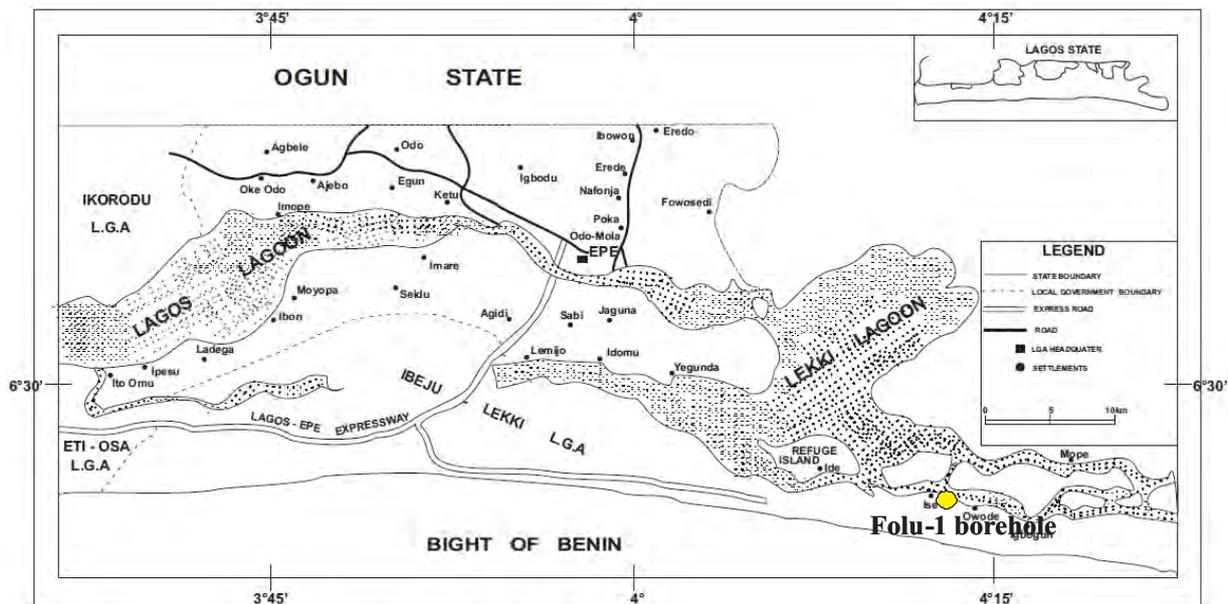


Figure 1: Map of the Eastern Part of Lagos State Showing the Location of Folu-1 Borehole

RESULTS AND DISCUSSION

Lithostratigraphy

The strata penetrated by the Folu-1 borehole are composed of unconsolidated sediments. The strata contain nine lithofacies units which can be grouped into two stratigraphic sequences (A and B) on the basis of the sedimentological characteristics (Fig. 2). Sequence A (25.50 – 9.00 m) represents the lowermost sequence in the section. This sequence is made up of whitish quartz sands and contains five lithofacies units A1 – A5. Unit A1 (25.50 – 22.5 m) which represents the oldest penetrated unit in the borehole is made up of fine to medium, occasionally coarse-grained sand. The coarse-grained fraction accounts for approximately 10% of the total sample. It is a poorly to moderately sorted mix of subangular to rounded grains. Observed increase in roundness and sorting was noticed from the bottom to the top of the unit. Recorded accessory minerals include carbonaceous detritus and shell fragments. Unit A2 (22.50 – 18.00 m) is characterized by fine to medium, subangular to subrounded sand. The degree of sorting increases uphole. The interval shows a fining upward profile. The accessory minerals recorded within

the unit include mica flakes and shell fragments. Unit A3 (18.00 – 17.25 m) is composed predominantly of greyish clay with about 10% sand. The sands are fine-grained, well sorted, angular to subrounded. Unit A4 (17.25 – 15.00 m) is made up of clayey sand. The sands within the unit are fine to medium-grained and moderately sorted. The clay content decreases uphole within the sequence thereby exhibiting a typical coarsening upward profile. Few ferruginous material and mica flakes were recorded in the upper part of the unit (15.75 - 15.00 m). Unit A5 is composed of predominantly fine to medium-grained moderately to poorly sorted sands. The degree of sorting decreases uphole from moderately sorted to poorly sorted. The sands are subrounded to well rounded. Recorded accessories include shell fragments and ferruginous materials.

Sequence B (9.00 - 0.00 m) consists of four lithofacies units (Fig. 2). Unit B1 (9.00 - 6.00 m) consists of medium to very coarse-grained (30%), poorly sorted, subangular to well rounded sands. Accessory minerals within the unit are composed of ferruginous materials and shell

fragments. Unit B2 (6.00 - 3.75 m) is made up of fine to coarse-grained (50%), poorly sorted, subangular to rounded sands with ferruginous materials accessories. Unit C3 (3.75 - 0.75 m)

consists of medium to coarse-grained (70%), moderately sorted, subangular to rounded sands with ferruginous materials as accessories.

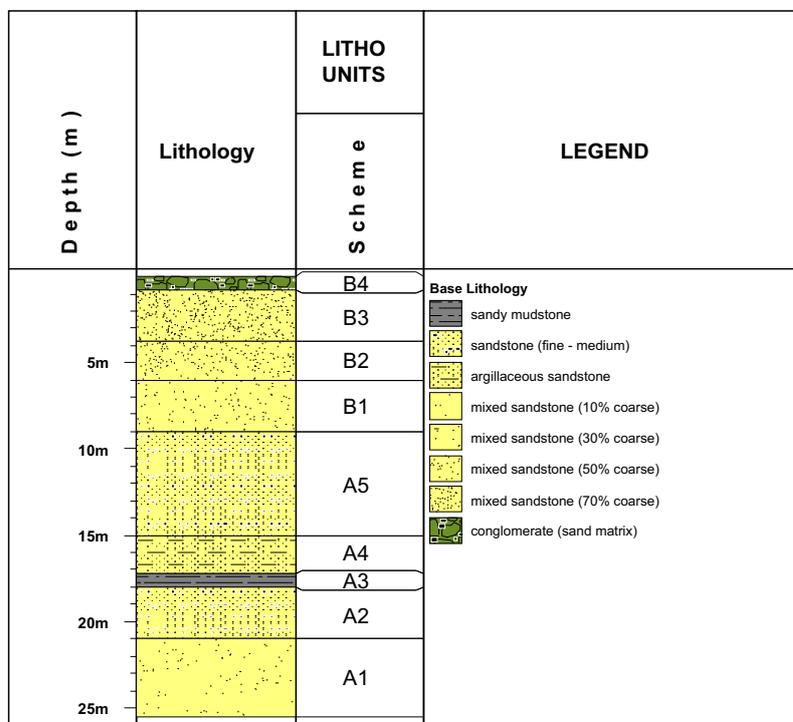


Figure 2: Lithofacies Units Recognized in Folu-1 Borehole

Unit B4 represents the topmost unit in the studied section (0.75 - 0.00 m). The unit is composed of gravel-sized particles (Conglomerate) with some medium to coarse-grained sands as matrix. The materials are poorly sorted and subangular to rounded.

Biostratigraphy

A total of forty-four (44) foraminiferal species were recorded within the studied section of the Folu-1 borehole. Thirteen (13) are planktics, twenty eight (28) are calcareous benthics while the remaining three (3) are arenaceous benthics. Recorded microfaunal accessories include ostracodes, gastropods, echinoid remains, pelecypods, sponges and shell fragments. The stratigraphic distribution of the recorded foraminiferal taxa is as shown in Figure 3. Interval 0.00 – 9.0 m has been found to be barren of foraminifera and microfaunal accessories. This has been attributed to the predominantly sandy lithology within the interval and a probable fluvial environment of deposition. Microfossils rarely thrive in such environment. Interval 9.75 – 25.50 m is characterized by abundant and diverse

foraminifera composed mainly of benthic and planktics. Only three (3) arenaceous species with high abundance distribution were recorded within the interval. Sketches of some important foraminiferal species were made as shown in Plate 1.

Planktic foraminifera zonation

The analysed section of the Folu-1 borehole has been zoned using the Blow (1969, 1979) planktic foraminiferal zonation scheme. A comparison of the zone was also made with other planktic foraminiferal zonation schemes erected by earlier workers (Fig. 5).

Zonal Description

- Stratigraphic interval:** 0.00m – 9.00 m
- Top:** First Analysed sample (0.00 m)
- Base:** Upper limit of foraminifera occurrence
- Zone:** Indeterminate
- Age:** Indeterminate
- Remarks:** Interval is barren of foraminifera.

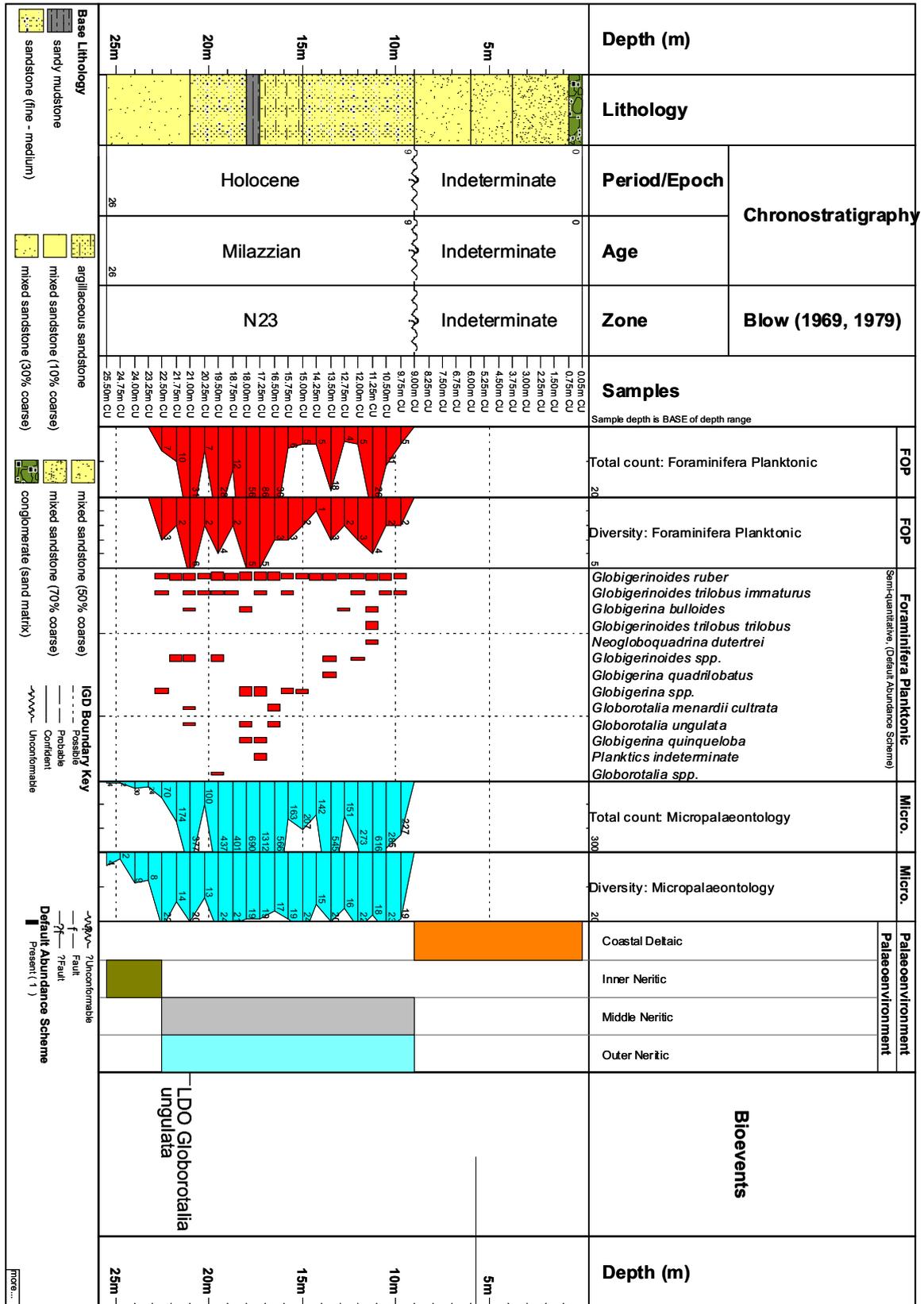


Figure 3: Planktic Foraminiferal Distribution Chart of Folu-1 Borehole.

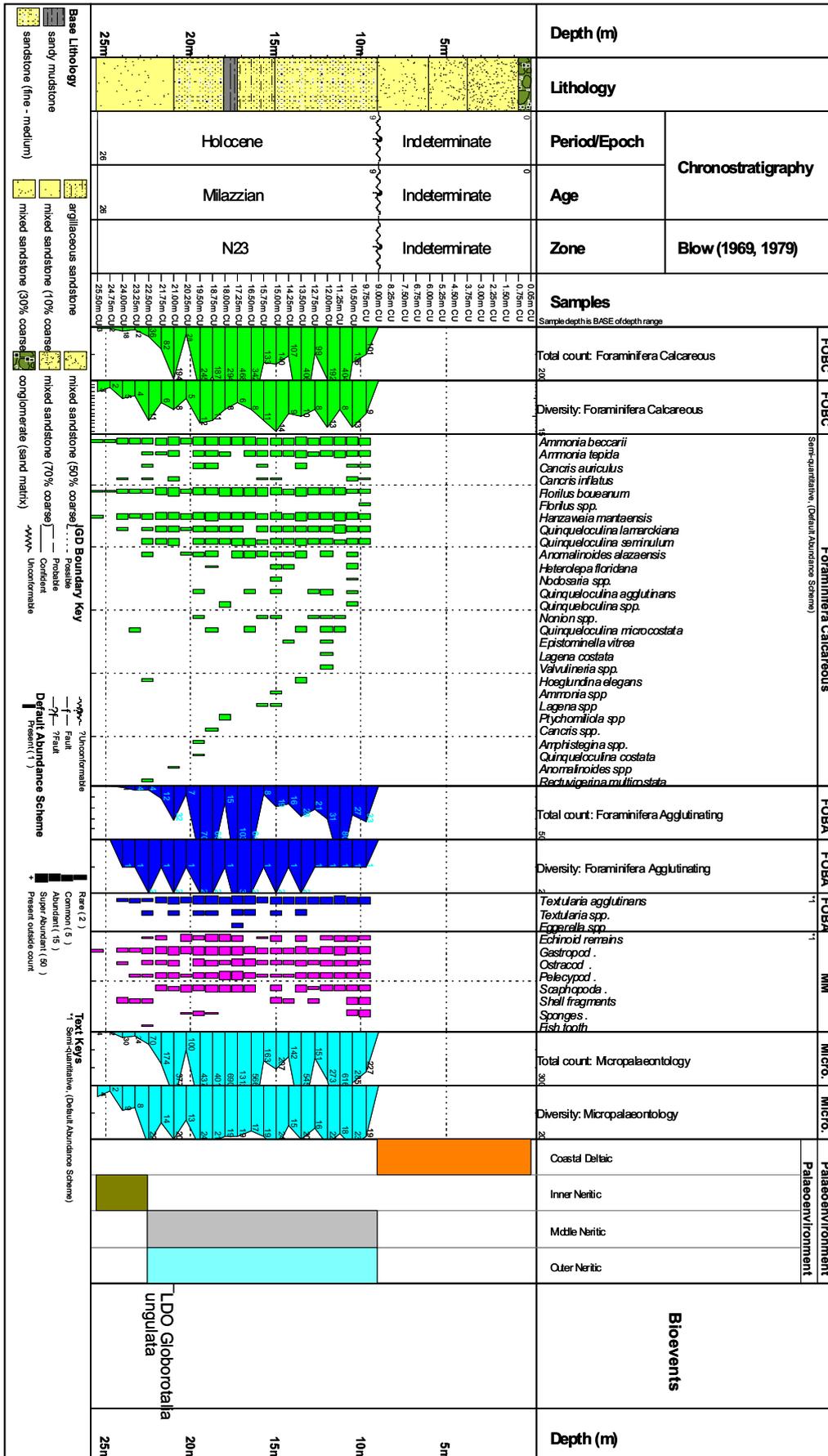


Figure 4: Benthic Foraminiferal Distribution Chart of Folu -1 Borehole.

Planktonic foraminifera zonations													
Age	Age (My)	Blow (1969,1979)		Poag and Valentine (1976)		Lamb and Beard (1972)		Bolli and Saunders (1985)			This study		
		Zone	Datum marker	Zone	Datum marker	Zone	Datum marker	Zone	Subzone	Datum marker	Zone	Datum marker	
Holocene	0.011	N23	<i>Globigerina calida</i> / <i>Sphaeroidinella dehiscens excavata</i>	<i>Globorotalia unguolata</i>	<i>Globorotalia unguolata</i>	<i>Globorotalia tumida</i>	<i>Globorotalia tumida</i>	<i>Globorotalia truncatulinoides</i>	<i>Globorotalia fimbriata</i>	<i>Globorotalia fimbriata</i>	<i>Globorotalia unguolata</i>	<i>Globorotalia unguolata</i>	
	<i>Globorotalia crassaformis</i>			<i>Globorotalia truncatulinoides</i>									
Late Pleistocene	0.056			<i>T. inflata</i> I									
	0.08								<i>Globigerina bermudezi</i>	<i>Globorotalia tumida flexuosa</i>	Indeterminate		

Figure 5 Comparison of important planktonic foraminiferal zonal schemes and marker species proposed by various researchers for the late Pleistocene to Holocene (Ages adapted from Bolli and Saunders, 1985).

Stratigraphic

- interval:** 9.00m – 25.50 m
- Top:** Upper limit of foraminifera occurrence
- Base:** Last analysed sample at the terminal depth (TD) - (25.50 m)
- Zone:** N23
- Age:** Holocene (Milazzian)

Correlation: This zone corresponds to the *Globorotalia tumida* zone of Lamb and Beard (1972); the *Globorotalia unguolata* zone of Poag and Valentine (1976) and the *Globorotalia fimbriata* subzone of Bolli and Saunders (1985) (Fig. 5).

Remarks:

This zone has been delineated based on the characteristic assemblage recorded within the interval. The assigned zone is further confirmed by the recognition of an important biodatum - the Last Downhole Occurrence (LDO) of *Globorotalia unguolata* at depth 21.00 m. This event has been documented within the N23 zone (Bolli and Saunders 1985). Recorded planktic assemblage include *Globorotalia unguolata*, *Globigerina quinqueloba*, *Globorotalia menardii cultrata* and *Globigerina quadrilobatus*. Other important planktic species recorded within the interval

include *Globigerinoides ruber*, *Globigerinoides trilobus immaturus* and *Globigerina bulloides*. Calcareous benthic foraminifera recorded within the interval include *Ammonia beccarii*, *Ammonia tepida*, *Florilus bouaneum*, *Hanzawaia mantaensis*, *Quinqueloculina larmackiana*, *Q. seminulum*, *Q. microcostata*, *Anomalinoides alazaensis*, *Heterolepa floridana*, *Nonion sp.*, *Cancris auriculus*, *Cancris inflatus* and *Epistominella vitrea*.

Age of Folu-1 Borehole

The Folu-1 borehole sequence has been dated Holocene (Milazzian). This is based on the recognition of the N23 planktic foraminifera zone. The Last Downhole Occurrence (LDO) of *Globorotalia unguolata* lends credence to the assigned age as the event is characteristic of the Holocene age. Furthermore, the benthonic genus *Ptychomiliola* which is a typical Holocene foraminifera genus (Cushman, 1927) is represented by *Ptychomiliola* sp. at depth 18.00 m (Fig. 4). The absence of foraminifera within the upper interval 0.00 – 9.00 m preclude a definite age assignment to the interval.

Paleoenvironmental Interpretation

The depositional environment of the strata penetrated by the Folu-1 borehole has been reconstructed based on the integration of the sedimentological characteristics of the

sediments as well as the qualitative and quantitative analyses of the foraminifera content. Palaeoenvironmental conditions such as salinity, nutrient and sediment supply, energy of the depositional environment and sea level changes were assessed. This interpretation is graphically presented in Figure 6. Sequences within the Folu-1 borehole has been found to be deposited in the marine and fluvial settings as discussed below:

benthic foraminiferal assemblage, planktic benthic ratio and accessory index minerals. Deposition commenced within the inner neritic environment from 25.50 – 22.50 m. Foraminifera distribution within the interval consist of few to common, relatively shallow water marine foraminifera including *Ammonia beccarii*, *Florilus boueanum*, *Cancris inflatus*, *Hanzawaiia mantaensis*, *Quinqueloculina larmackiana*, *Q. seminulum*,

Marine (shelf) paleoenvironment

This environment has been interpreted from the

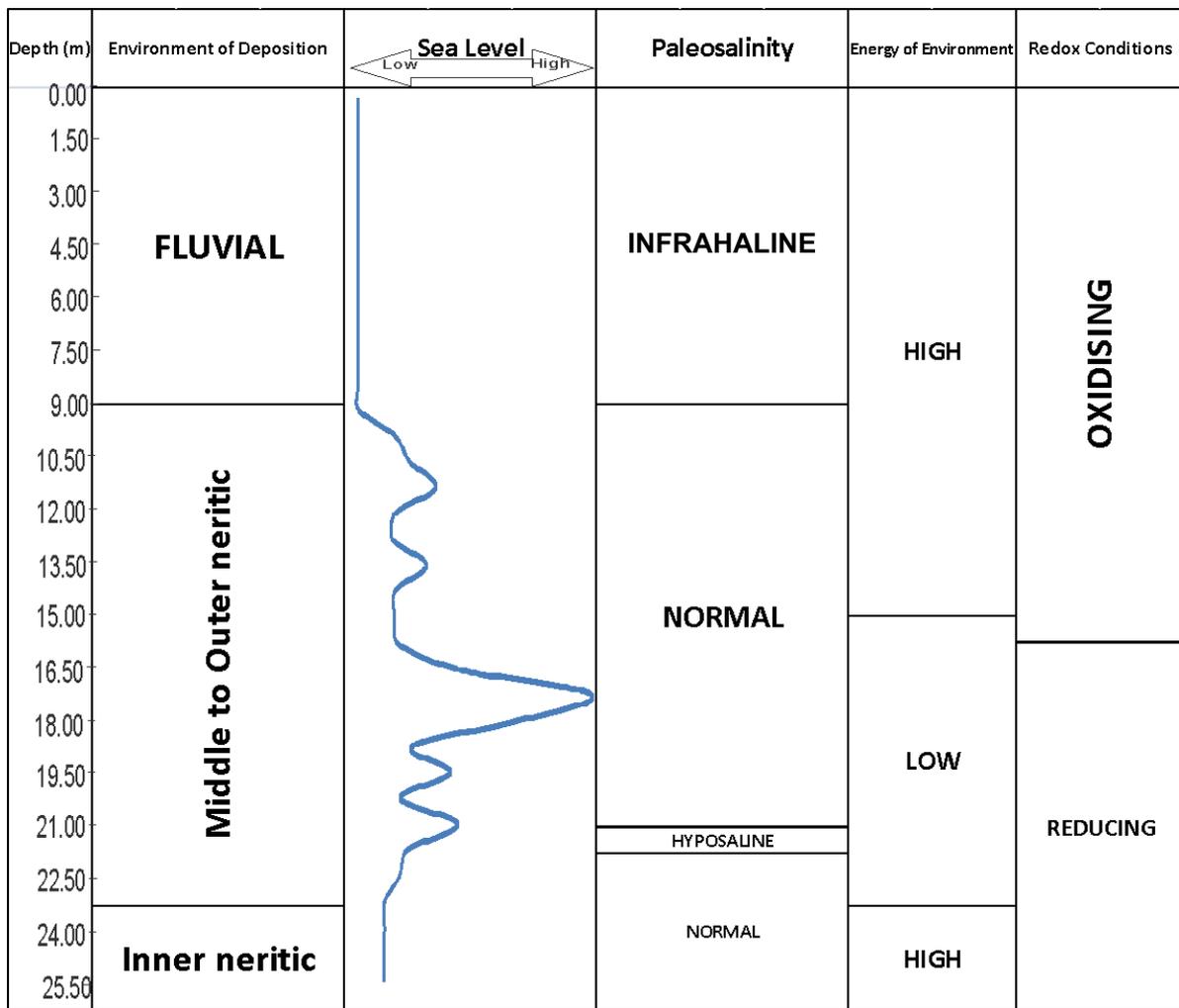


Figure 6: A Summary of the Paleoenvironment, Sea Level Flunctuation and Paleoenvironmental Conditions of Folu-1 Borehole Sequences

Q. microcostata, *Anomalinoidea alazaensis* and *Rectuvigerina multicostata*. The relatively low planktic/benthic (P/B) ratio due to high abundance of benthonic foraminifera is an indication of a shallow marine environment of deposition (Figs. 3 and 4). The occurrence of glauconite at some intervals supports a marine environment of deposition while the high abundance of calcareous fossils indicate deposition above the Carbonate Compensation Depth (CCD). The dominance of quartz sands revealed that the sequences between 25.50 - 9.00 m was deposited in the shallow marine waters (shelf environment) and did not go beyond the outer neritic realm (Figure 6; Boersma, 1978; Nichols, 2009).

The energy setting in the environment was relatively high as evident from the poorly sorted, fine to medium, occasionally very coarse sands found within the interval. The occurrence of carbonaceous detritus at the interval coupled with the absence of ferruginous materials and the whitish colour of the sands have been used to infer the anaerobic depositional environment for the interval. Where oxygen circulation is high, carbonaceous detritus which are remains of organic matter would have decayed. Ferruginous materials would have been present due to the alteration of Fe (II) to Fe (III) in iron-bearing minerals, and the whitish colour of the sands would have been altered to brown or yellow (Nichols, 2009).

A significant sea level rise in the Holocene caused deposition to shift from the inner neritic environment to deeper parts of the shelf (middle to outer neritic) at the present location of the Folu-1 borehole (interval 22.50 – 9.00 m). This is evident from the increased P/B ratio as well as abundant and diverse distribution of typical benthic foraminiferal species including *Florilus boneanum*, *Cancris inflatus*, *Cancris auriculus*, *Hanzawaiia mantaensis*, *Heterolepa floridana*, *Epistominella vitrea*, *Lagena costata* and *Hoeglundina elegans*. Other benthic foraminifera in high abundance include *Ammonia beccarii*, *Ammonia tepida*, *Quinqueloculina larmackiana*, *Q. seminulum*, *Q. microcostata* and *Anomalinoidea alazaensis*. Arenaceous benthic foraminifera with notable distribution within the interval include *Textularia agglutinans*, *Textularia* sp and *Eggerella* sp.

Globigerinoides ruber, *Globigerinoides trilobus immaturus* and some species of *Globigerinoides* and *Globorotalia* dominated the planktic assemblage.

The high clay/mudstone content within this interval indicated a shift from a high energy environment to a low energy environment (Fig. 6). The highest deepening indicating the maximum sea level rise was observed between 18.00 - 17.25 m. This interval is characterized by high abundance and diversity of fossils and of predominantly clayey/mudstone lithology. The relatively high amount of clay-sized sediments within this interval is indicative of deposition in a quiet, deeper water environment.

The anaerobic conditions observed in the underlying inner neritic deposit (25.50 - 22.50 m) persisted into parts of the middle to outer neritic sequence found within interval 22.50 - 15.75 m. In addition to the absence of ferruginous materials and the whitish colouration of the sands as observed in the underlying inner neritic deposits, the greyish colour of the clays have been used to infer an environment of low oxygen circulation. The grey colour of the clays is a pointer to the presence of organic matter which can only be preserved under anaerobic conditions. The topmost part of the middle to outer neritic strata (15.75 - 9.00 m) was deposited in an oxidizing environment with the abundant ferruginous materials and the yellowish to brownish colouration of the sediments.

An upward increase in shell fragments is also observed to occur along with the coarsening upward sequence (15.75 – 9.00 m). This is interpreted to be a consequence of increasing energy of the depositional environment. This is because in higher energy parts of the sea, currents move sand around and a lot of biogenic debris is broken up into bioclastic fragments ranging from sand-sized, unidentifiable to identifiable pieces up to larger pieces of shelly material.

Fluvial Environment

Interval 9.00 - 0.00 m is believed to be completely deposited in a fluvial environment. The characteristic poorly sorted and predominantly coarse-grained sizes of the

sediments and the absence of marine foraminifera within the interval lend credence to this interpretation. The presence of appreciable ferruginous material at 9.00 – 9.75 m depth is an indication of aerial exposure indicating an unconformity. The abrupt shallowing from the middle/outer neritic to fluvial environment is in agreement with this interpretation. Shelf deposits are normally found to be overlain by coastal, deltaic, estuarine or deeper marine facies (Nichols, 2009).

Deposits within interval 9.00 – 0.00 m were believed to be deposited in an oxidizing environment as indicated by the presence of ferruginous materials and the yellowish to brownish colouration of the sediments. Deposition was believed to be made under high energy conditions as indicated by highly variable mixture of the poor to very poorly sorted, fine to very coarse-grained sands and pebbles within the interval (Fig. 2). The absence of shell fragments within the interval ruled out any evidence of shoreline/marine deposition.

Sequence Stratigraphic Interpretation

A tentative stratigraphic interpretation of the

sequences penetrated by the Folu-1 borehole was attempted based on the sedimentological and biostratigraphic data acquired. The analysed section shows one complete sequence which commenced with a transgressive system tract (TST) at the base (25.05 – 17.25 m). This interval shows an upward fining / deepening sequence as discussed in section 3.1.1 and graphically depicted in Figure 7 (Sequence A - Unit A1, A2 and A3). The interval is also characterized by an upward increase in foraminiferal abundance and diversity (fig. 4). Unit A3 represents the hemipelagic shaly section capping the transgressive systems tract. The lowermost part of unit A3 represents the top of the transgressive systems tract. Biostratigraphically, Units A2 – A5 are characterized by abundant and diverse distribution of foraminifera representing a condensed section. The Maximum Flooding Surface is picked at depth 17.25 m having the highest abundance and diversity of fossils and the point of maximum shale/mudstone development in the hole. Interval 17.25 – 9.00 m is characterized by an upward coarsening / shallowing sequence as shown in figure 7 (Units A3 – A5). The interval is also characterized by an upward decrease in foraminiferal abundance and

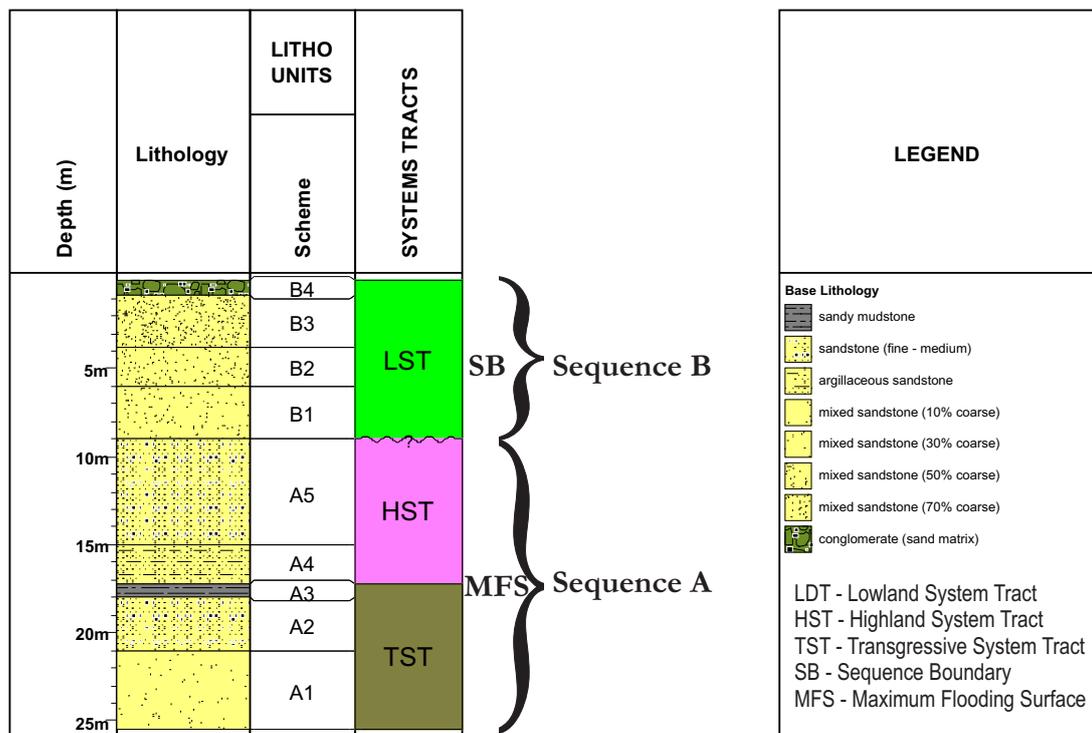


Figure 7: Tentative Sequence Stratigraphic Framework of Folu-1 Borehole

diversity interpreted as highstand system tract (HST). The abrupt truncation of unit A5 marked by sudden disappearance of foraminifera as well as truncation of the middle/outer neritic environment of deposition at 9.00 m depth is indicative of an unconformity thereby marking a sequence boundary (SB) at this depth. Interval 9.00 – 0.00 m is composed predominantly of poorly sorted sands which are more coarser at the upper part and is thought to represent a lowstand system tract and a probable base for the next sequence.

Stratigraphy and Implication for Construction Purposes

Detailed stratigraphic knowledge is required in areas of complex facies and most especially in coastal areas where stratigraphy varies within a very short distance due to local environmental changes. Even within short distances, it is still important to understand how facie changes and employ the obtained information within the local area. The lithologic sequence erected from the borehole section has shown the predominantly sandy sequence at the base, the sandy clay/mudstone in the middle and the sandy unit at the top. Having obtained the information on the presence of a clayey unit in the middle of the borehole, this will assist the construction engineers on the competency of the hole section as well as that of the individual units. This will also aid in the design of the structures to be erected (bridges, tunnel, buildings, etc.). The identification of the unconformity around 9.00 m depth will also aid in such designs as the presence of an unconformity or fault in a section has serious implication on the structures been erected in and around such faulted areas. Similar studies in nearby boreholes for construction purposes can be correlated to the Folu-1 borehole stratigraphy to establish the units recognized or detect new units in the case of variable sequences.

CONCLUSION

Two lithologic sequences (A and B) have been delineated in the Folu-1 borehole, Lekki, Lagos. The lowermost sequence (A) is composed of fine to medium-grained, moderately to poorly sorted sand at the lower part and fines upward into a middle sandy clay/mudstone unit which grades

into a clayey sandy unit. The upper sequence B is composed of a poorly sorted fine to coarse-grained, occasionally very coarse-grained sand with a thin conglomeratic layer at the top. The sequence penetrated by the borehole is characterized by abundant and diverse foraminifera within interval 25.50 - 9.00 m while the upper interval 9.00 – 0.00 m is barren of foraminifera due to the predominantly coarse-grained texture of the sands within this upper section. The studied section of the borehole has been dated Holocene (Milazzian) based on the planktic foraminiferal assemblage and the recognition of the Last Downhole Occurrence of *Globorotalia unguolata* within the studied section. The assigned age is further confirmed by the delineation of the N23 planktic foraminiferal zone in the section studied. An inner neritic environment of deposition has been interpreted for sediments deposited within interval 25.50 – 22.50 m while sediments within interval 22.50 – 9.00 m were believed to be deposited in a middle to outer neritic environment based on the benthic foraminiferal assemblages. Foraminifera and accessory microfauna were absent in the poorly sorted sand of the upper 9.00 – 0.00 m which informed an interpretation of a fluvial environment of deposition for the interval. A tentative stratigraphic framework for the studied section revealed one complete sequence beginning with a transgressive system tract (TST) (25.50 – 17.25 m), a maximum flooding surface (MFS) at 17.25 m depth and a highstand system tract (HST) (17.25 – 9.00 m) which ended with an unconformity at 9.00 m. The unconformity, recognized at the abrupt shallowing from a middle/outer neritic environment to a fluvial setting at 9.00 m depth has been interpreted as the sequence boundary (SB) which marks the beginning of a new sequence. Engineering and construction works in Lekki area will have to take into account the stratigraphy in the Folu-1 borehole as information on the unconformity surface and the clayey unit will assist in the design program for the structures to be erected in the area.

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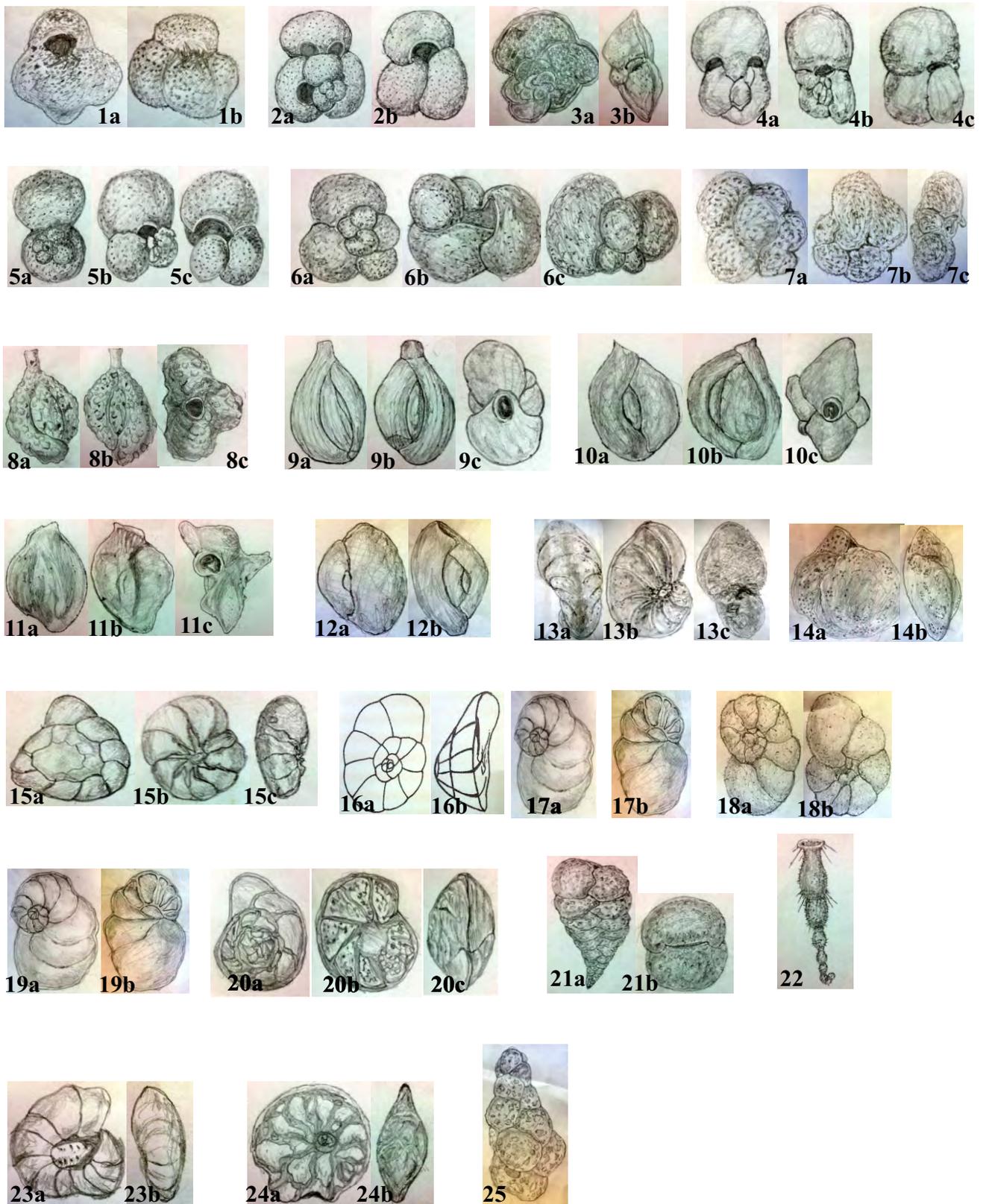
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PLATE 1



Explanation of Plate 1

Figure:

- | | |
|--|---|
| 1. <i>Globigerinoides quadrilobatus</i> | X60 (a. apertural view; b. side view) |
| 2. <i>Globigerinoides ruber</i> | X60 (a. dorsal view; b. ventral view) |
| 3. <i>Globigerinoides trilobus trilobus</i> | X40 (a. dorsal view; b. ventral view; c. lateral view) |
| 4. <i>Globigerinoides trilobus immaturus</i> | X40 (a. dorsal view; b. ventral view; c. lateral view) |
| 5. <i>Globorotalia unguolata</i> | X60 (a. dorsal view; b. ventral view; c. peripheral view) |
| 6. <i>Globigerina bulloides</i> | X70 (a. dorsal view; b. ventral view; c. lateral view) |
| 7. <i>Globigerina quinqueloba</i> | X60 (a. dorsal view; b. ventral view; c. peripheral view) |
| 8. <i>Quinqueloculina agglutinans</i> | X60 (a. dorsal view; b. ventral view; c. apertural view) |
| 9. <i>Quinqueloculina costata</i> | X50 (a. dorsal view; b. ventral view; c. apertural view) |
| 10. <i>Quinqueloculina lamarckiana</i> | X50 (a. dorsal view; b. ventral view; c. apertural view) |
| 11. <i>Quinqueloculina microcostata</i> | X60 (a. dorsal view; b. ventral view; c. apertural view) |
| 12. <i>Quinqueloculina seminulum</i> | X40 (a. dorsal view; b. ventral view) |
| 13. <i>Florilus boueanum</i> | X60 (a. peripheral view; b. side view; c. apertural view) |
| 14. <i>Heterolepa floridana</i> | X60 (a. side view; b. peripheral view) |
| 15. <i>Ammonia beccarii</i> | X40 (a. dorsal view; b. ventral view; c. apertural view) |
| 16. <i>Ammonia tepida</i> | X40 (a. side view; b. peripheral view) |
| 17. <i>Valvulineria sp.</i> | X60 (a. dorsal view; b. ventral view) |
| 18. <i>Cancris auriculus</i> | X50 (a. dorsal view; b. ventral view) |
| 19. <i>Hoeglundina elegans</i> | X60 (a. dorsal view; b. ventral view; c. peripheral view) |
| 20. <i>Hanzawaia mantaensis</i> | X50 (a. dorsal view; b. ventral view; c. peripheral view) |
| 21. <i>Textularia agglutinans</i> | X60 (a. side view; b. apertural view) |
| 22. <i>Rectuvigerina multicostata</i> | X60 (side view) |
| 23. Nonion sp. | X40 (a. side view; b. peripheral view) |
| 24. <i>Amphistegina sp.</i> | X50 (a. dorsal view; b. peripheral view) |
| 25. <i>Eggerella sp.</i> | X60 (side view) |