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Foraminifera abundance and diversity study of the succession penetrated by the drill in MF-3 Well: Indicator of the quality of the Sedimentary Environment, Niger Delta Basin, Southern Nigeria

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ABSTRACT

Foraminifera abundance and diversity of ditch cutting samples of the succession penetrated by the drill in MF-3 Well, Niger Delta Basin, Southern Nigeria were studied with the aim of evaluating the quality of the sedimentary environment. Five (5) ditch cutting samples collected from Shell Petroleum Development Company (SPDC) composited between predetermined depths 11,550 ft to 11,790 ft in the MF-3 Well located in the Niger Delta Basin were processed for foraminifera analysis. The study was carried out using standard micropaleontological sample procedures and analysis. A biostratigraphical distribution table embracing planktic, calcareous benthic and agglutinating benthic foraminifera was generated for the well. A total of one hundred and sixteen (116) foraminifera species were recovered; one (1) planktic, Seventy five (75) calcareous benthic and forty (40) agglutinating benthic. The benthic foraminifera were moderately counted while planktic foraminifera were poorly represented, representing 99.1% benthic and 0.9% planktic. The foraminifera genera Ammonia, Ammobaculites and Trochammina were recorded in the recovered samples with Ammonia being the dominant genera in the analyzed interval of the well section. The abundance of Ammonia was 18.9%, Ammobaculites is 2.6% and Trochammina is 5.2%. Ten (10), seven (7), eleven (11), eleven (11) and thirteen (13) species diversity were recorded at the analyzed section of the well. The occurrence of Ammonia, Ammobaculites, and Trochammina in the MF-3 Well intervals indicates reduced oxygen conditions, shifts in species diversity and abundance, and increased organic pollution. These features suggest environmental degradation of the sedimentary setting in the Niger Delta Basin, likely influenced by metal contamination.

1. INTRODUCTION

Foraminifera are single-celled protists characterized by their hard shells or tests, typically composed of calcium carbonate or agglutinated sediment particles. They are generally classified into two groups:

planktonic (free-floating in the water column) and benthic (bottom-dwelling) (Kinrin-ola, 2019). The benthic foraminifera occur from the abyssal zone to the intertidal coastal zone (Gomez-leon *et al.,* 2018). The abundance, diversity, and distribution of benthic foraminifera are dependent on environmental parameters that determine their ecology (Murray, 2006). Benthic foraminifera are an excellent tool that can be used as an environmental tracer because of their adaptability and rapid response to anthropogenic waste discharge (Donnici *et al.,* 2012). In sedimentary basins such as the Niger Delta, both types of foraminifera are well represented and serve different but complementary roles in biostratigraphy and paleoecology (Petters, 1982; Okosun and Liebau, 1999). Their fossilized remains, preserved in sedimentary successions, provide crucial information on the age and depositional environments of the strata in which they are found.

The Niger Delta region of Nigeria is the most significant hydrocarbon province on the West African continental margin. It lies mainly in the Gulf of Guinea to the southwest of the Benue Trough and constitutes the most important Cenozoic deltaic construction in the South Atlantic. Because of its petroliferous nature, the economy of Nigeria depends largely on the oil and gas derived from it. The Cenozoic Niger Delta is situated at the intersection of the Benue Trough and the South Atlantic Ocean where a triple junction developed during the separation of South America and Africa in the Late Jurassic (Whiteman, 1982). Geologically, it is found in the Tertiary period in the geologic column. The use of biofacies as tools and components in basin analysis has become increasingly important in recent times as seen in previous works (Lucas and Kinrin-ola 2019; Kinrin-ola *et al.,* 2024). This study is aimed at evaluating the quality of the sedimentary environment of the succession penetrated by the drill in MF-3 Well, Niger Delta Basin, Southern Nigeria.

2. MATERIALS AND METHODS

2.1. The Study Area

The MF-3 well is situated in the central swamp depobelt along the Imo River in the Niger Delta sedimentary Basin of Nigeria. It is bounded to the North by the River Niger and the Ughelli depobelt, and to the South by the coastal swamp depobelt (Figure 1).

2.2. The Geology of Niger Delta Basin

Sedimentary Niger Delta Basin is ranked among the best productive petroleum system throughout the globe ranges from longitudes 4^0E and 8.8^0E and latitudes 3^0N and 6^0N. It is situated along the aulacogen which initially builds up due to tectonism (Burke *et al.,* 1972). The remaining arms that moved with the southwestern and southeastern coast of Nigeria and Cameroon builds up into the passive continental margin of West Africa, whereas the third failed arm formed the Benue Trough and deltas begins to situate around the African Atlantic coast due to other depocenters. Syndrift sediments gathered with Albian age ascribed to the oldest about the Cretaceous to Tertiary.

2.3. Apparatus and Reagents

Materials used for the analysis include a microscope, sieves, a water jet, kerosene, aluminium bowls, liquid soap, and a hot plate

2.4. Methodology

2.4.1 Foraminifera sample collection and preparation

Five (5) dry ditch cuttings collected from the MF-3 well, ranging from 11,550 ft to 11,790 ft, were processed for micropaleontological analysis. The procedures adopted for the foraminifera extraction are in line with standard micropaleontological sample techniques and were guided by the work of Lucas and Kinrin-ola (2019).

2.4.2. Logging and composition of samples

Labelled samples were laid out and composed sequentially in batches in clean sample plates and placed on the hot plate inside the fume cupboard.

2.4.3. Samples treatment 1: drying and weighing

A measured amount of the ditch cuttings weighing 5 g was put into a plate (25 g), corresponding labels were attached, placed securely on the hot plate, and thereafter the hot plate was switched on to regulate the temperature of about 800°C. After 2 – 3 h, the hot plate was switched off, the sample plate was removed, and allowed to cool. After cooling, the dried samples were weighed

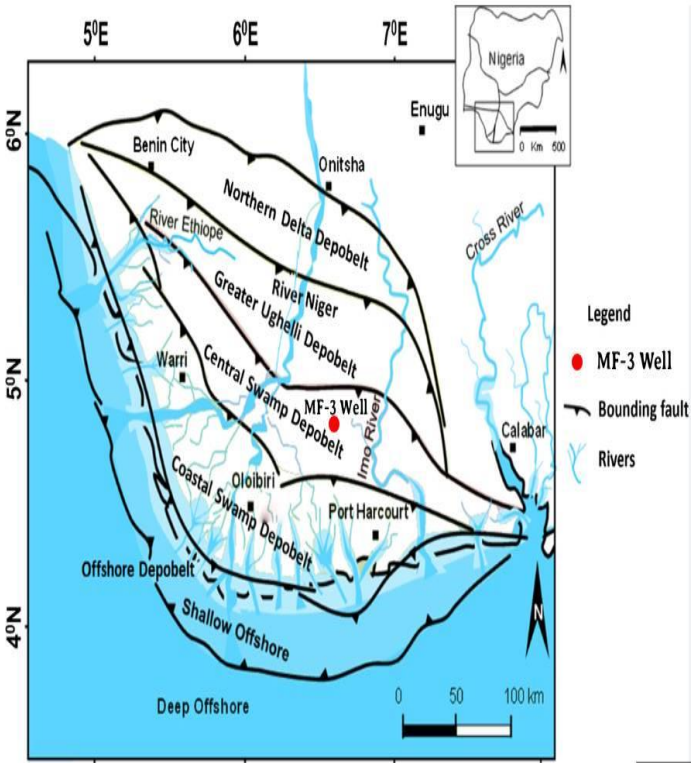

Figure 1: Map of the Niger Delta Basin showing EG-1Well (modified after Nwozor *et al.* (2013) and Kinrin-ola *et al.* (2024))

2.4.4. Sample treatment 2: soaking and decanting

The weighed samples were soaked in kerosene, left overnight to disaggregate; thereafter, the kerosene was decanted, and the samples were covered with water and left for 5 hours.

2.4.5. Sample treatment 3: sieving and drying

After 5 hours, sieves were passed in blue methyl (for easy identification of any intruding contaminants), and samples were washed with water through four sieves: 500, 250, 150, 63-micron sieves. The 4 fractions were then dried and transferred into 4 different bags/phials and label accordingly and then placed in one plastic bag and labelled. The packaged samples were transferred for picking, analysis and interpretation. A micropaleontological microscope was used to view the form and Interpretation of the foraminifera biofacies assembleages were carried out using qualitative and quantitative approaches. The qualitative method involves the use of extant forms while the quantitative method involved the use of abundance of calcareous to arenaceous benthic foraminifera. Foraminifera analysis was carried out by determining specimen to the specific level and / or generic level to identified the various forms then snapped.

2.4.6. Biostratigraphic distribution table

A biostratigraphic distribution table embracing planktic, calcareous and agglutinating foraminera was generated for the analyzed section of the well.

3. RESULTS AND DISCUSSION

3.1. Micropaleontological Analysis

The results of micropaleontological analysis carried out on five (5) dry ditch cutting samples collected from MF-3 well is presented in Table 1. Throughout the well depth, some forms recovered include one (1) planktic, seventy five (75) calcareous benthic and forty (40) agglutinating benthic foraminifera and are presented in (Table 1 to 6). The species recorded both for benthic and planktonic forms includes, *Ammonia beccarii, Uvigerina subperegrina, Bolivina scalprata miocenica, Hanzawaia strattonii, Cibicorbis inflata, Trochammina sp., and Ammobaculites agglutinans, Cassigerinella chipollensis and Globigerinoides ruber species.* The dominant foraminifera were the calcareous benthic forms which are higher in count in the well section. Preservation was moderate, with minimal diagenetic alteration of tests.

Table 1: Foraminifera distribution chart of MF-3 well

Depth (ft)	Planktic foraminifera	Calcareous benthic foraminifera	Agglutinating benthic foraminifera	Total foraminifera
11,550	0	10	13	23
11,610	0	13	3	16
11,670	0	18	5	23
11,730	0	16	7	23
11,790	1	18	12	31
Total	1	75	40	116

3.2. Abundance and Distribution

3.2.1. Depth 11,550 ft

The total species recovered in this interval constitute 100% benthic foraminifera, as depicted in Table 2. This interval is characterized by few foraminifera species. Ten (10) diverse species of foraminifera were recorded at this interval. Diagnostic foraminifera species recorded include *Uvigerina subperegrina, Haplophragmoides narivaensis, Florilus costiferum (Nonion 4 sp), Ammonia beccarii, Trochammina,* and *Uvigerina. Ammonia* and *Trochammina* genera were recorded five (5) and one (1), respectively, out of the twenty-three (23) foraminifera recorded at this interval, representing 21.7% and 4.4%, respectively. The presence of *Ammonia* and *Trochammina* genera in this well interval suggests oxygen or stress-related conditions, high-level organic waste pollution, environmental contamination, and environmental deterioration in the quality of the sedimentary environment of the MF-3 well section, and this is consistent with the work of Gomez-Leon *et al.* (2018).

Table 2: Foraminifera abundance of sample 1 (11,550ft)

Foraminifera	Count	Type
Uvigerina subperegrina	2	AB
Florilus constiferum (Nonion 4 sp)	3	AB
Haplophragmoides narivaensis	3	AB
Trochammina sp	1	AB
Haplophragmoides sp	4	AB
Valvulineria sp	1	CB
Hanzawaia strattonii	2	CB
Cibicorbis inflata	1	CB
Ammonia beccarii	5	CB
Calcareous indeterminate	1	CB

3.2.2. Depth 11,610 ft

The total species recovered in this interval constitute 100% benthic foraminifera as depicted in Table 3. This interval is characterized by few foraminifera species. Seven (7) diverse species of foraminifera were recorded at this interval. The sample is characterized by diagonistic foraminifera, *Ammobaculites agglutinans, Florilus costiferum (Nonion 4 sp), Spirosigmoilina oligocaenica* and *Ammonia beccarii*. *Ammonia, Ammobaculites* and *Trochammina* genera recorded three (3), one (1) and two (2), respectively, out of the sixteen (16) foraminifera recorded at this interval, representing 18.75%, 6.25% and 12.5%. The presence of *Ammonia, Ammobaculites* and *Trochammina* genera in this well interval suggests oxygen or stress-related conditions, changes in species richness and density, high-level organic waste pollution, environmental contamination and environmental deterioration in the quality of the sedimentary environment of the MF-3 well section, and this is consistent with the work of Gomez-leon *et al.* (2018).

Table 3: Foraminifera abundance of sample 2 (11,610 ft)

Foraminifera	Count	Type
Ammonia beccarii	3	CB
Florilus costiferum (Nonion 4 sp)	2	CB
Ammobaculites agglutinans	1	AB
Heterolepa pseudoungeriana	2	CB
Bolivina scalprata miocenica	4	CB
Spirosigmoilina oligocaenica	2	CB
Trochammina sp	2	AB

3.2.3 Depth 11,670 ft

The total species recovered in this interval constitute 100% benthic foraminifera as depicted in Table 4. This interval is characterized by few foraminifera species. Eleven (11) diverse species of foraminifera were recorded at this interval. This interval is characterized by diagonistic foraminifera such as *Spirosigmoilina oligocaenica*, *Uvigerina subperegrina, Haplophragmoides narivaensis, and Ammonia beccarii. The Ammonia* genus recorded five (5) out of the twenty-three (23) foraminifera recorded at this interval, representing 21.7%. The presence of the *Ammonia* genus in this well interval suggests environmental deterioration in the quality of the sedimentary environment of the MF-3 well section, and this is consistent with the work of Gomez-Leon *et al.* (2018).

Table 4: Foraminifera abundance of sample 3 (11,670 ft)

Foraminifera	Count	Type
Epistominella vitrea	2	CB
Cibicorbis inflate	2	CB
Hanzawaia strattonii	1	CB
Ammonia beccarii	5	CB
Spirosigmoilina oligocaenica	3	CB
Haplophragmoides narivaensis	3	AB
Bolivina scalprata miocenica	1	CB
Valvulineria sp	2	CB
Heterolepa pseudoungeriana	1	CB
Bathysiphon sp	2	AB
Uvigerina subperegrina	1	CB

3.2.4. Depth 11,730 ft

The total species recovered in this interval constitute 100% benthic foraminifera as shown in Table 5. This interval is characterized by few foraminifera species. The interval is characterized by few foraminifera species. Eleven (11) diverse species of foraminifera were recorded at this interval. This interval is characterized by diagonistic foraminifera such as *Ammobaculites agglutinans, Haplophragmoides narivaensis, Florilus costiferum (Nonion 4 sp), Ammonia beccarii, Trochammina*

sp and *Uvigerina subperegrina*. *Ammonia, Ammobaculites* and *Trochammina* genera recorded three (3), one (1) and one (1) respectively out of the twenty-three (23) foraminifera recorded at this interval, representing 13%, 4.4% and 4.4% respectively. The presence of *Ammonia, Ammobaculites* and *Trochammina* genera in this well interval suggests oxygen or stress-related conditions, changes in species richness and density, high-level organic waste pollution, environmental contamination and environmental deterioration in the quality of the sedimentary environment of the MF-3 well section, and this is consistent with the work of Gomez-leon *et al.* (2018).

Table 5: Foraminifera abundance of sample 4 (11,730 ft)

Foraminifera	Count	Type
Hanzawaia stratonii	4	CB
Valvulineria sp	1	CB
Ammonia beccarii	3	CB
Haplophragmoides sp	3	AB
Trochammina sp	1	AB
Epistominella vitrea	2	CB
Ammobaculites agglutinans	1	AB
Florilus costiferum	4	CB
Haplophragmoides narivaensis	2	AB
Cibicorbis inflata	1	CB
Uvigerina subperegrina	1	CB

CB = Calcareous benthic, AB= Arenaceous benthic, P = Planktic

3.2.5. Depth 11,790 ft

The total species recovered in this interval constitute 99% benthic and 3% planktic foraminifera as shown in Table 6. This interval is characterized by few foraminifera species. Thirteen (13) diverse species of foraminifera were recorded at this interval. This interval is characterized by diagonistic foraminifera such as *Cassigerinella chipollensis, Haplophragmoides narivaensis, Florilus costiferum (Nonion 4 sp), Ammobaculites agglutinans, Ammonia beccarii, Trochammina* sp *and Cassigerinella chipollensis*. *Ammonia, Ammobaculites* and *Trochammina* genera recorded six (6), one (1) and two (2), respectively, out of the thirty-one (31) foraminifera recorded at this interval, representing 19.4%, 3.2% and 6.4%, respectively. The presence of *Ammonia, Ammobaculites* and *Trochammina* genera in this well interval suggests oxygen or stress-related conditions, changes in species richness and density, high-level organic waste pollution, environmental contamination and environmental deterioration in the quality of the sedimentary environment of the MF-3 well section, and this is consistent with the work of Gomez-leon *et al.* (2018).

Table 6: Foraminifera abundance of sample 5 (11,790 ft)

Foraminifera	Count	Type
Cassigerina chipolensis	1	P
Florilus costiferum	2	CB
Bolivina scalprata miocenica	3	CB
Heterolepa pseudoungeriana	2	CB
Ammonia beccarii	6	CB
Haplophragmoides narivaensis	3	AB
Ammobaculites agglutinans	1	AB
Trochammina sp	2	AB
Epistominella vitrea	1	CB
Bathysiphon sp	1	AB
Cibicorbis inflate	4	CB
Arenaceous indeterminate	2	AB
Haplophragmoides sp	3	AB

CB = Calcareous benthic, AB= Arenaceous benthic, P = Planktic

4. CONCLUSION

The foraminifera species recovered in the analyzed section of the well were few, one hundred and sixteen (116). The dominant foraminifera recovered are benthic forms. The benthic foraminifera were moderately counted, while planktic foraminifera were poorly represented, representing 99.1% benthic and 0.9% planktic. Ten (10), seven (7), eleven (11), eleven (11), and thirteen (13) species diversity were recorded at the analyzed section of the well. The overall presence of *Ammonia, Ammobaculites* and *Trochammina* genera in the analyzed well interval suggests oxygen or stress-related conditions, changes in species richness and density, high levels of organic waste pollution, environmental contamination and environmental deterioration in the quality of the sedimentary environment of the MF-3 Well, Niger Delta Basin, Southern Nigeria, that may be due to metal pollution.

5. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

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