Benthic Foraminiferal Biozonation and Correlation of XY-1 Field, Offshore Western Niger Delta, Nigeria

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ABSTRACT

The aim of this paper is to subdivide the sequences within the depth intervals of the five wells in XY-1 Field, offshore western Niger Delta into biozones and correlate the wells. The micropaleontological standard for preparation of foraminiferal samples was employed. A total of 550 ditch cutting samples from five wells were analyzed for benthic foraminifera. The benthic foraminiferal assemblages identified were used for biostratigraphic interpretation. Two major benthic foraminiferal biozones were recognized and they are Spirosigmolina oligoceanica and Florilus ex. gr. N. costiferum Zones. These biozones are indicative of Middle to Late Miocene age for the wells depth intervals. The biozones erected and their use in well correlation is helpful in deepening the knowledge and development of the offshore western Niger Delta area of Nigeria.

Keywords: Benthic foraminifera, biozones, XY-1 Field, offshore western Niger Delta, well correlation

1. INTRODUCTION

The area of study is located in the offshore XY-1 Field of the offshore western Niger Delta, Nigeria (Fig. 1). The Niger Delta is situated in the Gulf of Guinea on the west coast of Central Africa. Niger Delta lies between latitudes 4° and 6° N and longitudes 3° and 9° E in the south-south geo-political region of Nigeria [1]. 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 [2].

The scope and objectives of the research study involved the following:

- Identification of foraminifera and their abundance in the strata penetrated in the wells.
- Foraminiferal biozonation of the wells intervals.
- Determination of the ages of the studied wells intervals.
- Correlation of wells in the study area.

2. GEOLOGICAL SETTING

Three main formations have been recognised in the subsurface of the Niger Delta [3], [4], [5], [6], [7], [8]. These are the Akata, Agbada, Benin and Formations. These formations were deposited in marine, transitional and continental environments, respectively; together they form a thick, overall progradational passive-margin wedge [9].

The Akata Formation is the basal unit composed mainly of marine shales believed to be the main source rock within the basin. The Agbada Formation is made up of alternating sandstone, siltstone and shale sequences that constitute the petroleum reservoirs of the basin. On the other hand, the Benin Formation largely consists of non-marine sands with a few shaly intercalations [9].

3. METHOD OF STUDY

There are five wells in the area of study and they are denoted as TMB-1, 2, 4, 5 & 6, respectively. A total of 550 ditch cutting samples were collected from these five wells at 18.29 metres intervals for analysis for benthic foraminifera fossils. The micropaleontological standard for preparation of foraminiferal samples was employed. The unwashed ditch cutting samples were initially rinsed to remove drilling mud and then dried. A standard weight (20 grams) of each dried sample was soaked for 4 hours in kerosene, followed by detergent solution-water soaking overnight. The disaggregated samples were then washed under a running tap water over a 63 µm mesh sieve. The washed residues were then dried over a hot electric plate and then they were sieved into three main size fractions, namely: coarse, medium and fine. They were then bagged and picked for foraminifera fossils and recorded. The statistical data were recorded using the StrataBugs software. The complete micropaleontological data were plotted in colour using the StrataBugs software at 1:5,000 scale with depth in Y-axis and the identified taxa in X-axis for each well. The StrataBugs software plotted charts were interpreted using the first and last occurrence of diagnostic taxa, the assemblages, ratio of taxa occurrence,
and taxon quantitative distribution within the stratigraphic interval.

Fig. 1. Index map of Niger Delta and Location of Study Area (after Doust and Omatsola [10])

4. RESULTS AND DISCUSSION

4.1 Benthic Foraminiferal Biozones

A total of 52 benthic calcareous and 16 benthic arenaceous/agglutinated species were identified from the five wells in the study area. The biozones were defined based on the first and last occurrence of diagnostic taxa [11], [12], [13].

Two major benthic foraminiferal zones recognized in the five wells studied are Spirosigmoilina oligoceanica and Florilus ex. gr. N. costiferum Zones, respectively. The benthic foraminiferal zones are given in Figs. 2-6.

4.1.1 Spirosigmoilina Oligoceanica Zone

Stratigraphic interval:

<table>
<thead>
<tr>
<th>Well</th>
<th>Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMB-1</td>
<td>3,150.41 – 3,446.37 m</td>
</tr>
<tr>
<td>TMB-2</td>
<td>3,218.08 – 3,404.92 m</td>
</tr>
<tr>
<td>TMB-4</td>
<td>-</td>
</tr>
<tr>
<td>TMB-5</td>
<td>2,933.10 – 3,466.80 m</td>
</tr>
<tr>
<td>TMB-6</td>
<td>3,622.55 – 3,907.23 m</td>
</tr>
</tbody>
</table>

Base: The base of this zone is defined by the first downhole occurrence of Cassidulina neocarinata (THALMANN) at the depths of 3,446.37 m, 3,404.92 m, 3,466.80 m and 3,907.23 m in wells number TMB-1, 2, 5 and 6, respectively. The associated species in this zone include: Eggerella scabra (WILLIAMSON), Rectoglandulina comatula (LOEBLICH & TAPPAN), etc.

Top: The top of this zone is defined by the first downhole occurrence of Spirosigmoilina oligoceanica (CUSHMAN) at the depths of 3,150.41 m, 3,218.08 m, 3,933.10 m and 3,622.55 m in wells number TMB-1, 2, 5 and 6, respectively.

Age and correlation: The age of this zone is Middle Miocene and it is equivalent to N13-N14 Zone of Blow [11], [12].

Remarks: This zone was not identified in TMB-4 well.

4.1.2 Florilus ex. gr. N. costiferum Zone

Stratigraphic interval:

<table>
<thead>
<tr>
<th>Well</th>
<th>Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMB-(1)</td>
<td>2,431.39 - 3,150.41 m</td>
</tr>
<tr>
<td>TMB-(2)</td>
<td>2,431.39 – 3,218.08 m</td>
</tr>
<tr>
<td>TMB-(4)</td>
<td>-</td>
</tr>
<tr>
<td>TMB-(5)</td>
<td>-</td>
</tr>
<tr>
<td>TMB-(6)</td>
<td>-</td>
</tr>
</tbody>
</table>

Base: The base of this zone is defined by the first downhole occurrence of Spirosigmoilina oligoceanica (CUSHMAN) at the depths of 3,150.41 m, 3,218.08 m and 3,218.99 m in wells number TMB-1, 2 and 4, respectively. The associated species include: Quinqueloculina microcostata (NATLAND), Amphicoryna scalaris caudata (SILVER), etc.

Top: The top of this zone is defined by the first downhole occurrence of Florilus ex. gr. N. costiferum and FDO: Uvigerina sparsicostata (CUSHMAN & LAIMING) at the depths of 2,431.39 m in wells number TMB-1 and 2.

Age and Correlation: The age of this zone is Middle to Late Miocene and correlated to N14-N16 Zones of Blow [11], [12].

Remarks: This zone was not identified in wells number TMB-4, 5 and 6.

Spirosigmoilina oligoceanica and Florilus ex. gr. N. costiferum Zones are identified and correlated in TMB-1 and 2 wells at differing depth intervals. These biozones are not identified in TMB-4 well due to the absence of the marker/zonal fossils needed for the characterization of the biozones. On the other hand, only Spirosigmoilina oligoceanica Zone was recognized in TMB-5 and 6 wells at various depth intervals (Fig. 7). The binocular microscopic images of the important identified marker species are given in Fig. 8.
**Fig. 2. Benthic Foraminiferal Stratigraphic Chart of TMB-1 Well**

**Fig. 4. Benthic Foraminiferal Stratigraphic Chart of TMB-4 Well**

*Table and diagrams showing benthic foraminiferal data and stratigraphic chart for TMB-1 and TMB-4 wells. Details of faunal assemblages and their distribution across different stratigraphic levels.*
Fig. 5. Benthic Foraminiferal Stratigraphic Chart of TMB-5 Well

Fig. 6. Benthic Foraminiferal Stratigraphic Chart of TMB-6 Well
Fig. 9. Benthic Foraminiferal Biozonation Correlation of XY-1 Field

Fig. 8. Binocular Microscopic Images of Marker Species

1. Spirosigmaollina oligoceanica CUSHMAN scale bar 100 µm.
2. Quinqueloculina microcostata; scale bar 100µm.
3. Amphicoryna scalaris caudata BATSCH scale bar 220 µm.
4. Eggerella scabra WILLIAMSON scale bar 100µm.
5. Rectoglandulina comatula LOEBLICH & TAPPAN scale bar 500 µm.
6. Uvigerina sparsicostata CUSHMAN & LAIMING scale bar 105 µm.
7. Florilus ex. gr. N. costiferum CUSHMAN scale bar 100 µm.
5. CONCLUSION AND RECOMMENDATION

The study aim and objectives were achieved; better understanding of the geology of the area useful for regional subsurface geological mapping. The benthic foraminiferal biozones defined indicated various stratigraphic variations in some taxa in the studied wells in comparison to standard biozonation schemes of Blow [11], [12]. Absolute ages were obtained for the biozones via correlation to Berggren et al. [14] and Haq et al. [15].

Spirosigmoilina oligoceanica Zone (N13-N14) and Florilus ex. gr. N. costiferum Zone (N14-N16) are the two main benthic foraminiferal biozones that were recognised in the studied wells intervals. These biozones are indicative of Middle to Late Miocene age for the wells intervals. The biozones and their use in correlation are valuable in the development of the offshore western Niger Delta as very necessary input to the petroleum exploration team in the area of study.

It is recommended that a unified benthic foraminiferal and calcareous nannofossil biozonation scheme should be established and published for the Niger Delta.

ACKNOWLEDGMENTS

The authors are grateful to Chevron Nigeria Limited for the provision of well data set used for the research study. The assistance of CGG-Veritas Nigeria Limited and the Nigerian Association of Petroleum Geologists (NAPE) as Ph.D. Grant-in-Aid to the first author is herein acknowledged. Professor S. O. Adegoke, the Managing Director of Mosunmolu Nigeria Limited is hereby acknowledged. Professor B to S. O. Obaje is gratefully acknowledged. Aid to the first author is herein acknowledged. Professor S. O. Adegoke, the Managing Director of Mosunmolu Nigeria Limited is hereby acknowledged. The assistance of CGG-Veritas Nigeria Limited and the Nigerian Association of Petroleum Geologists (NAPE) as Ph.D. Grant-in-Aid to the first author is herein acknowledged. Professor S. O. Adegoke, the Managing Director of Mosunmolu Nigeria Limited is hereby acknowledged.

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