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Formal and Informal Foraminiferal Biozonation Framework for Tertiary Sedimentary Succession in F- Well, Niger Delta

Ononeme, O E, Fregene, TJ & Lucas, F A

ABSTRACT

Foraminiferal biozonation of tertiary sediments in F-Well Niger Delta were carried out with the aim of establishing a formal and informal biozones. Fifty (50) ditch cutting samples, sampled at varying intervals were used to establish the biozonation framework for the studied intervals. A total of eighty (80) foraminiferal species were recorded, most of the species recorded are calcareous and arenaceous benthic foraminiferal species. Two planktic zones (*N₄-N₃* and *N₃ – N₂*) and nine informal assemblage zones ranging from A to I were established. *N₄-N₃* Planktic zone has a reference interval of 8,000ft – 9,400ft. The top of this zonal interval which ought to be marked by the FDO of *Ammonia becarril* was absent but was estimated to be 8,000 ft. The base of this zonal interval is marked by the LDO of *Epistominella Vitrea* at 9,400 ft. *N₃ – N₂* Planktic zone has a reference interval of 9,400ft – 10,000 ft. The top of this zonal interval is marked by the FDO of *Bolivina imperatrix* at 9,400 ft. The base of this zonal interval is marked by the LDO of *Spirosplectaminawrightii* at 10,000 ft. The presence of twenty-eight (28) diagnostic species aided in establishing nine informal biozones. These are *Haplophragmoides Sp* Assemblage zone A, *Bathysiphon sp.* Assemblage zone B, *Trochamminaspassemblage* zone C, *Ammo- baculites Sp* Assemblage zone D, *Arenaceous indeterminate* assemblage zone E, *Uvigerina Sparsicostata* assemblage zone F, *Haplophragmoides Nariva Ensis* Assemblage zone G, *Epistominella Vitrea* Assemblage zone H and *Cassigerinellachipollensis* Assemblage zone I.

Keywords: miocene – oligocene, biozone, arenaceous, foraminifera, niger delta.

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Foraminiferal biozonation of tertiary sediments in F-Well Niger Delta were carried out with the aim of establishing a formal and informal biozones. Fifty (50) ditch cutting samples, sampled at varying intervals were used to establish the biozonation framework for the studied intervals. A total of eighty (80) foraminiferal species were recorded, most of the species recorded are calcareous and arenaceous benthic foraminiferal species. Two planktic zones (N4-N3 and N3 – N2) and nine informal assemblage zones ranging from A to I were established. N4-N3 Planktic zone has a reference interval of 8,000ft – 9,400ft. The top of this zonal interval which ought to be marked by the FDO of Ammonia beccarii was absent but was estimated to be 8,000 ft. The base of this zonal interval is marked by the LDO of Epistominella Vitrea at 9,400 ft. N3 – N2 Planktic zone has a reference interval of 9,400ft – 10,000 ft. The top of this zonal interval is marked by the FDO of Bolivina imperatrix at 9,400 ft. The base of this zonal interval is marked by the LDO of Spirosplectaminawrightii at 10,000 ft. The presence of twenty-eight (28) diagnostic species aided in establishing nine informal biozones. These are Haplophragmoides Sp Assemblage zone A, Bathysiphon sp. Assemblage zone B, Trochamminas assemblage zone C, Ammobaculites Sp Assemblage zone D, Arenaceous indeterminate assemblage zone E, Uvigerina Sparsicostata assemblage zone F, Haplophragmoides Nariva Ensis Assemblage zone G, Epistominella Vitrea Assemblage zone H and Cassigerinellachipollensis Assemblage zone I.

Keyword: miocene – oligocene, biozone, arenaceous, foraminifera, niger delta.

I. INTRODUCTION

The study area lies within the Niger Delta Basin, which is situated on the continental margin of the Gulf of Guinea in equatorial West Africa (Klett et al., 1997). The Niger Delta ranks amongst the world's most prolific petroleum producing Tertiary deltas that together account for about 5% of the world's oil and gas reserves and for about 2.5% of the present day basin areas on earth. Biostratigraphy is defined as the classification of sediment units according to observable variations in fossil content (Lowe & Walker, 1997). This enables sediment sequence to be divided into biostratigraphic units or biozones, each characterised by a distinctive fossil assemblage. Foraminifera has a small size, global ecological extent and rapid evolutionary turnover provide an excellent means of biozonation study. It is necessary for correlation, paleoenvironmental reconstruction etc. It is essential to the petroleum industry as a tool for defining geologic constraints on prediction of exploration risk and modeling reservoir simulation. Deep-water agglutinated foraminifera have been used during hydrocarbon explorations since the 1970's when the first Deep Sea Drilling Programme (DSDP) established their value for both biostratigraphical and palaeoenvironmental studies (Gradstein & Berggren, 1981). Planktonic foraminifera are good stratigraphic indicators of the interval covering the Jurassic to present, while benthic foraminifera are found since the Cambrian (Ordovician to Present for calcareous species). They are very good biostratigraphic markers within marine environment. The use of foraminiferal analysis in this study enables us to determine biostratigraphic zonation of the sediments penetrated by the drill (Lucas & Ononeme, 2019; Fregene et al., 2021).

II. STRATIGRAPHY OF NIGER DELTA

2.1 Benin Formation

This is the uppermost unit in the basin and predominantly (over 90%) sandy with isolated clay/shale intercalations. The sands are coarse grained, granular, poorly sorted, subangular to well rounded. They are white or yellowish-brown and contain thin lignite streaks and wood fragments. The sediments are of continental to deltaic plain origin. The sands and sandstones may represent point bar deposits, channel fills and natural levees, whereas the shales may be interpreted as back swamp deposits or ox-bow fills. The Benin Formation is thicker in the central onshore part of the delta where it reaches about 2,000m (Avbovbo, 1978) and thins outwards towards the delta margins. It ranges in age from Oligocene to Recent.

2.2 Agbada Formation

This unit comprises cyclic sequences of alternating sands (fluvial, coastal, and fluvio-marine) and marine shales. Two (2) distinct intervals are easily recognizable: an upper sandy unit with minor shale intercalations and a more marine lower unit in which the shaly sections become prominent. The sandstones and sands are very coarse to very fine grained, unconsolidated or

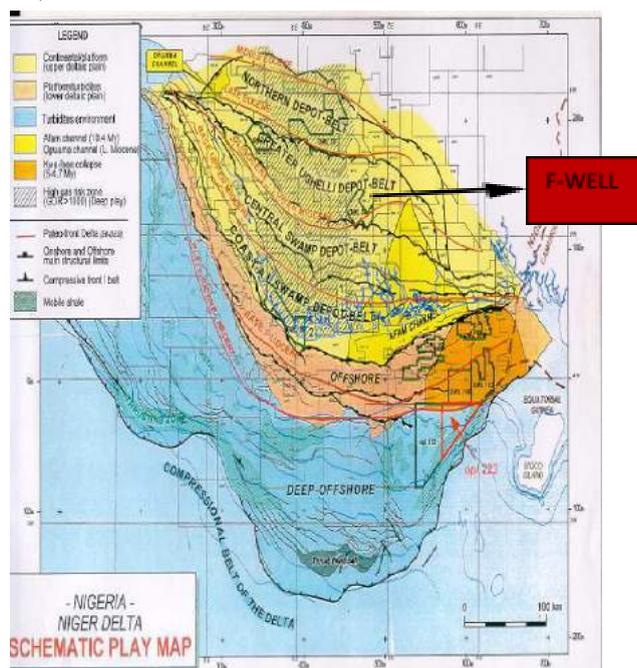
slightly consolidated and poorly sorted. Lignite streaks are common. The shales are grey and dense at the base becoming markedly sandy and silty upward. The Agbada Formation is up to 4,000m thick in the central part of the delta, thinning seaward and towards the delta margins. It is Eocene to Recent in age.

2.4 Akata Formation

This is the basal unit of the Niger Delta complex. It consists of uniformly developed shales deposited in an open marine environment. There is the presence of some sand beds considered to be of continental slope, channel-fills and turbidites (Weber & Daukoru, 1975). The formation is largely under compacted (overpressured). The actual thickness is not known due to inability to penetrate the formation fully except on the basin flanks. The age span is Eocene to Recent.

III. LOCATION OF WELL

F-Well is a well drilled to a total depth of 10,185 feet. It is located in the Greater Ughelli Depo belt of Niger Delta basin defined by the following coordinates: Between Longitude 6°E and 7° E and Latitude 5°N and 6° N.



Source: Nwozor et al., 2013

Figure 1: Location Map of F-Well

IV. MATERIALS AND METHOD

4.1 Foraminifera Slide Preparation

Labeling and Weighing: 20g of each collected sample was weighed, packaged and labeled accordingly indicating the well name, sample type and depth.

Soaking: Bowls were labeled for indicated sample depths contained and soaked with kerosene for about four (4) hours after which the samples were decanted. Water was later added to the labeled samples and allowed to stay/ soak overnight.

Wet sieving and Drying: Samples were washed through 230mesh sieve with 63 micron (um) aperture under running tap water with a shower head. Washed samples were dried on hot plate at about 60°C for about 45minutes.

Dry sieving and Bottling: A set of micro sieves (coarse, medium and fine) was stacked on each other and dried residue for each sample was run through them and sieved manually. The respective fractions were collected and bottled in three (3) already cleansed and properly labeled bottles.

Picking: Each fraction was spread on a gridded foraminifera tray of 4.5 by 6.0cm and moved along definite traverses to pick observed foraminifera under centered binocular microscope. Using a picking needle recognized fossils were picked and placed in the cavity of appropriately labeled slide. The recovered foraminifera were recorded in a picking sheet.

Splitting: This is the sorting/separation and grouping of fossils according to their morphological similarity. Different species are grouped together with the tip of a moistened fine brush and stocked in 10s, 20s, and 50s depending on the richness of the interval on the slide and glued onto the slide with a gum.

Analysis: Identification of the picked foraminifera was done with the aid of type collection and foraminifera album considering the test composition, chambers arrangement, sutures, aperture, habits and ornamentation. The results of the micro fauna analysis are plotted on range and distribution charts to show the sequence of

occurrences of the species. The groups of species identified will be described systematically later.

Dating and Biozonation: Age was determined based on the presence of marker species and correlated with the published chronostratigraphy of Haq *et al.*, (1988) and Harland *et al.*, (1990). The F-zones are of immense help in recognizing MFS and in understanding the cycle concept as well as sequence stratigraphy.

Zones were delineated in the well based on the recognition of the last appearance datum and first appearance datum of important diagnostic species. Furthermore/ maximum/minimum fauna abundance/diversity peaks were also employed to assist in the correlation of the determined horizons to global bioevents.

V. RESULT AND DISCUSSION

5.1 Sedimentology

The sedimentologic description of F-Well was carried out on six hundred and seventy nine (679) Ditch Cutting samples with the aid of both visual and a reflected light microscope with the guide of a standard textural comparison chart showing grain sizes, shapes and degree of sorting. The Sedimentological analysis allowed the erection of one hundred and three (103) lithozones of Clayey Sandstone, Sandstone, Sandy Shale, Shale and Shaly Sandstone lithofacies based on the textural properties observed. Associated minerals which include: Quartz, Iron oxide, and Mica were identified. Fifty (50) Shale and Sandy Shale lithofacies were collected at various intervals for Standard foraminifera analysis.

Table 1: Lithology and Lithozones with Depth

DEPTH(FT)	LITHOLOGY	LITHOZONES
<u>15 – 1,995</u>	<u>Sandstone</u>	<u>1</u>
<u>2,010 – 2,175</u>	<u>Clay</u>	<u>2</u>
<u>2,190 – 2,535</u>	<u>Clayey sandstone</u>	<u>3</u>
<u>2,550 – 2,595</u>	<u>Shaly sandstone</u>	<u>4</u>
<u>2,610 – 2,970</u>	<u>Sandstone</u>	<u>5</u>
<u>2,985 – 3,015</u>	<u>Sandy shale</u>	<u>6</u>
<u>3,030 – 3,105</u>	<u>Shaly sandstone</u>	<u>7</u>
<u>3,120 – 3,150</u>	<u>Sandstone</u>	<u>8</u>
<u>3,165 – 3,315</u>	<u>Shaly sandstone</u>	<u>9</u>
<u>3,330 – 3,345</u>	<u>Sandstone</u>	<u>10</u>
<u>3,360 – 3,405</u>	<u>Shaly sandstone</u>	<u>11</u>
<u>3,420</u>	<u>Sandstone</u>	<u>12</u>
<u>3,435 – 3,495</u>	<u>Shaly sandstone</u>	<u>13</u>
<u>3,510</u>	<u>Sandy shale</u>	<u>14</u>
<u>3,525 – 3,600</u>	<u>Shaly sandstone</u>	<u>15</u>
<u>3,615 – 3,660</u>	<u>Sandstone</u>	<u>16</u>
<u>3,675 – 3,705</u>	<u>Shaly sandstone</u>	<u>17</u>
<u>3,720 – 3,765</u>	<u>Sandy shale</u>	<u>18</u>
<u>3,780 – 3,795</u>	<u>Shaly sandstone</u>	<u>19</u>
<u>3,810</u>	<u>Sandy shale</u>	<u>20</u>
<u>3,825 – 3,885</u>	<u>Sandstone</u>	<u>21</u>
<u>3,900 – 3,930</u>	<u>Shaly sandstone</u>	<u>22</u>
<u>3,945 – 4,155</u>	<u>Sandstone</u>	<u>23</u>
<u>4,170</u>	<u>Clay</u>	<u>24</u>
<u>4,184 – 4,785</u>	<u>Sandstone</u>	<u>25</u>
<u>4,800 – 4,845</u>	<u>Shaly sand</u>	<u>26</u>
<u>4,860</u>	<u>Sandstone</u>	<u>27</u>
<u>4,875</u>	<u>Shaly sandstone</u>	<u>28</u>
<u>4,890</u>	<u>Sandstone</u>	<u>29</u>
<u>4,905 – 5,280</u>	<u>Sandstone</u>	<u>30</u>
<u>5,295</u>	<u>Shaly sandstone</u>	<u>31</u>
<u>5,310 – 5,385</u>	<u>Sandy shale</u>	<u>32</u>
<u>5,400 – 5,505</u>	<u>Sandstone</u>	<u>33</u>
<u>5,520 – 5,550</u>	<u>Shaly sandstone</u>	<u>34</u>
<u>5,565 – 5,595</u>	<u>Sandstone</u>	<u>35</u>
<u>5,610 – 5,715</u>	<u>Shaly sandstone</u>	<u>36</u>
<u>5,730 – 5,985</u>	<u>Sandstone</u>	<u>37</u>
<u>6,000</u>	<u>Shaly sandstone</u>	<u>38</u>
<u>6,015 – 6,030</u>	<u>Sandstone</u>	<u>39</u>
<u>6,045</u>	<u>Shaly sandstone</u>	<u>40</u>
<u>6,060</u>	<u>Sandy shale</u>	<u>41</u>
<u>6,075 – 6,090</u>	<u>Sandstone</u>	<u>42</u>

<u>6,105 – 6,180</u>	<u>Shaly sandstone</u>	<u>43</u>
<u>6,195 – 6,225</u>	<u>Sandstone</u>	<u>44</u>
<u>6,240</u>	<u>Shaly sandstone</u>	<u>45</u>
<u>6,255 – 6,330</u>	<u>Sandstone</u>	<u>46</u>
<u>6,345</u>	<u>Shaly sandstone</u>	<u>47</u>
<u>6,360 – 6,525</u>	<u>Sandstone</u>	<u>48</u>
<u>6,540 – 6,600</u>	<u>Shaly sandstone</u>	<u>49</u>
<u>6,615</u>	<u>Sandy shale</u>	<u>50</u>
<u>6,630 – 6,690</u>	<u>Shale</u>	<u>51</u>
<u>6,705 – 6,735</u>	<u>Sandstone</u>	<u>52</u>
<u>6,750 – 6,810</u>	<u>Shaly sandstone</u>	<u>53</u>
<u>6,825 – 6,900</u>	<u>Sandstone</u>	<u>54</u>
<u>6,915 – 6,960</u>	<u>Shaly sandstone</u>	<u>55</u>
<u>6,975 – 6,990</u>	<u>Sandstone</u>	<u>56</u>
<u>7,005 – 7,020</u>	<u>Shale</u>	<u>57</u>
<u>7,035</u>	<u>Sandy shale</u>	<u>58</u>
<u>7,050 – 7,065</u>	<u>Shaly sandstone</u>	<u>59</u>
<u>7,080</u>	<u>Sandstone</u>	<u>60</u>
<u>7,095</u>	<u>Shaly sandstone</u>	<u>61</u>
<u>7,110</u>	<u>Sandstone</u>	<u>62</u>
<u>7,125 – 7,170</u>	<u>Shaly sandstone</u>	<u>63</u>
<u>7,185</u>	<u>Sandstone</u>	<u>64</u>
<u>7,200 – 7,260</u>	<u>Shaly sandstone</u>	<u>65</u>
<u>7,275 – 7,305</u>	<u>Sandstone</u>	<u>66</u>
<u>7,320 – 7,425</u>	<u>Shaly sandstone</u>	<u>67</u>
<u>7,440 – 7,500</u>	<u>Sandstone</u>	<u>68</u>
<u>7,515</u>	<u>Shaly sandstone</u>	<u>69</u>
<u>7,530 – 7,560</u>	<u>Sandstone</u>	<u>70</u>
<u>7,575 – 7,590</u>	<u>Shaly sandstone</u>	<u>71</u>
<u>7,605 – 7,665</u>	<u>Sandstone</u>	<u>72</u>
<u>7,680</u>	<u>Shaly sandstone</u>	<u>73</u>
<u>7,695 – 7,710</u>	<u>Sandstone</u>	<u>74</u>
<u>7,725 – 7,755</u>	<u>Shaly sandstone</u>	<u>75</u>
<u>7,770 – 7,830</u>	<u>Sandy shale</u>	<u>76</u>
<u>7,845 – 7,860</u>	<u>Sandstone</u>	<u>77</u>
<u>7,875</u>	<u>Shaly sandstone</u>	<u>78</u>

<u>7,890 – 7,905</u>	<u>Sandstone</u>	<u>79</u>
<u>7,920 – 7,965</u>	<u>Shaly sandstone</u>	<u>80</u>
<u>7,980 – 8,010</u>	<u>Sandstone</u>	<u>81</u>
<u>8,025 – 8,100</u>	<u>Sandy shale</u>	<u>82</u>
<u>8,115 – 8,130</u>	<u>Sandstone</u>	<u>83</u>
<u>8,145</u>	<u>Sandy shale</u>	<u>84</u>
<u>8,160 – 8,235</u>	<u>Shaly sandstone</u>	<u>85</u>
<u>8,250 – 8,325</u>	<u>Sandy shale</u>	<u>86</u>
<u>8,340 – 8,550</u>	<u>Shale</u>	<u>87</u>
<u>8,565</u>	<u>Sandy shale</u>	<u>88</u>
<u>8,580 – 8,595</u>	<u>Shaly sandstone</u>	<u>89</u>
<u>8,610 – 8,670</u>	<u>Shale</u>	<u>90</u>
<u>8,685 – 8,730</u>	<u>Sandy shale</u>	<u>91</u>
<u>8,745 – 8,760</u>	<u>Shale</u>	<u>92</u>
<u>8,775 – 8,865</u>	<u>Sandy shale</u>	<u>93</u>
<u>8,880 – 9,210</u>	<u>Shaly sandstone</u>	<u>94</u>
<u>9,225 – 9,240</u>	<u>Sandy shale</u>	<u>95</u>
<u>9,255 – 9,450</u>	<u>Shaly sandstone</u>	<u>96</u>
<u>9,465 – 9,780</u>	<u>Shale</u>	<u>97</u>
<u>9,795</u>	<u>Sandy shale</u>	<u>98</u>
<u>9,810</u>	<u>Shaly sand</u>	<u>99</u>
<u>9,825</u>	<u>Sandy shale</u>	<u>100</u>
<u>9,840 – 10,005</u>	<u>Shale</u>	<u>101</u>
<u>10,020 – 10,095</u>	<u>Sandy shale</u>	<u>102</u>
<u>10,110 – 10,185</u>	<u>Shale</u>	<u>103</u>

5.2 Foraminiferal Abundance

A total of Eighty (80) foraminiferal species were recorded, most of the species recorded are calcareous and arenaceous benthic foraminiferal species. Planktic foraminiferal species are generally scarce in the well. The non-recovery of planktic and the general poor recovery of foraminiferal species might be due to environmental factor.

Species recorded include: *Haplophragmoides* sp., *Bathysiphon* sp., *Pori Textularia Panamensis*, *Haplophragmoides Compressa*, *Trochamminasp*,

Floriluscostiferum, *Calcareous indeterminate*, *Ammobaculites* sp., *Pori Textularia Panamensis*, *Bolivina* sp., *Arenaceous indeterminate*, *Calcareous indeterminate*, *Pori Textularia Panamensis*, *Uvigerina Sparsicostata*, *Haplophragmoides Arvensis*, *Arenaceous indeterminate*, *Spirospectamina Wrightii*, *Hanzawaia concentric*, *Hopkinsinabemoniensis*, *Brizalina imperatrix*, *Ostracod*, *Epistominella Vitrea*, *Hanzawaia concentric*, *Haplophragmoides Arvensis*, *Fursenko Punctata*, *Valvulineria* sp., *Fissurina* sp., *Bathysiphon* sp., *Hanzawaia concentric*.

5.3 Foraminiferal Zonation

The foraminiferal zonation of the well was guided by the works of Blow (1969, 1979). Though planktic foraminiferal species are generally scarce in the well but benthic foraminiferal species whose stratigraphic distributions have been well established in the Niger Delta and have been calibrated with planktic foraminiferal species were used to assign ages and zonation in this Well. The non-recovery of planktic and the general poor recovery of foraminiferal species might be due to environmental factor.

Important foraminiferal bio-events considered include:

- First Downhole Occurrence (FDO) of chronostratigraphically significant planktic/benthic foraminiferal species.
- Last Downhole Occurrence (LDO) of planktic/benthic foraminiferal marker species.
- Foraminiferal abundance and diversity peaks dated with foraminiferal markers species whose stratigraphic ranges are well established world wide.

Table 3: Foraminifera Biostratigraphic summary of the Well

(First Downhole Occurrence of stratigraphically important Foraminifera species)				
Depth (ft)	Epoch/Period	Age (Ma)	Zones (Blow 1969, 1979)	Significant Foraminifera data
2,010	<i>First sample analysed</i>			
2,010 – 8,000	Indeterminate	-	Indeter-minate	Interval barren of foraminifera species
8,000- 9,400	Early Oligocene – Early Miocene	22.2 - 24.3	N4 – N3	Interval characterized by occurrences of <i>Spiroplectamina wrightii</i> and <i>Uvigerina parsicostata</i> .
9,400 – 10,000	Early Oligocene	24.3 - 33.0	N3 – N2	<i>Hanzawaiaconcentrica</i> , <i>Hopkinsinabemoniensis</i> , <i>Brizalina imperatrix</i> and <i>Bolivinaadertonensis</i>

Index species among the recovered foraminifera assemblages have been used in dating and zoning the intervals. Details are given below:

Planktic Zone n4 – n3

Early Miocene - Oligocene

Interval: 8,000ft – 9,400ft

Estimated numerical age: 22.2 - 24.3Ma

Definition

The top of this zonal interval which ought to be marked by the FDO of *Ammonia becarril* was absent but was estimated to be 8,000 ft.

The base of this zonal interval is marked by the LDO of *Epistominellavitria* at 9,400 ft.

Features

- ✓ Interval is characterized by benthic foraminifera species.
- ✓ Interval characterized by the co-occurrence of *Spiroplectaminawrightii* and

Uvigerinasparsicostata. Signifying (N4-N3) Early Miocene - Oligocene age.

Planktic Zone n3 – n2

Interval: 9,400ft – 10,000ft

Estimated numerical age: 24.3 - 33.0Ma

Definition

The top of this zonal interval is marked by the FDO of *Bolivina imperatrix* at 9,400 ft.

The base of this zonal interval is marked by the LDO of *Spiroplectaminawrightii* at 10,000 ft.

Features

- ✓ Interval is characterized by benthic foraminifera species.
- ✓ Interval characterized by the co-occurrence of *Hanzawaiaconcentrica*, *Hopkinsinabemoniensis*, *Brizalina imperatrix* and *Bolivinaadertonensis* signifying (N3-N2) Oligocene age.

VI. INFORMAL FORAMINIFERA BIOZONATION

A total of nine foraminifera assemblage biozones have been identified. These are compared with works of Blow (1969, 1979). The biozones are coded and discussed alphabetically in ascending order below from A-I.

1. Haplophragmoides Sp Assemblage Biozone A

Reference section: F-Well 8,025ft-8,055ft
Definition: Selected species last appearing include Haplophragmoides Sp. and Bathysiphon Sp.

The top of the biozone is defined by the last stratigraphic occurrence of Haplophragmoides Sp and the base by Bathysiphon Sp.

2. Bathysiphon Sp Assemblage Biozone B

Reference Section: F-Well 8,055ft-8,250ft
Definition: Selected species last appearing include Bathysiphon Sp. and Trochammina Sp.

The top of this biozone is defined by the last stratigraphic occurrence of Bathysiphon Sp. and the base by the last appearing of Trochammina Sp.

3. Trochammina Sp. Assemblage Biozone C

Reference Section: F-Well 8,250ft-8,295ft
Definition: Selected species last appearing include Trochammina Sp. and Ammobaculites Sp,

The top of this biozone is defined by the last stratigraphic occurrence of Trochammina Sp. and the base by the last occurrence of Ammobaculites Sp,

4. Ammobaculites Sp Assemblage Biozone D

Reference Section: F-Well 8,295ft-8,385ft
Definition: Selected species last appearing include Ammobaculites Sp, and Arenaceous Indeterminate.

The top of this biozone is defined by the last stratigraphic occurrence of Ammobaculites Sp, and the base by the last occurrence of Arenaceous Indeterminate.

5. Arenaceous Indeterminate Assemblage Biozone E

Reference Section: F-Well 8,385ft-8,535ft
Definition: Selected species last appearing include

Arenaceous Indeterminate and Uvigerina Sparsicostata.

The top of this biozone is defined by the last stratigraphic occurrence of Arenaceous Indeterminate and the base by the last occurrence of Uvigerina Sparsicostata.

6. Uvigerina Sparsicostata Assemblage Biozone F

Reference Section: F-Well 8,535ft-9,240ft
Definition: Selected species last appearing include Uvigerina Sparsicostata and Haplophragmoides Narivaensis.

The top of this biozone is defined by the last stratigraphic occurrence of Uvigerina Sparsicostata and the base by the last occurrence of Haplophragmoides Narivaensis.

7. Haplophragmoides Narivaensis Assemblage Biozone G

Reference Section: F-Well 9,240ft-9,540ft
Definition: Selected species last appearing include Haplophragmoides Narivaensis and Epistominella Vitrea.

The top of this biozone is defined by the last stratigraphic occurrence of Haplophragmoides Narivaensis and the base by the last occurrence of Epistominella Vitrea.

8. Epistominella Vitrea Assemblage Biozone H

Reference Section: F-Well 9,540ft-9,855ft
Definition: Selected species last appearing include Epistominella Vitrea and last appearance of Cassigerinella Chipollensis

The top of this biozone is defined by the last stratigraphic occurrence of Epistominella Vitrea and the base by the last occurrence of Cassigerinella Chipollensis.

9. Cassigerinella Chipollensis Assemblage Biozone I

Reference Section: F-Well 9,855ft-10,170ft
Definition: Selected species last appearing include Cassigerinella Chipollensis

The top of this biozone is defined by the last stratigraphic occurrence of Epistominella Vitrea and the base could not be determined.

VII. CONCLUSION

This study was carried out on ditch cutting samples. The lithology of the well is composed of grey to dark grey shale and sandy shales. Biostratigraphic characteristic of the well were analysed using foraminifera. Two planktic foraminiferal zones were recognized N₄-N₃ and N₃-N₂ zones while nine assemblage zones A - I according to the present study. The studied intervals in the well are dated Early Miocene - Oligocene. Using the lithologic and foraminiferal studies, it is inferred that the intervals penetrated by the well correspond to Agbada Formation. The alternation of shales and sandy shales/mudstones within the sequence provides the combination of source, reservoir and cap rocks essential for hydrocarbon generation, accumulation and trap.

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