AJHSE Vol: 4(2): 11-23, 2023
DOI: 10.52417/ajhse.v4i2.365
Accepted Date: June 30, 2023
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www.ajhse.org

**African Journal of Health, Safety and Environment**
***An official publication of the***
**Applied Environmental Bioscience and Public Health Research Group**
University of Benin, Benin City, Nigeria
Open Access | Bi-annual | Peer-reviewed | International
ISSN (Online): 2695-1819 | ISSN (Print): 2695-2386

**RESEARCH ARTICLE** **AJHSE040202**

# GEOLOGICAL AGE EVALUATION OF SAPELE DEEP FIELD, DELTA STATE, SOUTH-SOUTH NIGERIA.

**[1]Mujakperuo, B. J. O. &*[1]Airen, O. J.**

*[1]Department of Physics, Faculty of Physical Sciences, University of Benin, Nigeria*
**Corresponding Author's Email: osariere.airen@uniben.edu, Phone: +2348039591347*

## ABSTRACT

One of the most productive fields in the Niger Delta is the Sapele Deep field, an onshore field of OML 41 that is situated in the Northwestern region (Greater Ughelli depobelt) of the oil province. The Niger Delta chronostratigraphic map from SPDC (2010) and well-log, seismic, and biostratigraphic data from six wells within the Niger Delta Province were used to conduct the age assessment of the field. Petrel®2016 (Schlumberger software) was used in the interpretation of seismic and well log data used in this research. Age of rocks within the depositional basins of the study area ranges from early Miocene to late Miocene and this was established through the delineated maximum flooding surface and marker fauna from the regional seal of marine transgression which are Me-2-Bolivina-48, Me-1-Haplophragmoides-24, Tor-2-Uvigerina-8, Tor-1-Nonion-4, Ser-3-Dodo Shale, Ser-2-Cassidulina-7, Ser-1-Bolivina-25, Lang-1-Bur-5-Chiloguembelina-3, and Bur-3-Ogara Shale. The specified reference fossils from depths of 6814.5 ft to 12573 ft include Globorotalia plesiotumida, Globigerinoides extremus, Neogloboquadrina acostaensis, Globorotalia lenguaensis, Globoturborotalita nepenthes, Orbulina suturalis, Fohsella robusta, Fohsella fohsi, Fohsella peripheroacuta, Fohsella praefohsi, Praeorbulina glomerosa, Fohsella birnageae, Globigerinatella insueta, Praeorbulina sicana, and Catapstdrax dissimilis. The depth range for these markers spans from 6814.5 ft to 12573 ft.

***Keywords:*** *Biostratigraphic, Chronostratigraphic, Ser-1-Bolivina-25, Lang-1-Bur-5-Chiloguembelina-3, Bur-3-Ogara Shale*

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## INTRODUCTION

Heavy According to the order of their sedimentation, the Tertiary Niger Delta is classified into the Benin, Agbada, and Akata Formations. Based on the ratio of sand to shale, these formations are differentiated. The pro-delta, deltaic front, and delta top environments are each represented by the interfingering lithofacies equivalents of the Akata, Agbada, and Benin Formations. According to Doust and Omatsola (1990), the heterogeneity of the source rock type is probably related to the dispersion of petroleum.

Sandstone and loose sands, primarily from the Agbada Formation, are used to make petroleum in the Niger Delta. The development of the Tertiary Niger Delta was dependent on the pace of subsidence and sedimentation, which fluctuated in response to changes in sea level and produced progradation, retrogradation, and aggradation deposition. According to Doust and Omatsola (1990), the thickness of the Akata Formation (Miocene to Recent) is estimated to be 7000 m. The main petroleum-bearing unit of the Niger Delta stratigraphic sequence, the Agbada Formation (Miocene to Recent), is thought to be 3700 m thick and is located in the deltaic region. There is a major issue of knowing the depositional pattern of the most productive hydrocarbon fields in the Niger Delta age and depositional pattern, which will help with the field's further classification. The siliciclastic sediments are laid down in environments with deltaic fronts, delta top-sets, and fluvial deltas. Typically, as depth increases, the sand-to-shale ratio diminishes.

The youngest lithostratigraphic unit in the Niger Delta is the Benin Formation (Late Miocene to Recent) Short and Stauble, 1967. It has a minimum thickness of more than 6000 feet, is composed primarily of continental sands and sandstones (>90%), has minimal intercalations of shale, and has accumulated relatively little petroleum.

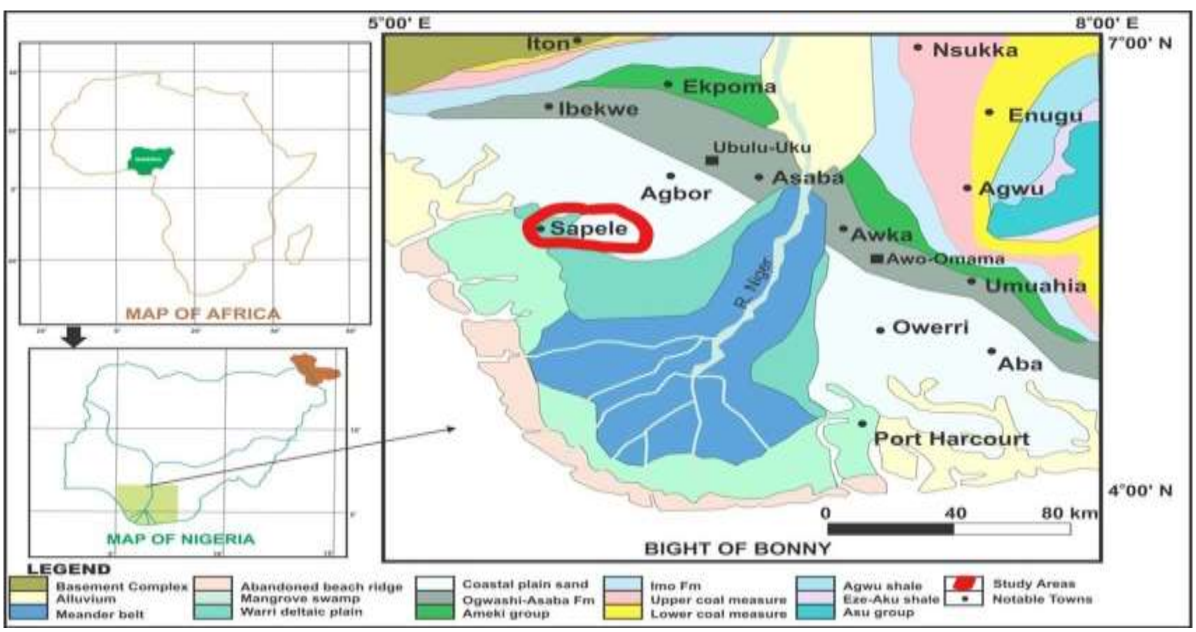


**Figure 1**: Geological Map of the Niger Delta Basin showing the Study Area (Oyebanjo *et al.*, 2018).

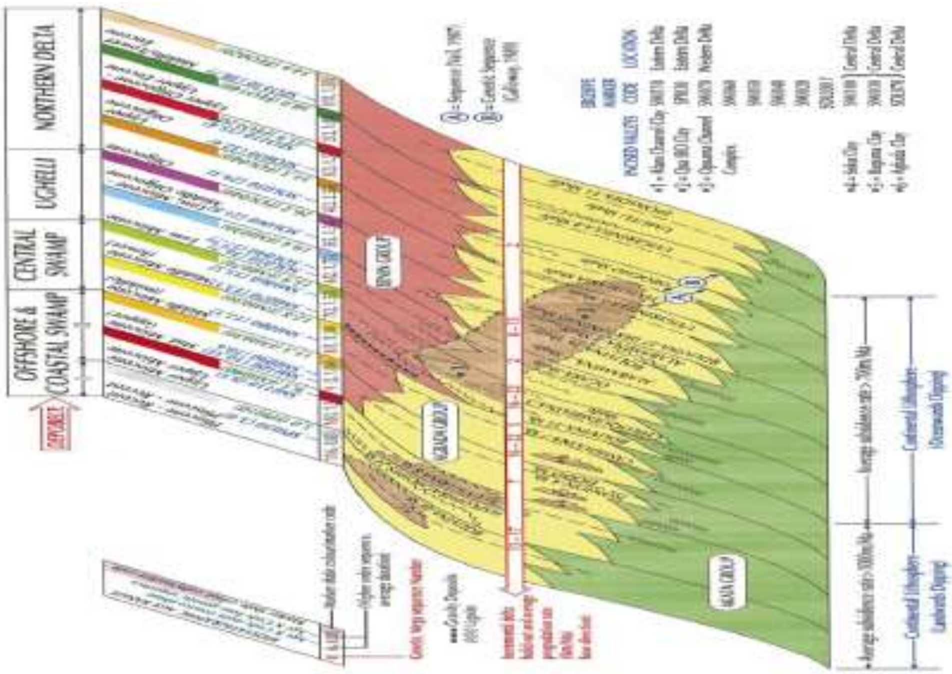


**Figure 2:** Diagrammatic Representation of the Stratigraphic Evolution of the Niger Delta (Reijers, 2011).

## MATERIALS AND METHODS

**Sampling:**

This study was conducted using well-log data, seismic data, and biostratigraphic data from the study area. These subsurface data were made public with the Department of Petroleum Resources (DPR) permission and remains the property of Seplat Petroleum Development Company PLC (Seplat Energy PLC). The SPDC (2010), Niger Delta Chronostratigraphic Chart (Figures 3 and 4) and Cenozoic Chronostratigraphic Chart of Blow (1969), Berggren *et al*.(1995), and Wade *et al*. (2011) all contain proven zonation schemes that were used to calibrate the data. These surfaces were mapped across the seismic volume and correlated on well logs. The main data sources were core samples, wireline logs, and geological map data. Volumetric calculations are frequently used to estimate reserves before production begins and to assess recovery effectiveness, reservoir area, and as a foundation for more advanced studies like reservoir simulations, which are used to calculate the reservoirs' various ages using a combination of species from the benthonic, planktonic, and palynomorph indexes. Stratigraphic bounding surfaces were defined using interpreted biostratigraphic data (palynological, P-zone and foraminifera, F-zones) and biofacies data made up of planktonic and benthic foraminifera abundance and diversity.

The depth of this data was compared with related well logs, and the information was calibrated. To improve log trends, aid in lithofacies delineation, and facilitate the identification of stacking pattern, well-log suites were exhibited at consistent scales.

## RESULTS AND DISCUSSION

### Sapele Deep Field Maximum Flooding Surface

Nine Maximum Flooding Surfaces (MFS) were identified from Figure 5 with corresponding ages (Ma) across the Sapele Deep region. They range in age from late early to late Miocene, as described below;

(i) **19.4 Ma maximum flooding surface (MFS_19.4):** This MFS was dated 19.4 Ma using a local marker, Bur-3-Ogara Shale, and was correlated across all wells (Sapele 01, Sapele 06, Sapele 17, Sapele 18, Sapele 19, and Sapele 27) in Sapele deep. The Ogara genetic mega sequence starts here, and the surface is found in the P70/650 and F9300 biozones. The conclusion of the Ogara mega sequence's creation coincided with the sea level decline (regression) at 17.7 Ma, which led to the extinction of the late early Miocene planktonic foraminifers Catapsydrax dissimilis and Globigerinatella ensuite.

(ii) **15.9 Ma maximum flooding surface (MFS_15.9):** was correlated among the six wells and dated to 15.9 Ma using the regional marker Lang-1-Bur-5-Chiloguembelina-3. This is the starting point of the genetic mega sequence for Chiloguembelina-3 (Streptochilus dubeyi), and it is found on the surface in the P680 and F9500 biozones. The sea level fall (regression) about 15.6 Ma, which coincides with the extinction of planktonic foraminifera from the early middle Miocene such as Chiloguembelina sp., Orbulina suturalis, and Praeorbulina glomerosa, marked the end of the creation of the Chiloguembelina-3 mega series

**(iii) 15.0 Ma maximum flooding surface (MFS_15.0):** was connected amongst all Sapele deep wells, and it was dated at 15.0 Ma using the regional marker Ser-1-Bolivina-25. The Bolivina-25 genetic mega sequence begins here, and the surface is found in the P720/P740 and F9500 biozones. The sea level fall (regression) about 13.1 Ma, which coincides with the extinction of the planktonic foraminifers Fohsella peripheroacuta and Fohsella praefohsi from the early middle Miocene, marked the end of the creation of the Bolivina-25 mega series.

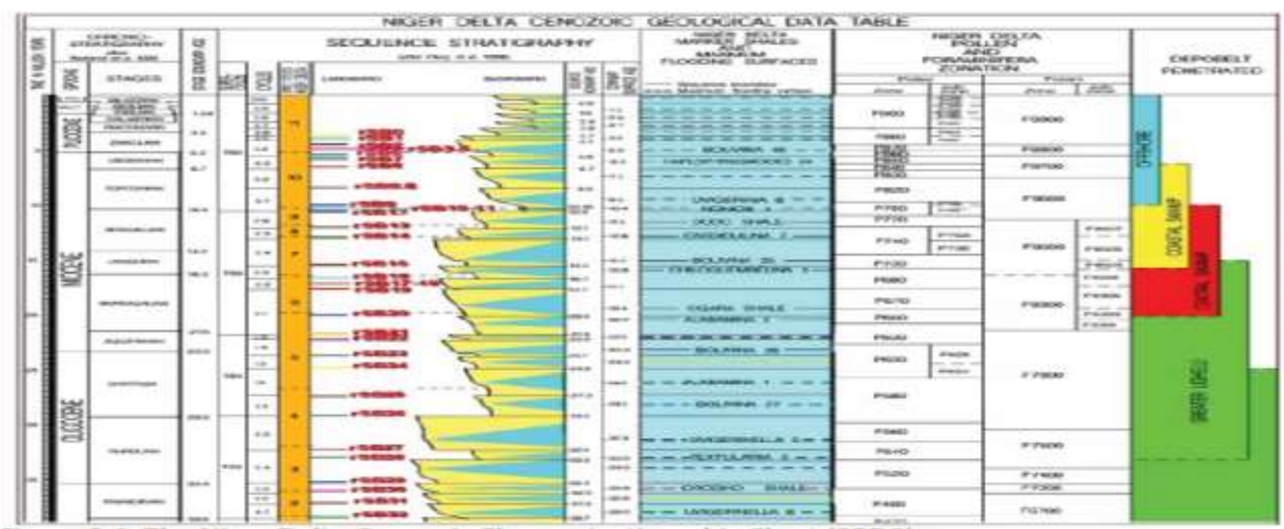


**Figure 3:** Niger Delta Chronostratigraphic chart showing geologic interval (SPDC, 2010).

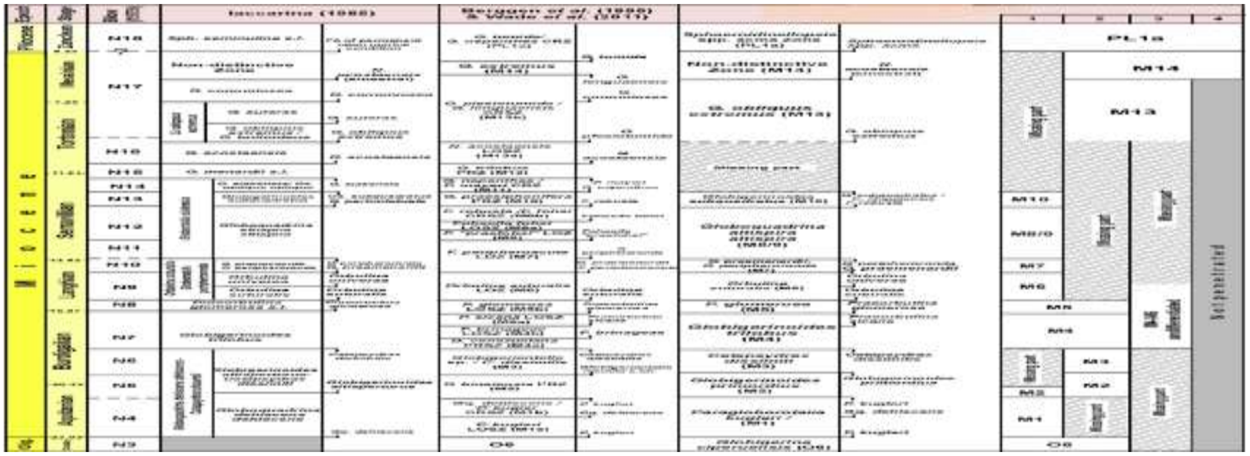

**Figure 4:** Miocene-Pliocene Chronostratigraphic chart of Blow (1979), Berggren *et al.* (1995) and Wade *et al.* (2011).

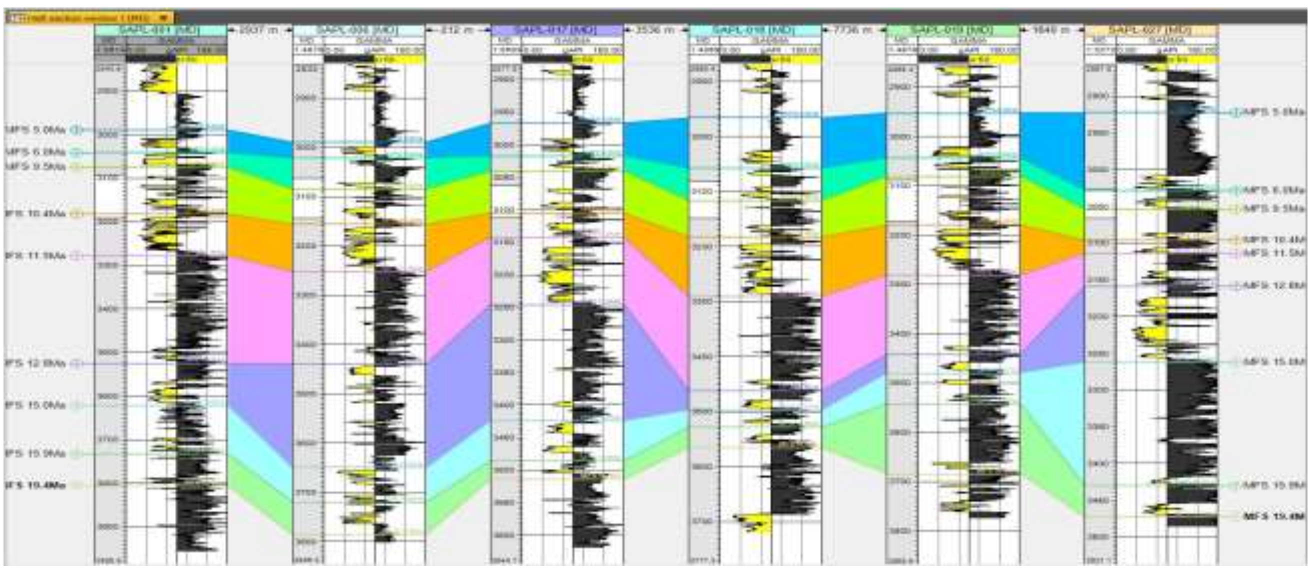

**Figure 5:** Sapele Deep Maximum Flooding Surface Age correlation panel (Using Petrel)

**(iv) 12.8 Ma maximum flooding surface (MFS_12.8):** was identified in all deep wells and was dated at 12.8 Ma using the regional marker Ser-2-Cassidulina-7. This represents the genetic megasequence base for Cassidulina-7 (Cassidulina neocarinata), and the surface happened in the P740 and F9500 biozones. The middle Miocene foraminifers Fohsella robusta, Fohsella fohsi, and Cassidulina sp all went extinct with the end of the creation of the Cassidulina-7 mega series, which occurred at 12.1 Ma.

**(v) 11.5 Ma maximum flooding surface (MFS_11.5):** was identified in every well in the research area and was dated at 11.5 Ma using a regional marker called Ser-3-Dodo Shale. The surface occurred within the P780/P770 and F9600/F9500 biozones, and thus is the base of the Dodo Shale genetic mega sequence. Globoturborotalita nepenthes, Paragloborotalia mayeri, and benthonic foraminifer Valvullineria gasparensis of the late middle Miocene went extinct as a result of the sea level falling (regression) at 10.8 Ma, which marked the end of the creation of the Dodo Shale mega series.

**(vi) 10.4 Ma maximum flooding surface (MFS_10.4)**: was dated 10.4 Ma using a local marker, Tor-1-Nonion-4, and was correlated throughout the deep. Within the biozones P780 and F9600, this surface can be found. The creation of the Nonion-4 mega series came to a stop with the sea level decline (regression) about 10.35 Ma, which coincides with the demise of the late middle Miocene planktonic foraminifers Globoturborotalita trilobus, Cibicorbis inflata, and Lenticula grandis.

**(vii) 9.5 Ma maximum flooding surface (MFS_9.5**): was dated at 9.5 Ma using the Tor-2-Uvigerina-8 marker shale and correlated across the deep. The biozones P820/P780 and F9600 contained this surface. At 8.5 Ma, the sea level fell (regressed), ending the creation of the Uvigerina-8 mega series and causing the extinction of early late Miocene foraminiferal species including Neogloboquadrina acostaensis and Uvigerina species.

**(viii) 6.0 Ma maximum flooding surface (MFS_6.0):** was identified, correlated, and dated at 6.0 Ma using the regional marker Me-1-Haplophragmoides-24. The location of this surface was between P860/P840 and F9700. Sea level fall (regression) about 5.6 Ma marked the end of the creation of the Haplophragmoides-24 mega sequence and the extinction of foraminiferal species like Globorotalia plesiotumida and Haplophragmoides species from the middle to late Miocene.

**(ix) 5.0 Ma maximum flooding surface (MFS_5.0**): was also correlated throughout the deep, and it was dated to 5.0 Ma using the regional marker Me-2-Bolivina-48. The location of this surface was between P870/P860 and F9600. Sea level fall (regression) at 4.1 Ma marked the end of the creation of the Bolivina-48 mega series and the extinction of late Miocene foraminifera including Bolivina sp. and Globorotalia extremus. For each well in the deep field, the well log sequence stratigraphic correlation utilizing the MFS was used (Figure 5), while the depth at which each MFS occurred in different wells was listed in Table 1.

**Sapele Deep Sequence Boundary**

Eight sequence boundaries were identified from Figure 6 and associated from the oldest to the youngest sequence in all deep field wells. The oldest sequence boundary was SB_17.5 ma in age. This surface is an extensive erosional surface that was established before the MFS_15.8 ma. According to Table 2, other sequence boundaries are dated at 15.6, 13.2, 12.1, 10.8, 10.35, 8.5, and 5.6 ma.

**Sapele Deep Depositional Sequence**

Eight depositional sequences delineated from oldest to youngest (Table 2) are detailed below:

**(i) Sequence One (SEQ 1):** This is the initial depositional sequence (SEQ 1) of the deep; it is limited on top and bottom by maximum flooding surfaces that are 19.4 Ma and 15.9 Ma, respectively, and has an average thickness of 36.3 m (119.7 ft). The lower shoreface sand that was deposited in the continental slope region during sea level fall is understood to be the lowstand system tract (LST) sand. The 15.9 Ma MFS marker (Lang-1-Bur-5-Chiloguembelina-3) caps the Transgressive System Tract (TST) unit of this sequence. This aggradational sequence stacking pattern was laid down in the Bathyal (BA) depositional environment.

**(ii) Sequence Two (SEQ 2):** The greatest flooding surface at the top and bottom of the second sequence (SEQ 2), which has an average thickness of 27.8 m (91.85 ft), is 15.9 Ma and 15 Ma, respectively. The 15 Ma MFS marker (Ser-1-Bolivina-25) was placed at the top of a thick sand deposit that the lowstand system tract (LST) of this sequence created. This thick sand deposit is thought to be lower/middle shoreface sand that was deposited in the continental slope/continental shelf region during sea level decline. The Outer Neritic to Bathyal (ON-BA) depositional environment is where this sequence stacking pattern, which is aggradational, was deposited.

**Table 1:** Sapele Deep Maximum Flooding Surface, Marker Fauna and Biozones.

| Epoch | Well | Age | Depth (M) | MFS Age (Ma) | MFS & Marker Fauna | Biozones | |
|---|---|---|---|---|---|---|---|
| | | | | | | P-Zone | F-Zone |
| | Sapele 01 | Messinian | 2910 (9603 ft) | 5.0 | Me-2-Bolivina-48 | P870/P860 | F9800 |
| | | | 3040 (10032 ft) | 6.0 | Me-1-Haplophragmoides-24 | P860/P840 | F9700 |
| | | Tortonian | 3080(10164 ft) | 9.5 | Tor-2-Uvigerina-8 | P820/P780 | F9600 |
| | | | 3170 (10461 ft) | 10.4 | Tor-1-Nonion-4 | P780 | F9600 |
| | | Serravallian | 3265 (10774.5 ft) | 11.5 | Ser-3-Dodo Shale | P780/P770 | F9600/F9500 |
| | | | 3525 (11632.5 ft) | 12.8 | Ser-2-Cassidulina-7 | P740 | F9500 |
| | | | 3620 (11946 ft) | 15.0 | Ser-1-Bolivina-25 | P740/P720 | F9500 |
| | | Langhian/ Burdigalian | 3730 (12309 ft) | 15.9 | Lang-1-Bur-5-Chiloguembelina-3 | P720/P680 | F9500/ F9300 |
| | | Burdigalian | 3810 (12573 ft) | 19.4 | Bur-3-Ogara Shale | P670/P650 | F9300 |
| | Sapele 06 | Messinian | 2885 (9520.5 ft) | 5.0 | Me-2-Bolivina-48 | P870/P860 | F9800 |
| | | | 3020 (9966 ft) | 6.0 | Me-1-Haplophragmoides-24 | P860/P840 | F9700 |
| | | Tortonian | 3080 (10494 ft) | 9.5 | Tor-2-Uvigerina-8 | P820/P780 | F9600 |
| | | | 3145 (10378.5 ft) | 10.4 | Tor-1-Nonion-4 | P780 | F9600 |
| | | Serravallian | 3240 (10692 ft) | 11.5 | Ser-3-Dodo Shale | P780/P770 | F9600/F9500 |
| | | | 3463 (11427.9 ft) | 12.8 | Ser-2-Cassidulina-7 | P740 | F9500 |
| | | | 3650 (12045 ft) | 15.0 | Ser-1-Bolivina-25 | P740/P720 | F9500 |
| | | Langhian/ Burdigalian | 3720 (12276 ft) | 15.9 | Lang-1-Bur-5-Chiloguembelina-3 | P720/P680 | F9500/ F9300 |
| | | Burdigalian | 3768 (12434.4) | 19.4 | Bur-3-Ogara Shale | P670/P650 | F9300 |
| | Sapele 17 | Messinian | 2946.2(9722.5 ft) | 5.0 | Me-2-Bolivina-48 | P870/P860 | F9800 |
| | | | 3015 (9949.5 ft) | 6.0 | Me-1-Haplophragmoides-24 | P860/P840 | F9700 |
| | | Tortonian | 3040 (10032 ft) | 9.5 | Tor-2-Uvigerina-8 | P820/P780 | F9600 |
| | | | 3098 (10223.4 ft) | 10.4 | Tor-1-Nonion-4 | P780 | F9600 |
| | | Serravallian | 3140 (10362 ft) | 11.5 | Ser-3-Dodo Shale | P780/P770 | F9600/F9500 |
| | | | 3245 (10708.5 ft) | 12.8 | Ser-2-Cassidulina-7 | P740 | F9500 |
| | | | 3446 (11371.8 ft) | 15.0 | Ser-1-Bolivina-25 | P740/P720 | F9500 |
| | | Langhian/ Burdigalian | 3475 (11467.5 ft) | 15.9 | Lang-1-Bur-5-Chiloguembelina-3 | P720/P680 | F9500/ F9300 |
| | | Burdigalian | 3510 (11583 ft) | 19.4 | Bur-3-Ogara Shale | P670/P650 | F9300 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Sapele 18 | Messinian | 2959 (9756 ft) | 5.0 | Me-2-Bolivina-48 | P870/P860 | F9800 |
| | | 3055 (10081 ft) | 6.0 | Me-1-Haplophragmoides-24 | P860/P840 | F9700 |
| | Tortonian | 3115 (10279.5 ft) | 9.5 | Tor-2-Uvigerina-8 | P820/P780 | F9600 |
| | | 3175 (10477.5 ft) | 10.4 | Tor-1-Nonion-4 | P780 | F9600 |
| | Serravallian | 3285 (10840.5 ft) | 11.5 | Ser-3-Dodo Shale | P780/P770 | F9600/F9500 |
| | | 3450 (11385 ft) | 12.8 | Ser-2-Cassidulina-7 | P740 | F9500 |
| | | 3495 (11533.5 ft) | 15.0 | Ser-1-Bolivina-25 | P740/P720 | F9500 |
| | Langhian/ Burdigalian | 3522 (11622.6 ft) | 15.9 | Lang-1-Bur-5-Chiloguembelina-3 | P720/P680 | F9500/ F9300 |
| | Burdigalian | 3560 (11748 ft) | 19.4 | Bur-3-Ogara Shale | P670/P650 | F9300 |
| Sapele 19 | Messinian | 2710 (8943 ft) | 5.0 | Me-2-Bolivina-48 | P870/P860 | F9800 |
| | | 2790 (8943 ft) | 6.0 | Me-1-Haplophragmoides-24 | P860/P840 | F9700 |
| | Tortonian | 2920 (9636 ft) | 9.5 | Tor-2-Uvigerina-8 | P820/P780 | F9600 |
| | | 3070 910131 ft) | 10.4 | Tor-1-Nonion-4 | P780 | F9600 |
| | Serravallian | 3172 (10467.6) | 11.5 | Ser-3-Dodo Shale | P780/P770 | F9600/F9500 |
| | | 3275 (10807.5 ft) | 12.8 | Ser-2-Cassidulina-7 | P740 | F9500 |
| | | 3440 (11352 ft) | 15.0 | Ser-1-Bolivina-25 | P740/P720 | F9500 |
| | Langhian/ Burdigalian | 3540(11470.8 ft) | 15.9 | Lang-1-Bur-5-Chiloguembelina-3 | P720/P680 | F9500/ F9300 |
| | Burdigalian | 3765 (11566.5 ft) | 19.4 | Bur-3-Ogara Shale | P670/P650 | F9300 |
| Sapele 27 | Messinian | 2940 (9702 ft) | 5.0 | Me-2-Bolivina-48 | P870/P860 | F9800 |
| | | 3027 (9989.1 ft) | 6.0 | Me-1-Haplophragmoides-24 | P860/P840 | F9700 |
| | Tortonian | 3052 (10071.6 ft) | 9.5 | Tor-2-Uvigerina-8 | P820/P780 | F9600 |
| | | 3093 (10206.9 ft) | 10.4 | Tor-1-Nonion-4 | P780 | F9600 |
| | Serravallian | 3115 (10279.5 ft) | 11.5 | Ser-3-Dodo Shale | P780/P770 | F9600/F9500 |
| | | 31589(10421.4 ft) | 12.8 | Ser-2-Cassidulina-7 | P740 | F9500 |
| | | 3260 (10758 ft) | 15.0 | Ser-1-Bolivina-25 | P740/P720 | F9500 |
| | Langhian/ Burdigalian | 3427 (11309.1 ft) | 15.9 | Lang-1-Bur-5-Chiloguembelina-3 | P720/P680 | F9500/ F9300 |
| | Burdigalian | 3470 (11451 ft) | 19.4 | Bur-3-Ogara Shale | P670/P650 | F9300 |

**(iii) Sequence Three (SEQ 3):** The greatest flooding surface at the top and bottom of the third sequence (SEQ3), which has an average thickness of 41.6 m (137.4 ft), is 15 Ma and 12.8 Ma, respectively. This sequence's lowstand system tract (LST) produced thick sand deposits that were thought to be lower/middle shoreface sand that had been deposited on a continental slope or shelf during sea level decrease. The 12.8 Ma MFS (Ser-2-Cassidulina-7) marker represents the end of this sequence's transgressive systems tract (TST) unit. This series stacking pattern is aggradational and was deposited in the depositional environment of the Outer Neritic to Bathyal (ON-BA).

**(iv) Sequence Four (SEQ 4):** Sequence Four (SEQ 4) has a maximum flooding surface of 11.5 Ma at the top and bottom and an average thickness of 35.3 m (116.5 ft). This sequence's lowstand system tract (LST) is thought to be middle shoreface sand that was deposited on the continental shelf area during the sea level decline. The 11.5 Ma MFS (Ser-3-Dodo Shale) marker marks the end of the sequence's transgressive systems tract (TST) unit. The Middle Neritic to Outer Neritic (MN-ON) depositional environment is where the sequence stacking patterns, which are aggradational, were deposited.

**(v) Sequence Five (SEQ 5):** The fifth sequence (SEQ 5) has a top and bottom boundary of 11.5 Ma and 10.4 Ma maximum flooding surfaces, respectively, with an average thickness of 77.5 m (255.6 ft). The sequence has aggradational stacking patterns and was deposited in the Middle Neritic to Outer Neritic (MN-ON) depositional environment. This sequence's low stand system tract (LST) is thought to be middle shoreface sand that was deposited on the continental shelf area during the sea level decline. The 10.4 Ma MFS (Tor-1-Nonion-4) marker marks the end of the sequence's transgressive systems tract (TST) unit.

**(vi) Sequence Six (SEQ 6):** Sequence six (SEQ 6) has a maximum flooding surface of 9.5 Ma at the top and bottom, and an average thickness of 40.2 m (132.8 ft). The sequence has aggradational stacking patterns and was deposited in the Middle Neritic to Outer Neritic (MN-ON) depositional environment. This sequence's lowstand system tract (LST) is thought to be middle shoreface sand that was deposited on the continental shelf area during the sea level decline. The 9.5 Ma MFS (Tor-2-Uvigerina-8) regional marker serves as the capstone for the transgressive systems tract (TST) unit of this sequence.

**(vii) Sequence Seven (SEQ 7):** The seventh sequence (SEQ 7) has a thickness of 33.9 m (111.7 ft) on average and is bordered at the top and bottom by the maximum flooding surfaces of 9.5 Ma and 6.0 Ma, respectively. The sequence has aggradational stacking patterns and was deposited in the Inner Neritic to Middle Neritic (IN-MN) depositional environment. The 9.5 Ma MFS (Me-1-Haplophragmoides-24) marker caps the transgressive systems tract (TST) unit of this sequence. This sequence's lowstand system tract (LST) is thought to be middle shoreface sand that was deposited on the continental shelf area during the sea level decline.

**(viii) Sequence Eight (SEQ 8):** The Sapele Deep's uppermost/youngest series is this one. It has a maximum flooding surface of 5.0 Ma at the top and bottom and an average thickness of 27.4 m (90.3 ft). The sequence has aggradational stacking patterns and was deposited in the Inner Neritic to Middle Neritic (IN-MN) depositional environment. The 5.0 Ma MFS (Me-2-Bolivina-46) regional marker serves as the capstone for the transgressive systems tract (TST) unit of this sequence. This sequence's lowstand system tract (LST) is thought to be upper shoreface sand that was dumped on the continental shelf area during the sea level decrease.

The well logs signature reveals that all sequences in Sapele deep field exhibit an aggradational stacking pattern (Saw Teeth shape) which implies that the sediments accommodation rate equals the sediments deposition rate. This agrees with Emery and Myers (1996) and Van Wagoner *et al.* (1990).

### Identified Datum Markers

### Early Miocene

Based on the last downhole occurrence (LDO) of Praeorbulina glomerosa and the first downhole occurrence (FDO) of Catapsydrax dissimilis, the study area's upper and lower limits for the early Miocene are marked at 3470 m (11451 ft) and 3810 m (12573 ft), respectively (Table 3). Another characteristic of early Miocene planktonic species, like Fohsella birnageae and Globigerinatella insueta, are present throughout this period. According to Wade *et al*. (2011), the majority of the taxa that make up the early Miocene assemblage are non-diagnostic taxa such as Catapsydrax, Globigerina, Globigerinoides, Globorotalia praescitula, and Globoquadrina.

### Middle Miocene

Based on the last downhole occurrence (LDO) of both Fohsella robusta and Fohsi, the upper limit is placed as 3115m (10279.5 ft). Based on the first downhole occurrences (FDO) of Orbulina suturalis and Praeorbulina glomerosa, the lower limit is designated at 3620 m (11946 ft) (Table 3). Fohsella praefohsi and Fohsella peripheroacuta are two additional planktonic species that are present.

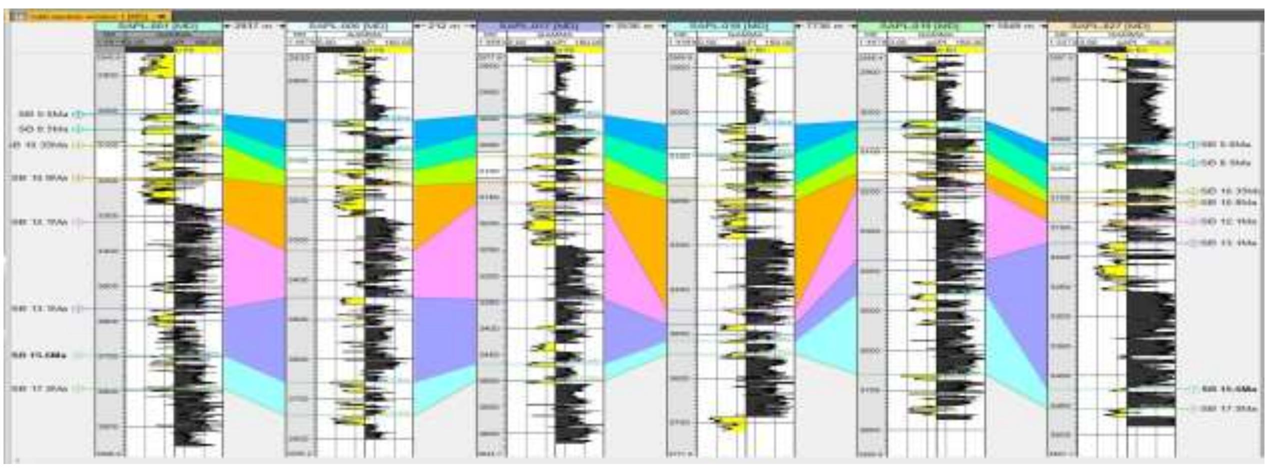

**Figure 6:** Sapele Deep Sequence Boundary Age Correlation Panel (Using Petrel).

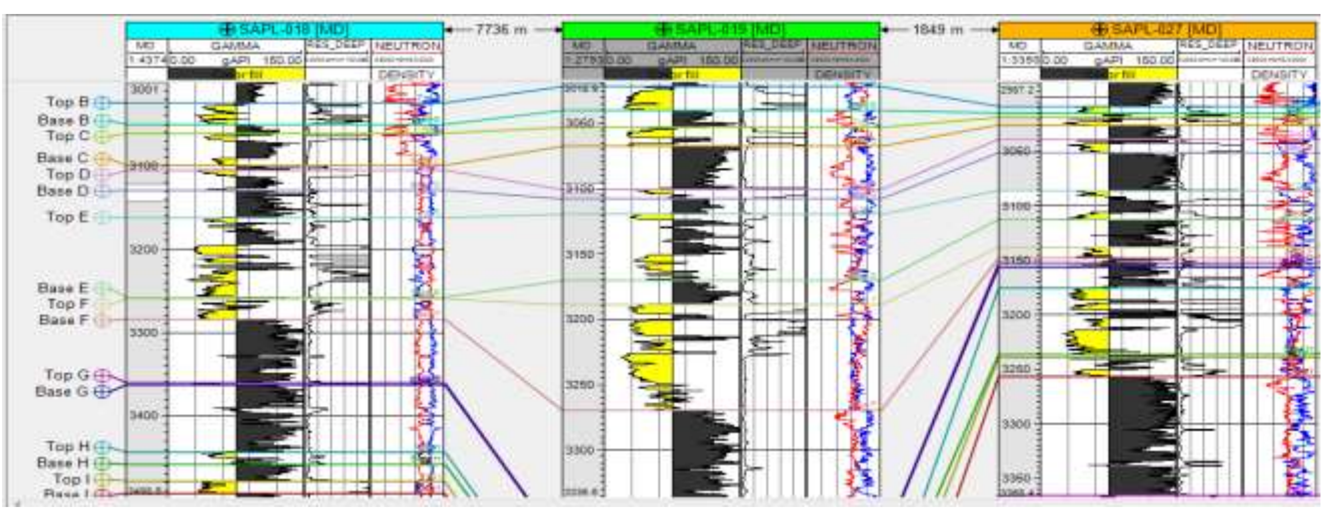


**Figure 7:** Sapele Deep Wells Neutron and Density log showing hydrocarbon presence (Using Petrel).

**Table 2:** Sapele Deep sequence boundary and age

| Wells | Depth (m) | SB Age (ma) | Depositional Sequence |
|---|---|---|---|
| Sapele 01 | 3009 (9929.7 ft) | 5.60 | SEQ 8 |
| | 3042 (10038.6 ft) | 8.50 | SEQ 7 |
| | 3099.5 (10228.35) | 10.35 | SEQ 6 |
| | 3190.1 (10527.33 ft) | 10.80 | SEQ 5 |
| | 3320 (10956 ft) | 12.10 | SEQ 4 |
| | 3560.5 (11749.65 ft) | 13.10 | SEQ 3 |
| | 3699.8 (12209.34 ft) | 15.60 | SEQ 2 |
| | 3785 (12490.5 ft) | 17.50 | SEQ 1 |
| Sapele 06 | 3000 (9900 ft) | 5.60 | SEQ 8 |
| | 3070 (10131 ft) | 8.50 | SEQ 7 |
| | 3121 (10299.3 ft) | 10.35 | SEQ 6 |
| | 3159 (10424.7 ft) | 10.80 | SEQ 5 |
| | 3325 (10972.5 ft) | 12.10 | SEQ 4 |
| | 3486 (11503.8 ft) | 13.10 | SEQ 3 |
| | 3705 (12226.5 ft) | 15.60 | SEQ 2 |
| | 3742.5 (12350.25 ft) | 17.50 | SEQ 1 |
| Sapele 17 | 2988 (9860.4 ft) | 5.60 | SEQ 8 |
| | 3027 (9989.1 ft) | 8.50 | SEQ 7 |
| | 3069 (10127.7 ft) | 10.35 | SEQ 6 |
| | 3120 (10296 ft) | 10.80 | SEQ 5 |
| | 3159 (10424.7 ft) | 12.10 | SEQ 4 |
| | 3345 (11038.5 ft) | 13.10 | SEQ 3 |
| | 3460 (11418 ft) | 15.60 | SEQ 2 |
| | 3497 (11540.1 ft) | 17.50 | SEQ 1 |
| Sapele 18 | 3022 (99726 ft) | 5.60 | SEQ 8 |
| | 3088 (10190.4 ft) | 8.50 | SEQ 7 |
| | 3160 (10428 ft) | 10.35 | SEQ 6 |
| | 3190 (10527 ft) | 10.80 | SEQ 5 |
| | 3441 (11355.3 ft) | 12.10 | SEQ 4 |
| | 3474 (11464.2 ft) | 13.10 | SEQ 3 |
| | 3515 (11599.5 ft) | 15.60 | SEQ 2 |
| | 3540 (16682 ft) | 17.50 | SEQ 1 |
| | 2730 (9009 ft) | 5.60 | SEQ 8 |
| | 2816 (9292.8 ft) | 8.50 | SEQ 7 |
| | 3019 (9962.7 ft) | 10.35 | SEQ 6 |

| | | | |
|---|---|---|---|
| Sapele 19 | 3118 (10289.4 ft) | 10.80 | SEQ 5 |
| | 3190 (10527 ft) | 12.10 | SEQ 4 |
| | 3371 (11124.3 ft) | 13.10 | SEQ 3 |
| | 3460 (11418 ft) | 15.60 | SEQ 2 |
| | 3661 (12081.3 ft) | 17.50 | SEQ 1 |
| Sapele 27 | 3009 (9929.7 ft) | 5.60 | SEQ 8 |
| | 3040 (10032 ft) | 8.50 | SEQ 7 |
| | 3084 (10177.2 ft) | 10.35 | SEQ 6 |
| | 3107 (10253.1 ft) | 10.80 | SEQ 5 |
| | 3138 (10355.4 ft) | 12.10 | SEQ 4 |
| | 3172 (10467.6 ft) | 13.10 | SEQ 3 |
| | 3420 (11286 ft) | 15.60 | SEQ 2 |
| | 3453 (11394.9 ft) | 17.50 | SEQ 1 |

**Late Miocene**

According to the last downhole occurrences (LDO) of Globigerinoides extremus and Globorotalia lenguaensis, the upper limit of the late Miocene is set at 2065 m (6814.5 ft). The first downhole occurrence (FDO) of Neogloboquadrina acostensis and Globoturborotalita nepenthes, respectively, set the lower limit at 3175 m (10477.5 ft) (Table 3). Globorotalia plesiotumida, Paragloborotalia mayeri, and Cassigerinella chipolensis are other planktonic species that can be found in this area

## CONCLUSION

The age of rocks within the depositional basins of the study area ranges from early Miocene to late Miocene as established through the delineated maximum flooding surface and marker faunal of Me-2-Bolivina-48 (5.0Ma), Me-1-Haplophragmoides-24 (6.0Ma), Tor-2-Uvigerina-8 (9.5Ma), Tor-1-Nonion-4 (10.4Ma), Ser-3-Dodo Shale (11.5Ma), Ser-2-Cassidulina-7 (12.8Ma), Ser-1-Bolivina-25 (15.0Ma), Lang-1-Bur-5-Chiloguembelina-3 (15.9Ma) and Bur-3-Ogara Shale (19.4Ma). The identified lithology is primarily composed of sand and shale formations, with sporadic sand-shale intercalation, and the hydrocarbon in the studied area is trapped in fault closures of the aforementioned regional seal of transgressive marine (Figure 7). A strata package thickens from the northern to the southern part (basinward directions), as evidenced by the presence of the specified chronostratigraphic surfaces at varying depths along dip and strike directions in the wells. As a result, because sediment input is from the north, the sediments are thinner up-dip and thicker down-dip. One of the most productive hydrocarbon fields in the Niger Delta age and depositional pattern have been better-understood thanks to this study, which will help with the field's further classification.

## CONFLICT OF INTERESTS

All authors declare that they have no conflicts of interest

## ACKNOWLEDGMENT

The authors acknowledge SEPLAT ENERGY PLC for the data used for this study

**Table 3**: Identified datum markers for Sapele Deep

| Age | Zones | | | Datum Markers |
|---|---|---|---|---|
| | Blow (1969) | Berggren *et al.* (1995) | Wade *et al.* (2011) | |
| Late Miocene | N15-N17 | M12-M14 | M11-M14 | *Globorotalia plesiotumida, Globigerinoides extremus, Neogloboquadrina acostaensis and Globorotalia lenguaensis, Globoturborotalita nepenthes*@2065 m (6814.5 ft) to 3175 m (10477.5 ft) |
| Middle Miocene | N8-N14 | M5a-M11 | M5b-M10 | *Orbulina suturalis, Fohsella robusta, Fohsella fohsi, Fohsella peripheroacuta, Fohsella praefohsi and Praeorbulina glomerosa*@3115m (10279.5 ft) to 3620 m (11946 ft) |
| Early Miocene | N6-N7 | M3-M4 | M3-M5a | *Fohsella birnageae, Globigerinatella insueta, Praeorbulina sicana and Catapstdrax dissimilis*@3470 m (11451 ft) to 3810 m (12573 ft) |

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