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Age Evaluation of Sapele Shallow Field, Niger Delta, Southern Nigeria

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ABSTRACT

The study area is synonymous with poor reservoir performance which is evidenced after physical investigation was carried out by SEPLAT drilling and production team. Hence, wells are constantly serviced to burst production. This led to the evaluation of the subsurface geology of the study area using well logs, and biostratigraphy data, to acquire a better understanding of the geological age and depositional environment of the study area. Five Maximum Flooding Surfaces (MFS) were delineated and correlated across the field and very few marker faunas were present due to its proximity to the surface and they are of Late Miocene to Early Pleistocene age as established through the delineated regional seal of marine transgression. Also, six Sequence Boundaries (SB) were delineated and correlated across all wells in the study from oldest to youngest sequence. The oldest sequence boundary delineated was dated SB_4.1 ma. This surface represents a substantial erosional surface defined before the MFS_3.8 ma. Other sequence boundaries delineated are dated 3.7, 3.0, 2.4, 1.6 and 0.8 ma respectively. This corroborates with SPDC (2010) and the work of other researchers in the Niger-Delta oil field.

1. INTRODUCTION

Sapele Shallow as the name implies, is made up of shallow reservoirs with heavy oil as its hydrocarbon content. The field is in the Northwestern part of the Niger Delta, which has been actively producing for over 3 decades, and for the past few years has been experiencing production decline and sometimes failed wells. Thus, there is a need to approach the study area with an improved reservoir evaluation for a better understanding of the geologic age, depositional environment, and complexities of the field, to improve hydrocarbon recovery from existing oil and gas reservoirs of the study area (Mujakperuo and Airen, 2023).

Sapele shallow field is one of the fields in the Niger Delta Basin, located in the Northwestern Portion of the Delta. The Niger Delta Basin to date is the most prolific and economic sedimentary basin in Nigeria by virtue of the impact size of petroleum accumulations discovered and produced, as well as the spatial distribution of the petroleum resources to the onshore and continental shelf through Deepwater terrains (Godwin, 2016).

Classic integrated geological studies have shown that several different depobelts are abound in the Niger Delta basin.

Previous studies have shown that the Niger Delta Basin has spectacularly maintained a thick sedimentary apron and salient petroleum geological features favourable for petroleum generation, expulsion and trapping from the onshore through the continental shelf and to the deep-water terrains (Kalu, 2020). According to Weber and Daukoru (1975), Avbovbo (1978), the modern Niger Delta is made up of three subsurface stratigraphic units. The delta sequence is mainly a succession of marine clays (Akata Formation) overlain by paralic sediments (Agbada Formation) which were finally capped by continental sands (Benin Formation).

The source rocks for the petroleum accumulations in the Niger Delta has been a controversial subject. Some workers favour the shales of the Agbada Formation as the main source rock (Short and Stauble, 1967; Lambert-Aikionbare, 1982). Whereas others believe the main source to be the marine Akata Formation (Weber and Daukoru 1975; Ekweozor and Daukoru, 1984). Short and Stauble, (1967) and Frankl and Cordy, (1967) were the first to propose an origin from the Agbada Formation, but were challenged by Weber and Daukoru, (1975) and Ekweozor and Daukoru, (1984) who claimed that in most parts of the delta, the Agbada Formation is immature. They sought a source within the Akata shales, which they expected would be a better-quality source because there were deeper and more mature than the Agbada shales (Doust and Omatsola, 1990).

The main source rock in the Niger Delta is related to the position of the oil generative window (OGW) over time (Evamy *et al.,* 1978; Ejedawe, 1981). In the central part of the delta where the OGW is very deep, Akata shale is believed to be mainly gas generating, while Agbada shale is the main oil source. In the western delta, the OGW lies within the Agbada Formation, and it is the main oil source, whereas the underlying Akata shale is the main gas source. In the eastern delta, however, the Agbada Formation is relatively thin and the top of the OGW lies well within the Akata shales, which are the main source of hydrocarbons in this area. Bustin (1988), established that it is a mixture of type 2 kerogen (characterized by the relatively hydrogen-rich maceral exinite, e.g. spores and pollen of land plants, primarily marine phytoplankton cysts) and type 3 kerogen (contains sufficient hydrogen to be gas generative but not enough hydrogen to be oil prone), which generates light oil and gas respectively, Ejedawe *et al.,* (1984), suggested that thermal conditions rather than kerogen type is the main factor influencing oil and gas occurrence in the Niger Delta. Tissot *et al.,* (1987) also supported this conclusion.

In general, migration of generated hydrocarbon postdates the cessation of sedimentation and structural deformation. In some places, migration is very local and occurred from the paralic shales into the sands. Weber (1971), proposed that when the overpressure shales on the up thrown side of a fault are juxtaposed against hydrostatic pressured sands on the down thrown side, cross fault migration takes place due to pressure differential.

Allen (1964), Hospers (1971), Burke *et al.,* (1972) and Whiteman (1982), establish in detail, the history, evolution, and structural features of the Niger Delta. Stoneley (1966), examined the mega tectonic setting of the Niger Delta. The syn-sedimentary tectonics of the tertiary delta was extensively analyzed by Evamy *et al.,* (1978).

According to Lehner and De Ruiter (1977), the tectonic framework of the continental margin in the Niger Delta is controlled by Cretaceous fracture zones expressed as trenches and ridges in the deep Atlantic. The fracture zone ridges divide the margin into individual basins and in Nigeria, form the boundary faults of the Cretaceous Benue-Abakaliki trough, which cuts extreme into the West African shield. The trough represents a failed arm of a rift triple junction associated with the opening of the South Atlantic. In this region, rifting started in the Late Jurassic and persisted into the Middle Cretaceous. Asseez (1976), reviewed the stratigraphy, sedimentation, and structures of the Niger Delta. Merki (1972), described the structural geology of the Tertiary Niger Delta, which is on the overlap sequence that is deformed by syn-sedimentary faulting and folding. Ekweozor and Daukoru (1984, 1994), presented a detailed report on the petroleum geology and stratigraphy of the Niger Delta showing the relationship between depositional patterns, structures and stratigraphy and their influence on the oil generation in the Niger Delta basin.

Weber and Daukoru (1975), Doust and Omatsola (1990), Reijers *et al.,* (2011) ,Nton and Adebambo (2009), Nton and Adesina (2009), gave a detailed explanation on the tectonic, stratigraphy, depositional environment, petrophysics, sedimentology and hydrocarbon potential of the Niger Delta. The Niger Delta, on the passive western margin of Africa, has long been recognized as a classic example of continental-margin structural collapse under sediment loading (Khalivov and Kerimov, 1983; Morley, 1992).

2. MATERIALS AND METHODS

2.1. Study Area

Sapele shallow field is an onshore field of OML 41, located in the Northwestern part (Greater Ughelli depobelt) of the Niger Delta oil province (Figure 1). It lies within Latitude 5^0 53' 54.43" N and Longitude 5^0 33' 42.22" E. This study area was chosen due to its complex subsurface structure and poor reservoir production.

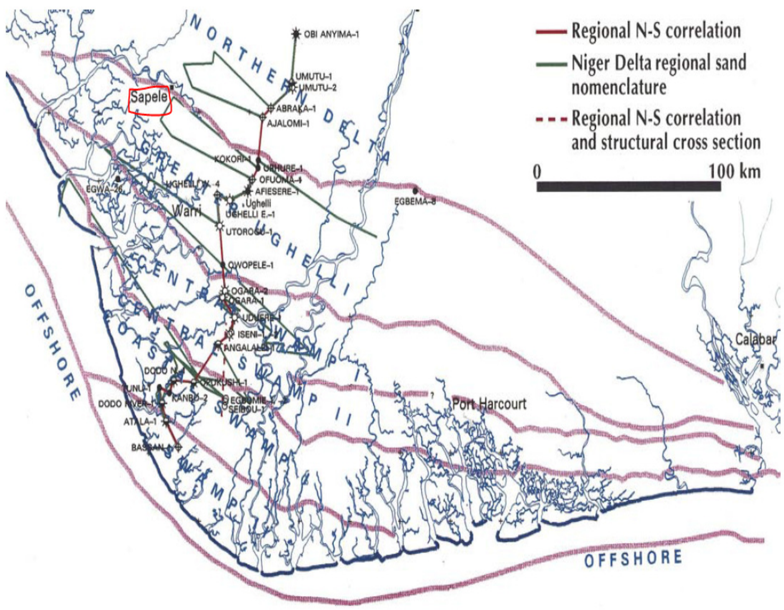

Figure 1: Location map of Niger Delta Depobelts showing the study area (Reijers *et al.,* 2011).

2.2. Data Collection

Well log data and biostratigraphic data from the study area were used in carrying out this research. These subsurface data belong to Seplat Petroleum Development Company Plcand were released under the approval of the Department of Petroleum Resources (DPR), Nigeria. The data were calibrated using the established zonation schemes contained in the SPDC, 2010 Niger Delta Chronostratigraphic Chart (Figure 1) and Cenozoic Chronostratigraphic Chart of Blow (1969), Berggren *et al* (1995 and Wade et al (2011), as shown in Figures 2 and 3 respectively. These surfaces were also correlated on well logs and mapped across the seismic volume respectively to determine their various age using the combined benthonic, planktonic, and palynomorph index species. Interpreted biostratigraphic data (palynological P-zone and foraminifera F-zones) and biofacies data comprising planktonic and benthic foraminifera abundance and diversity were used for delineating stratigraphic bounding surfaces. This information was calibrated, and depth matched with corresponding well logs. Well log suites were displayed at consistent scales to enhance log trends and aid lithofacies delineation and stacking pattern recognition.

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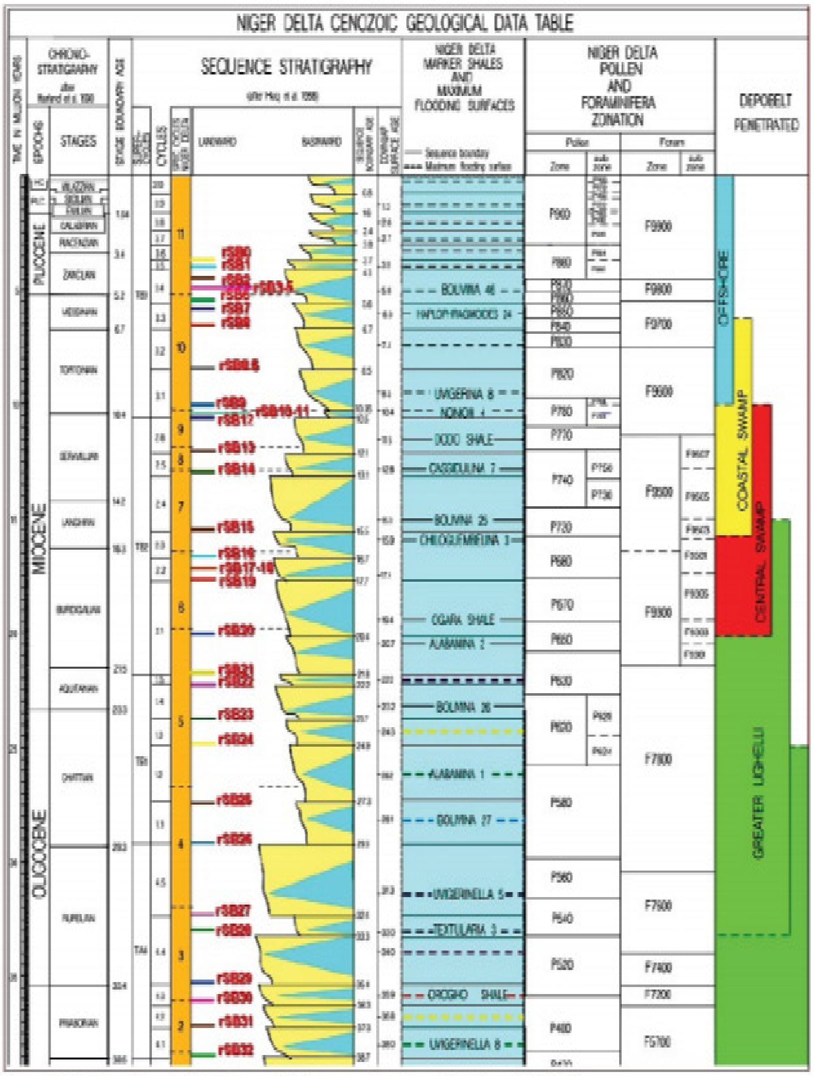

Figure 2: Niger Delta chronostratigraphic chart showing geologic interval (SPDC, 2010 Niger Delta Chronostratigraphic Chart)

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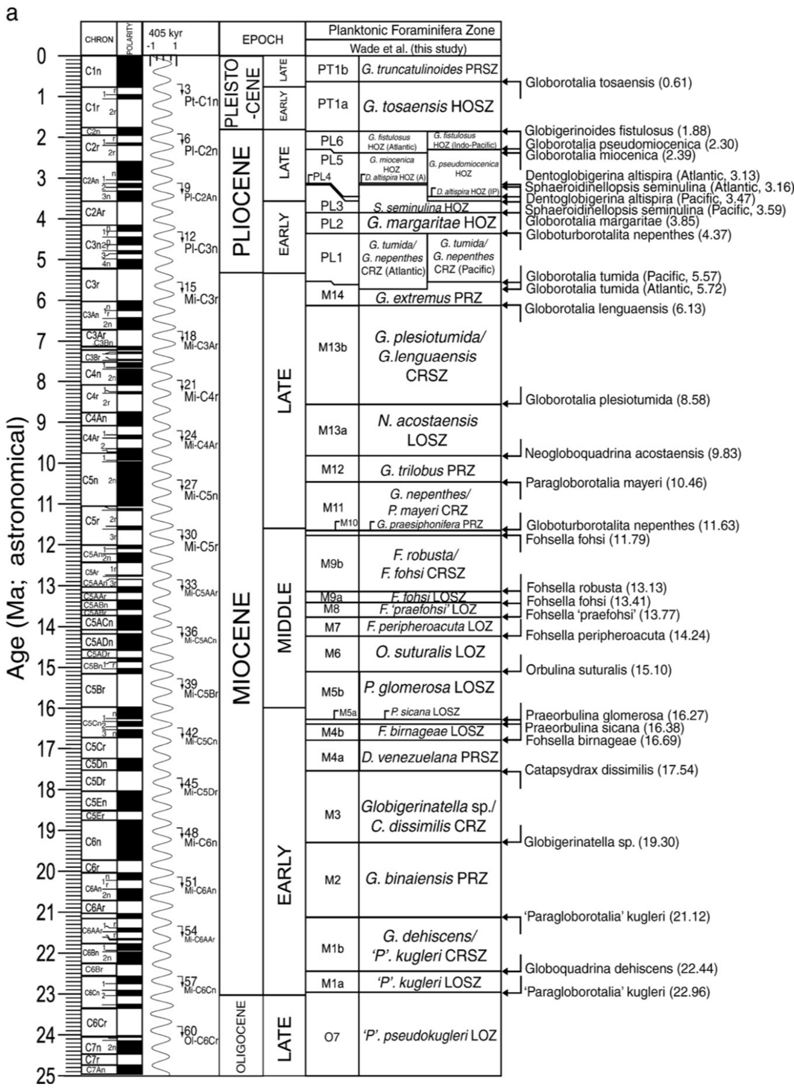

Figure 3: Planktonic foraminifera bioevents for neogene and late paleogene (Wade et al., 2011)

3. RESULTS AND DISCUSSION

3.1. Maximum Flooding Surface

From Figure 5, five (5) Maximum Flooding Surfaces (MFS) were delineated and correlated across Sapele Shallow field and very few markers fauna was present due to its proximity to the surface and they are of Pliocene to Pleistocene age which agrees with the findings of Okosun et al., (2012).

3.2. 3.8 ma Maximum Flooding Surface (MFS_3.8)

This was correlated across all wells (Sapele 21, Sapele 22, Sapele 29, Sapele 30, Sapele 31 and Sapele 32) in the Shallow field and was dated 3.8 ma using Za-1 regional marker. This surface occurred within P880 and F9900 biozones. The formation of this sequence ended with sea-level fall (regression) at 3.7 Ma, which marks the extinction of Globorotalia tumida of the early Pliocene.

3.3. 3.3 ma Maximum Flooding Surface (MFS_3.3)

This was correlated across all wells in the shallow field and was dated 3.3 using Za-2 regional marker. This MFS occurred within P880 and F9900 biozones. The formation of this sequence ended with sea-level fall (regression) at 3.0 Ma, which marks the extinction of Globorotalia margaritae of the middle Pliocene.

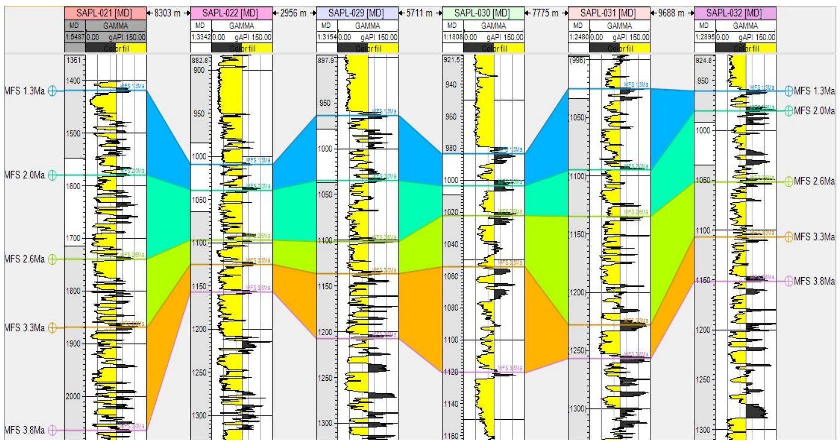

Figure 5: Sapele shallow maximum flooding surface age correlation panel

3.4. 2.6 ma Maximum Flooding Surface (MFS_2.6)

This was correlated across all wells in the shallow field and was dated 2.6 using Pia-1 regional marker. This MFS occurred within P900 and F9900 biozones. The formation of this sequence ended with sea-level fall (regression) at 2.4 Ma, which marks the extinction of Sphaeroidinellopsis seminulina of the late Pliocene.

3.5. 2.0 ma Maximum Flooding Surface (MFS_2.0)

This was correlated across all wells in the shallow field and was dated 2.0 using Pia-2 regional marker. This MFS occurred within P900 and F9900 biozones. The formation of this sequence ended with sea-level fall (regression) at 1.6 Ma, which marks the extinction of Globigerinoides fistulosus of the early Pleistocene.

3.6. 1.3 ma Maximum Flooding Surface (MFS_1.3)

This was correlated across all wells in the shallow field and was dated 1.3ma using Gel-1 regional marker. This MFS occurred within P900 and F9900 biozones. The formation of this sequence ended with sea-level fall (regression) at 0.8 Ma, which marks the extinction of Globorotalia tosaensis of the late early Pleistocene.

Table 1: Sapele shallow mfs, marker fauna and biozones

Period	Epoch	Wells	Age	Depth (M)	MFS age (ma)	MFS & Marker Fauna	Biozones P-zone	Biozones F-Zone
Quaternary	Pleistocene	Sapele 21	Gelasian	1420 (4686 ft)	1.3	Gel-1 (Marker Fauna Absent)	P900	F9900
Neogene	Pliocene		Piacenzian	1580 (5214 ft)	2.0	Pia-2 (Marker Fauna Absent)	P900	F9900
				1735 (5725.5 ft)	2.6	Pia-1 (Marker Fauna Absent)	P900	F9900
			Zanclean	1870 (6171 ft)	3.3	Zan-2 (Marker Fauna Absent)	P880	F9900
				2065 (6814.5)	3.8	Zan-1 (Marker Fauna Absent)	P880	F9900
Quaternary	Pleistocene	Sapele 22	Gelasian	1009 (3329.7 ft)	1.3	Gel-1 (Marker Fauna Absent)	P900	F9900
Neogene	Pliocene		Piacenzian	1045 (3448.5 ft)	2.0	Pia-2 (Marker Fauna Absent)	P900	F9900
				1090 (3597 ft)	2.6	Pia-1 (Marker Fauna Absent)	P900	F9900
			Zanclean	1125 (3712.5 ft)	3.3	Zan-2 (Marker Fauna Absent)	P880	F9900
				1157 (3818.1 ft)	3.8	Zan-1 (Marker Fauna Absent)	P880	F9900
Quaternary	Pleistocene	Sapele 29	Gelasian	960 (3168 ft)	1.3	Gel-1 (Marker Fauna Absent)	P900	F9900
Neogene	Pliocene		Piacenzian	1025 (3382.5 ft)	2.0	Pia-2 (Marker Fauna Absent)	P900	F9900
				1102 (3636.6 ft)	2.6	Pia-1 (Marker Fauna Absent)	P900	F9900
			Zanclean	1135 (3745.5 ft)	3.3	Zan-2 (Marker Fauna Absent)	P880	F9900
				1205 (3976.5 ft)	3.8	Zan-1 (Marker Fauna Absent)	P880	F9900
Quaternary	Pleistocene	Sapele 30	Gelasian	980 (3234 ft)	1.3	Gel-1 (Marker Fauna Absent)	P900	F9900
Neogene	Pliocene		Piacenzian	1000 (3300 ft)	2.0	Pia-2 (Marker Fauna Absent)	P900	F9900
				1020 (3366 ft)	2.6	Pia-1 (Marker Fauna Absent)	P900	F9900
			Zanclean	1055 (3481.5 ft)	3.3	Zan-2 (Marker Fauna Absent)	P880	F9900
				1120 (3696 ft)	3.8	Zan-1 (Marker Fauna Absent)	P880	F9900
Quaternary	Pleistocene	Sapele 31	Gelasian	1015 (3349.5 ft)	1.3	Gel-1 (Marker Fauna Absent)	P900	F9900
Neogene	Pliocene		Piacenzian	1092 (3603.6 ft)	2.0	Pia-2 (Marker Fauna Absent)	P900	F9900
				1138 (3755.4 ft)	2.6	Pia-1 (Marker Fauna Absent)	P900	F9900
			Zanclean	1225 (4042.5 ft)	3.3	Zan-2 (Marker Fauna Absent)	P880	F9900
				1255 (4141.5 ft)	3.8	Zan-1 (Marker Fauna Absent)	P880	F9900
Quaternary	Pleistocene	Sapele 32	Gelasian	960 (3168 ft)	1.3	Gel-1 (Marker Fauna Absent)	P900	F9900
Neogene	Pliocene		Piacenzian	977 (3224.1 ft)	2.0	Pia-2 (Marker Fauna Absent)	P900	F9900
				1020 (3366 ft)	2.6	Pia-1 (Marker Fauna Absent)	P900	F9900
			Zanclean	1110 (3663 ft)	3.3	Zan-2 (Marker Fauna Absent)	P880	F9900
				1148 (3788.4 ft)	3.8	Zan-1 (Marker Fauna Absent)	P880	F9900

3.7. Sequence Boundary

Six sequence boundaries were delineated and correlated across all wells in the study area from oldest to youngest sequence (Figure 6). The oldest sequence boundary delineated was dated SB_4.1 ma. This surface represents a substantial erosional surface defined before the MFS_3.8 ma. Other sequence boundaries delineated are dated 3.7, 3.0, 2.4, 1.6 and 0.8 ma respectively (Table I).

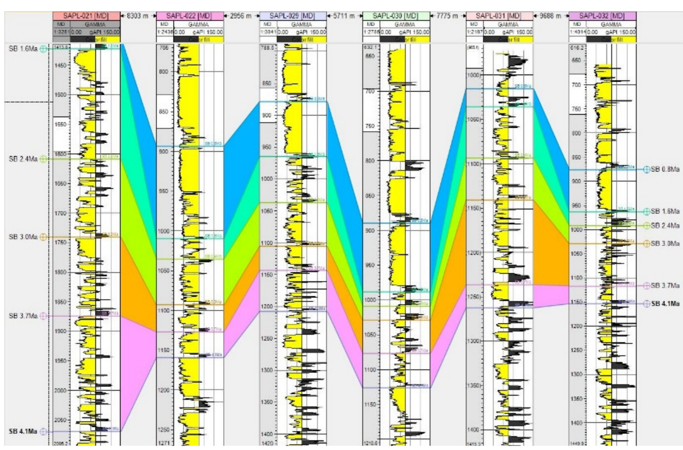

Figure 6: Sapele shallow sequence boundary age correlation panel

3.8. Depositional Sequence

Six (6) depositional sequence delineated from oldest to youngest in Sapele shallow are of Littoral to Outer Neritic age (Table 2). These sequences are detailed below:

3.8.1. Sequence nine (SEQ 9)

This mark the first depositional sequence of the shallow field which has an average thickness of 30 m (100.7 ft) thick and is bounded top by 3.8 Ma maximum flooding surface. The Lowstand System Tract (LST) sands are interpreted as middle shoreface sands deposited in the continental shelf region during sea level fall. The Transgressive System Tract (TST) unit of this sequence is capped by the 3.8 ma MFS marker (Za-1). This Sequence was deposited in the Middle-Outer Neritic (MN-ON) setting and its stacking patterns is progradational.

3.8.2. Sequence ten (SEQ 10)

This mark the second depositional sequence of the shallow field which has an average thickness of 57.9 m (191.1 ft) thick and is bounded top and bottom by 3.3 Ma and 3.8 Ma maximum flooding surface. The Lowstand System Tract (LST) sands are interpreted as middle shoreface sands deposited in the continental shelf region during sea level fall. The Transgressive System Tract (TST) unit of this sequence is capped by the 3.3 Ma MFS marker (Za-2). This Sequence was deposited in the Middle-Outer Neritic (MN-ON) setting and its stacking patterns is progradational.

3.8.3. Sequence eleven (SEQ 11)

This sequence has an average thickness of 60.5 m (199.7 ft) thick and is bounded top and bottom by 2.6 Ma and 3.3 Ma maximum flooding surface. The Lowstand System Tract (LST) sand is interpreted as middle shoreface sands deposited in the continental shelf region during sea level fall. The Transgressive System Tract (TST) unit of this sequence is capped by the 2.6 Ma MFS marker (Pia-1). This Sequence was deposited in the Middle-Outer Neritic (MN-ON) setting and its stacking patterns is progradational.

3.8.4. Sequence twelve (SEQ 12)

This sequence has an average thickness of 44.3 m (146.3 ft) thick and is bounded top and bottom by 2.0 Ma and 2.6 Ma maximum flooding surface respectively. The Lowstand System Tract (LST) sands are interpreted as upper shoreface sand deposited in the continental shelf region during sea level fall. The Transgressive System Tract (TST) unit of this sequence is capped by the 2.0 Ma MFS marker (Pia-2). This Sequence was deposited in the Inner Neritic to Middle Neritic (IN-MN) setting and its stacking patterns is progradational.

3.8.5. Sequence thirteen (SEQ 13)

This sequence has an average thickness of 42.9 m (141.6 ft) thick and is bounded top and bottom by 1.3 Ma and 2.0 Ma maximum flooding surface, respectively. The Lowstand System Tract (LST) sands are interpreted as upper shoreface sand deposited in the continental shelf region during sea level fall. The Transgressive System Tract (TST) unit of this sequence is capped by the 1.3 Ma MFS marker (Gel-1-Absent Fauna). This Sequence was deposited in the Littoral to Inner Neritic (LI-IN) setting and its stacking patterns is progradational.

3.8.6. Sequence fourteen (SEQ 14)

This sequence has an average thickness of 51.4 m (169.7 ft) thick from the point it was captured on the log, but it extends above that point and is bounded bottom by 1.3 Ma maximum flooding surface, the MFS bounding the top could not be seen or determined. The Lowstand System Tract (LST) sand is interpreted as upper shoreface sand, deposited in the continental plain region during sea level fall. The MFS that caps the Transgressive System Tract (TST) unit of this sequence could not be determined (not captured on the well log). This Sequence was deposited in the Littoral to Inner Neritic (LI-IN) setting and its stacking patterns is progradational. The well logs signature reveals that all sequences in Sapele shallow field exhibits progradational stacking pattern (Even Block Shape) which implies that the rate of sediment deposition is greater than the rate of sediment accommodation. This agrees with Emery and Myers (1996) and Van-Wagoner *et al* (1990).

Table 2: Sapele shallow delineated sequence boundary and age

Wells	Depth (m)	SB Age (ma)	Depositional Sequences
Sapele 21	1400 (4620 ft)	0.8	SEQ 14
	1425 (4702.5 ft)	1.6	SEQ 13
	1590 (5247 ft)	2.4	SEQ 12
	1743 (5751.9 ft)	3.0	SEQ 11
	1875 (6187.5 ft)	3.7	SEQ 10
	2070 (6831 ft)	4.1	SEQ 9
Sapele 22	910 (3003 ft)	0.8	SEQ 14
	1010 (3333 ft)	1.6	SEQ 13
	1050 (3465 ft)	2.4	SEQ 12
	1092 (3603.6 ft)	3.0	SEQ 11
	1130 (3729ft	3.7	SEQ 10
	1160 (3828 ft)	4.1	SEQ 9
Sapele 29	895 (2953.5 ft)	0.8	SEQ 14
	967 (3191.1 ft)	1.6	SEQ 13
	1038 (3425.4 ft)	2.4	SEQ 12
	1105 (3646.5 ft)	3.0	SEQ 11
	1145 (3778.5 ft)	3.7	SEQ 10
	1207 (3983.1 ft)	4.1	SEQ 9
Sapele 30	933 (3078.9 ft)	0.8	SEQ 14
	990 (3267 ft)	1.6	SEQ 13
	1007 (3323.1 ft)	2.4	SEQ 12
	1027 (3389.1 ft)	3.0	SEQ 11
	1078 (3557.4 ft)	3.7	SEQ 10
	1125 (3712.5 ft)	4.1	SEQ 9
Sapele 31	1009.5 (3331.4 ft)	0.8	SEQ 14
	1025 (3382.5 ft)	1.6	SEQ 13
	1095 (3613.5 ft)	2.4	SEQ 12
	1148 (3788.4 ft)	3.0	SEQ 11
	1237 (4082.1 ft)	3.7	SEQ 10
	1260 (4158 ft)	4.1	SEQ 9
Sapele 32	895.8 (2956.14 ft)	0.8	SEQ 14
	963 (3177.9 ft)	1.6	SEQ 13
	994 (3280.2 ft)	2.4	SEQ 12
	1025 (3382.5 ft)	3.0	SEQ 11
	1113 (3672.9 ft)	3.7	SEQ 10
	1155 (3811.5 ft)	4.1	SEQ 9

3.9. Identified Datum Markers

3.9.1. Late miocene

The upper limit of the late Miocene is marked at 2065 m (6814.5 ft) based on the last down hole occurrence (LDO) of both Globigerinoides extremus and Globorotalia lenguaensis. The lower limit, however, is marked at 3175 m (10477.5 ft) based on the first down hole occurrence (FDO) of both Globoturborotalita nepenthes and Neogloboquadrina acostaensis (Table 3). Other planktonic forms present here are Paragloborotalia mayeri, Globorotalia plesiotumida and Cassigerinella chipolensis. This age cut across both sapele deep and sapele shallow.

3.9.2. Early pliocene

The upper limit of the early Pliocene is marked at 1055 m (3481.5 ft) based on the last down hole occurrence (LDO) of Globorotalia margaritae. The lower limit, however, is marked at 1225 m (4042.5 ft) based on the first down hole occurrence (FDO) of both Globorotalia tumida and Globorotalia cibaoensis. Other planktonic forms present here are Globoturborotalita nepenthes and Sphaeroidinella dehiscens.

3.9.3. Late pliocene

The upper limit of the late Pliocene is marked at 977 m (3224.1 ft) based on the last down hole occurrence (LDO) of Dentoglobigerina altispira. The lower limit, however, is marked at 1138 m (3755.4 ft) based on the First Downhole Occurrence (FDO) of Sphaeroidinellopsis seminulina. Other planktonic forms present are Globorotalia miocenica and Globorotalia pseudomiocenica.

3.9.4. Pleistocene

The upper limit of the late Pliocene is marked at 960 m (3168 ft) based on the Last Downhole Occurrence (LDO) of Globorotalia tosaensis. The lower limit, however, is marked at 1138 m (3755.4 ft) based on the First Downhole Occurrence (FDO) of Globigerinoides fistulosus (TableIII). Other planktonic forms present are Globorotalia miocenica and Globoturborotalita aperture.

Table 3: Identified datum markers for sapele shallow

Age	Blow (1969)	Zones Berggren et al., (1995)	Wade et al., (2011)	Datum Markers
Early pleistocene	N21	PT1a	PT1a	Globorotalia tosaensis, Globoturborotalita aperture and Globigerinoides fistulosus@ 960 m (3168 ft) to 1138 m (3755.4 ft)
Late pliocene	N20	PL3-PL6	PL3b-PL6	Globorotalia pseudomiocenica, Globorotalia miocenica, Dentoglobigerina altispira and Sphaeroidinellopsis seminulina@ 977 m (3224.1 ft) to 1138 m (3755.4 ft)
Early pliocene	N18-N19	PL1a-PL2	PL1-PL3a	Globorotalia margaritae, Globoturborotalita nepenthes, Globorotalia tumida, Sphaeroidinella dehiscens and Globorotalia cibaoensis@ 1055 m (3481.5 ft) to 1225 m (4042.5 ft)
Late miocene	N15-N17	M12-M14	M11-M14	Globorotalia plesiotumida, Globigerinoides extremus, Neogloboquadrina acostaensis and Globorotalia lenguaensis@ 2065 m (6814.5 ft) to 3175 m (10477.5 ft)

4. CONCLUSION

Based on the lithologic and foraminiferal analysis, this study has established that the well interval for Sapele shallow penetrated the late Agbada to early Benin formation with deposition occurring during late Miocene to early Pleistocene for Sapele shallow. Four datum markers were identified, and they range from N21 to N15-N17 of Blow, (1969), PT1a to M12-M12 of Berggren *et al.,* (1995) and PT1a to M11-M14 of Wade et al., (2011). The hydrocarbon in the study area are trapped in fault closures below regional seal of the transgressive marine Gel-1, Pia-2, Pia-1, Zan-2 and Zan-1 which ranges in age from 1.3ma to 3.8ma. The geological age of the study area ranges from Late Miocene to Early Pleistocene. For the first time to the best of our knowledge, the presence of non-sealing shale in Sapele shallow has been attributed to the depletion in hydrocarbon recovery and the presence of hydrocarbon seepage found in hand-dug wells and roadside of the study area.

5. ACKNOWLEDGEMENT

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6. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

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