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Hydrocarbon Movability Study Of Sapele Deep Field, Niger Delta, Southern Nigeria

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Abstract

Sapele Deep field is an onshore field of OML 41, located in the North-western part (Greater Ughelli depobelt) of the Niger Delta oil province, and it is one of the most prolific fields in the Niger Delta. Well logs from six wells were integrated to study the hydrocarbon movability potential of the field. The hydrocarbon movability potential of the field was delineated by looking at the various hydrocarbon movability factors such as the flushed zone, movable oil saturation, residual oil saturation and hydrocarbon movability index. The study area on an average has flushed zone water saturation (S_{xo}) *of 0.84, hydrocarbon saturation of 0.55, movable hydrocarbon saturation of 0.39, residual hydrocarbon saturation of 0.19 and movable hydrocarbon index of 0.51.*

Keywords: Flushed zone, Movable oil saturation, Movable hydrocarbon index, Residual oil saturation, Hydrocarbon movability index.

INTRODUCTION

The integration of multidisciplinary teams of geologists, geophysicists, petrophysicists, and petroleum engineers working together has changed our perception of the characteristics of oil and gas reservoirs. Whereas it used to be commonly perceived that oil and gas reservoirs were relatively simple geologic features, the reality is that they are quite complex, and they can be subdivided into architectural elements or compartments on the basis of several structural and stratigraphic features (Mujakperuo and Airen, 2023).

The importance of hydrocarbon movability study of a reservoir cannot be over emphasized due to the fact that only a fraction of oil in place is ultimately produced in most reservoirs. This poses a challenge to attain better recovery, requiring a better understanding of reservoir behavior. This necessitates the estimation of movable oil saturation which represents the maximum volume of oil that can be moved or produced ultimately from a reservoir (Airen and Mujakperuo, 2023a).

During the displacing process of the crude oil system from the porous media by water or gas injection (or encroachment) there will be some remaining oil left that is quantitatively characterized by a saturation value that is larger than the critical oil saturation (Airen and Mujakperuo, 2023b). This saturation value is called the residual oil saturation, ROS. The term residual saturation is usually associated with the non-wetting phase when it is being displaced

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by a wetting phase. Composite well log data (Gamma Ray, Resistivity, Density and Neutron Logs) were used for the petrophysical evaluation of the reservoirs. Table 1 shows all formulas used in calculating the petrophysical parameters.

Table 1. Formulae Algorithms used for Evaluation of hydrocarbon movability of Sapele Deep.

S/N	Formula	Petrophysical parameters	Author(s)
1	$V_{sh} = 0.083 \times (2^{3.7 \times I_{GR}} - 1)$	**Shale Volume**: Reservoirs are mostly associated with shale content and from the gamma ray logs, shale volume can be determined from gamma ray index due to the high radioactive material that exist in shale. Gamma-ray log reading will increase as the shale content in the formation increases compared to other formation like carbonate or sandstone.	(Larionov, 1969).
2	$\Phi = \frac{\rho_{ma} - \rho_b}{\rho_{ma} - \rho_f}$	**Porosity:** Percentage of pore volume or void space, or that volume within rock that can contain fluids, is porosity. Porosity values will differ based on the type of formations, grain orientations and other factors.	(Owolabi *et al.,* 1994).
3	Sw = $\frac{0.082}{\Phi\_Den}$	**Water Saturation**: This is the percentage or ratio of water present in a reservoir rock.	(Owolabi *et al.,* 1994).
4	$F = \Phi_D \frac{0.62}{2.15}$	**Formation Factor:** The ratio of the resistivity of a rock filled with water (Ro) to the resistivity of that water (Rw).	(Owolabi *et al.,* 1994).
5	$S_{wirr} = \sqrt{\frac{F}{200}}$	**Irreducible Water Saturation:** Irreducible water saturation (critical water saturation) defines the maximum water saturation that a formation with a given permeability and porosity can retain without producing water.	(Owolabi *et al.,* 1994).
6	$K = 307 + 26552\ \Phi^2 - 3450(\Phi S_{wirr})^2$	**Permeability:** In addition to being porous, a reservoir rock must have the ability to allow petroleum fluids to flow through its interconnected pores. The rock's ability to conduct fluids is termed permeability.	(Owolabi *et al.,* 1994).
7	$S_h = (1 - S_w)$	**Hydrocarbon Saturation**: This is the percentage or ratio of hydrocarbon present in a reservoir rock.	(Owolabi *et al.,* 1994).
8	NTG = $\frac{\sum Net\ Sand\ thickness}{Gross\ Sand\ thickness}$	**Net-to-Gross Ratio**: This is a measure of the thickness of the productive (Net) reservoir sands within the total (Gross) reservoir thickness.	(Owolabi *et al.,* 1994).

MATERIALS AND METHODS.

The materials used while carrying out this research work are a suit of subsurface data which includes 3D seismic cube and well logs data provided across the field. These subsurface data belong to Seplat Petroleum Development Company PLC and was released under the approval of the Department of Petroleum Resources (DPR). Petrel®2016 (Schlumberger software) was used in the interpretation of seismic and well log data.
The following data were used to analyze the field:

- ♦ 3D Seismic data
- ♦ Checkshot survey data
- ♦ Well deviation survey data
- ♦ Digital wireline log data
- ♦ Formation tops files

The field is fully covered by a good 3D Seismic data, though the resolution of the data is poor at the deeper levels (beyond 2 seconds). The 3D seismic data is a high-resolution Post-Stack Time Migration in SEG-Y format. The base map covers approximate area of 8.37 sqkm with in-lines range of 6414-6813 and crosslines range of 3210-3609.

Checkshot velocity data was used in establishing Seismic to well tie during horizon interpretation. The deviation survey data from the wells were all available for the study. This usually indicates if a well is vertical or slanty.

Tops and bases of the reservoir exist in all the wells files. These data were used as a guide when picking the tops and bases of the Reservoir.

Log data were available for all the wells used in this study, the data is generally of good quality and were drilled with water-based mud. The log types used for quantitative analysis in this study are the gamma ray, resistivity, sonic, density and neutron logs.
The various log types used for the subsurface evaluation are listed as:

1. Gamma ray log
2. Resistivity log
3. Neutron log
4. Density log
5. Sonic log

RESULTS AND DISCUSSION

Well 01 Analysis

As specified in figure 1, well 01 penetrated three reservoirs (B, C and D) out of the thirteen reservoirs present in the field.

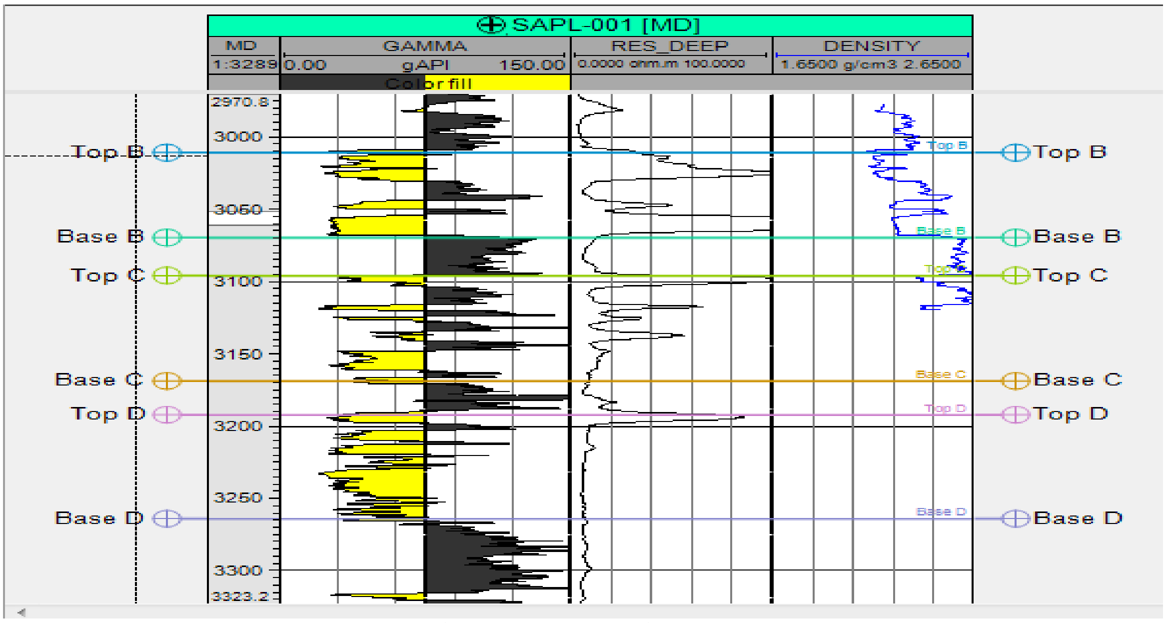

Figure 1: Well Log Signature of Well 01 (Using Petrel®2016).

Hydrocarbon Movability Analysis of well 01 Reservoirs
The petrophysical properties as indicated in Table 2 were used for computation.

Table 2: Petrophysical Summary of Well 01

Reservoirs	*Gross Thickness (m)*	V_{sh}	*Net Sand (m)*	Φ	$Eff\Phi$	$K(mD)$	F	NTG	S_{wirr}
B	56.55	0.10	13.34	0.24	0.22	1703.45	25.98	0.71	0.11
C	70.91	0.20	5.92	0.18	0.10	1168.22	43.80	0.33	0.15
D	71.80	0.10	4.45	0.20	0.20	1504.20	42.50	0.31	0.15
			Average						
	66.42	**0.14**	**7.90**	**0.21**	**0.18**	**1458.60**	**37.43**	**0.50**	**0.14**

(i) Water Saturation of Flushed Zone (S_{xo})

$S_{XO} = S_W^{0.2}$

Reservoir B: S_{XO}= 0.12$^{0.2}$ = 0.65
Reservoir C: S_{XO} = 0.30$^{0.2}$ = 0.79
Reservoir D: S_{XO} = 0.73$^{0.2}$ = 0.94

(ii) Movable Hydrocarbon Saturation (MHS)

MHS = S_{XO} - S_W

Reservoir B: MHS = 0.65 – 0.12 = 0.53 (53 % movable HC)
Reservoir C: MHS = 0.79 – 0.30 = 0.49 (49 % movable HC)
Reservoir D: MHS = 0.94 – 0.73 = 0.21 (21 % movable HC)

(iii) Residual Hydrocarbon Saturation (RHS)

RHS = S_h– MHS

Reservoir B: RHS = 0.88 – 0.53 = 0.35 (35 % unmovable HC)
Reservoir C: RHS = 0.70 – 0.49 = 0.21 (21 % unmovable HC)
Reservoir D: RHS = 0.27 – 0.21 = 0.06 (0.6 % unmovable HC)

(iv) Hydrocarbon Movability Index (HMI)

$$\text{HMI} = \frac{\text{Sw}}{\text{Sxo}}$$

Reservoir B: HMI = $\frac{0.12}{0.65}$ = 0.18 (Movable Hydrocarbon)
Reservoir C: HMI = $\frac{0.30}{0.79}$ = 0.38 (Movable Hydrocarbon)
Reservoir D: HMI = $\frac{0.73}{0.94}$ = 0.70 (Movable Hydrocarbon).

On average, well 01 reservoirs have flushed zone saturation of 0.79 (79%), movable hydrocarbon saturation of 0.41 (41%), residual hydrocarbon saturation of 0.21 (21%) and hydrocarbon movability index of 0.42 which indicates that hydrocarbon will move out of reservoirs to well surface during production. Therefore, well 01 is a prolific well with high hydrocarbon recoverability.

Table 3: Hydrocarbon Movability Summary of Well 01

Reservoirs	S_{xo}	S_h	*MHS*	*RHS*	*HMI*
B	0.65	0.88	0.53	0.35	0.18
C	0.79	0.70	0.49	0.21	0.38
D	0.94	0.27	0.21	0.06	0.70
		Average			
	0.79	**0.62**	**0.41**	**0.21**	**0.42**

Well 06 Analysis
Well 06 penetrated seven reservoirs (B, C, D, E, F, G and H) out of the thirteen reservoir sands present in the field (Figures 2a and 2b).

(a)

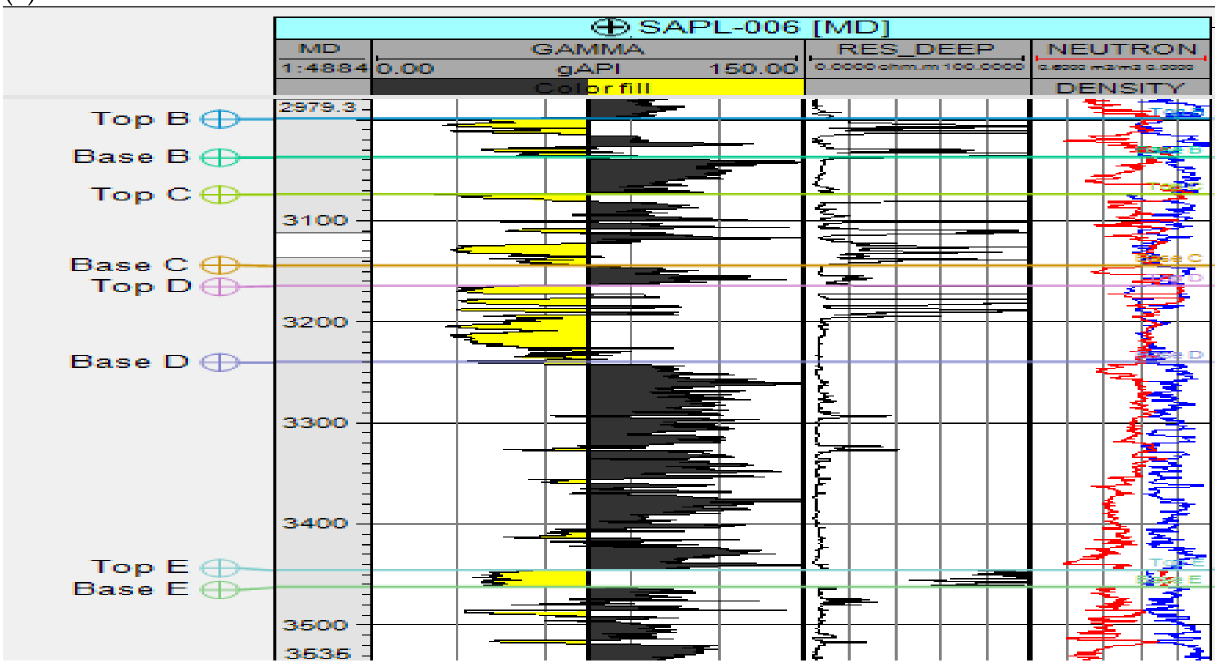

Figure 2a: Well log signature of well 06 from 2979.3 m to 3535 m (Using Petrel®2016).

(b)

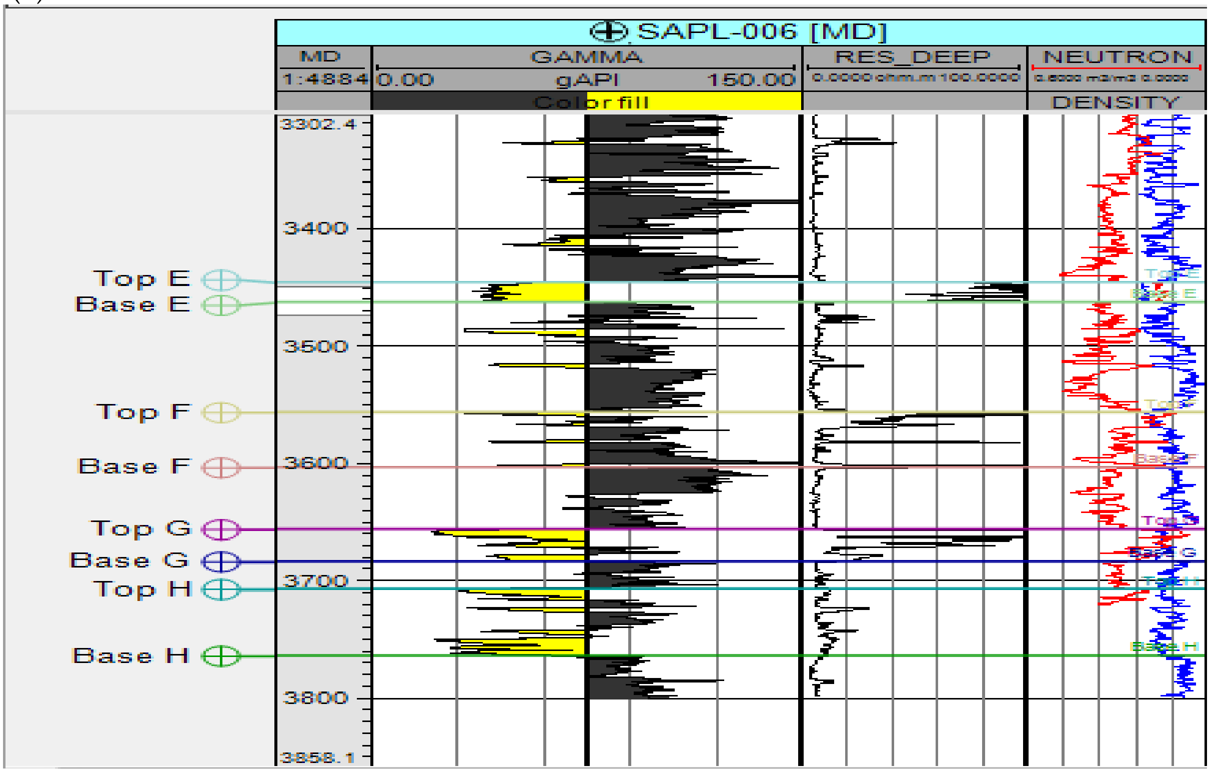

Figure 2b: Well log signature of well 06 from 3302.4 m to 3800 m (Using Petrel®2016).

Hydrocarbon Movability Analysis of well 06 Reservoirs

The petrophysical properties as indicated in Table 4 were used for computation.

Table 4: Petrophysical Summary of Well 06

Reservoir	*Gross Thickness (m)*	V_{sh}	*Net Sand (m)*	Φ	$Eff\Phi$	$K(mD)$	F	NTG	S_{wirr}
B	37.32	0.110	9.250	0.22	0.20	1605.60	18.47	0.50	0.10
C	70.67	0.080	5.3460	0.24	0.22	1836.27	14.76	0.38	0.09
D	75.43	0.270	5.520	0.23	0.18	1720.13	21.98	0.44	0.10
E	18.00	0.060	16.060	0.22	0.20	1552.00	17.26	0.89	0.09
F	47.65	0.200	1.630	0.19	0.16	1305.26	21.79	0.17	0.10
G	28.00	0.065	8.790	0.17	0.16	1038.15	30.16	0.63	0.12
H	55.24	0.250	2.000	0.15	0.12	856.22	46.82	0.07	0.15
			Average						
	47.47	**0.150**	**6.940**	**0.20**	**0.18**	**1416.233**	**24.46**	**0.44**	**0.11**

The statistics displayed in table 4, indicates that well 06 reservoirs on average, have a flushed zone saturation of 0.85 (85%), hydrocarbon saturation of 0.53 (53%), movable hydrocarbon saturation of 0.38 (38%), residual hydrocarbon saturation of 0.15 (15%) and hydrocarbon movability index of 0.54 which indicates that hydrocarbon will move out of reservoirs to well surface during production. Hence, well 06 is a productive well with soaring hydrocarbon recoverability.

Table 5: Hydrocarbon Movability Summary of Well 06

Reservoirs	S_{xo}	S_{xo}	*MHS*	*RHS*	*HMI*
B	0.84	0.59	0.41	0.18	0.51
C	0.82	0.64	0.46	0.18	0.44
D	0.88	0.46	0.34	0.12	0.61
E	0.79	0.7	0.49	0.21	0.38
F	0.82	0.63	0.45	0.18	0.45
G	0.84	0.59	0.43	0.16	0.49
H	0.97	0.12	0.09	0.03	0.91
Average					
	0.85	**0.53**	**0.38**	**0.15**	**0.54**

Well 17 Analysis

This well intercepted eight reservoirs (B, C, D, E, F, G, H, and I) out of the thirteen reservoirs present in the field (Figures 6a and b) and ranges in depth from 2967.2 (9791.76) m to 3630 m (11979 ft). Well 17 is made up of three single phase gas reservoirs, three single phase oil reservoir and two double phase reservoirs (Gas/Oil).

(a)

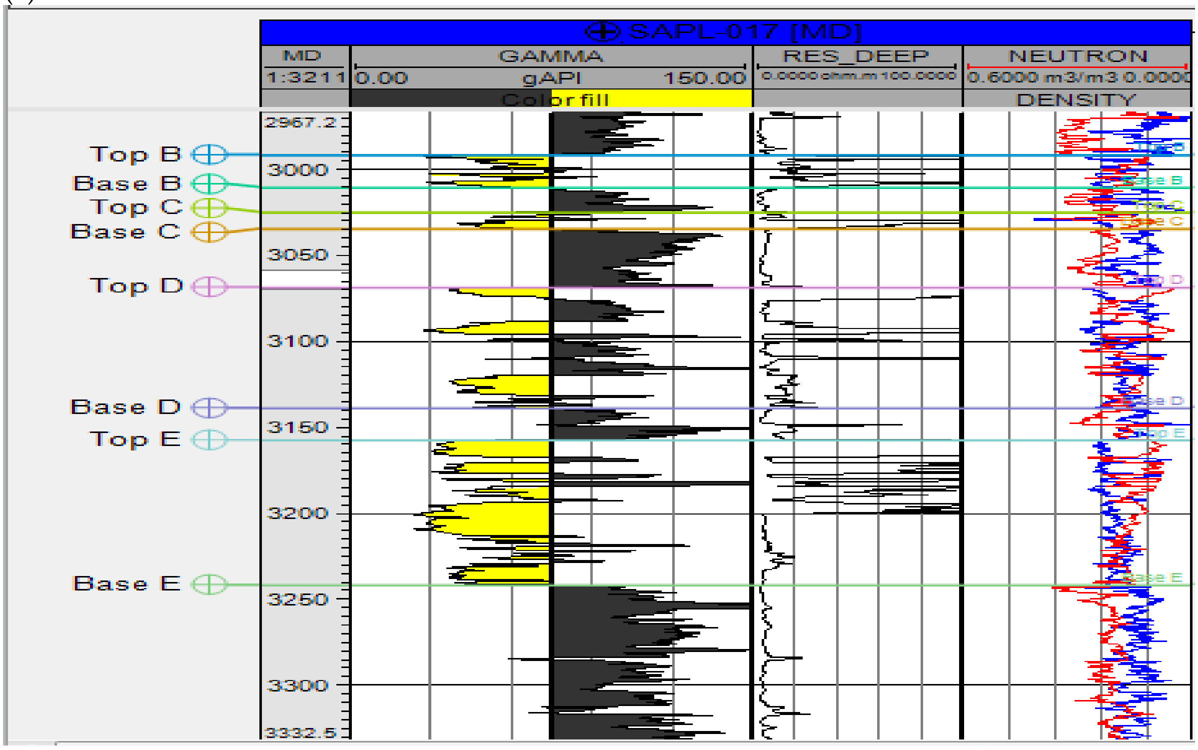

Figure 3a: Well log signature of well 17 from 2967.2 m to 3332.5 m (Using Petrel®2016).

(b)

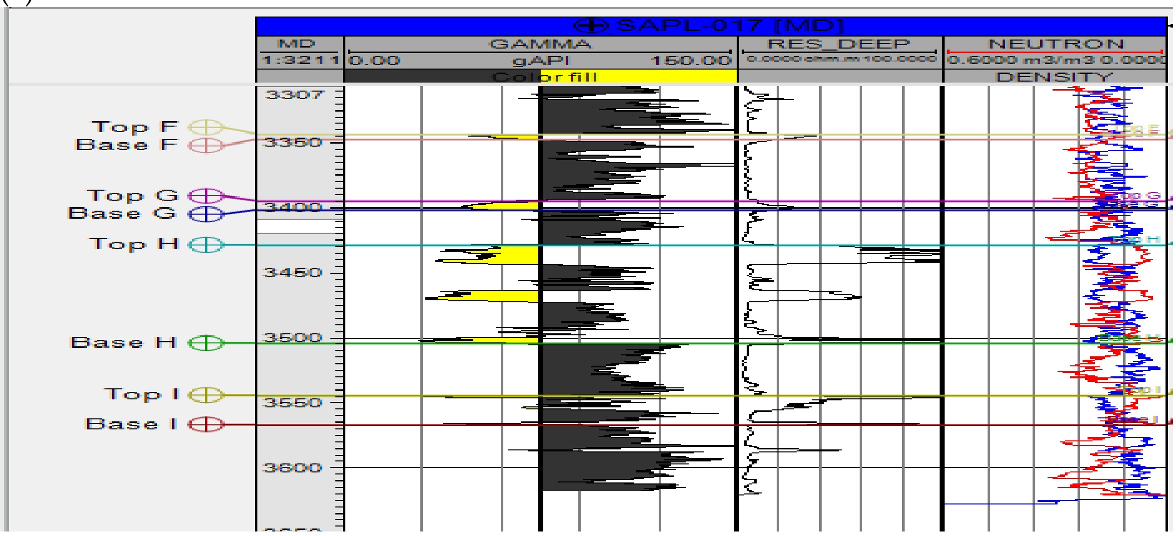

Figure 3b: Well log signature of well 17 from 3307 m to 3630 m (Using Petrel®2016).

Hydrocarbon Movability Analysis of well 17 Reservoirs

The petrophysical properties as indicated in Table 6 were used for computation.

Table 6: Petrophysical Summary of Well 17.

Reservoir	*Gross Thickness(m)*	V_{sh}	*Net Sand(m)*	Φ	$Eff\Phi$	$K(mD)$	F	NTG	S_{wirr}	S_w	S_h
B	18.99	0.15	13.39	0.20	0.18	1393.54	31.86	0.71	0.13	0.53	0.47
C	9.50	0.20	6.32	0.24	0.19	1866.85	15.52	0.67	0.09	0.59	0.41
D	70.67	0.12	4.96	0.23	0.21	1740.15	16.29	0.35	0.09	0.42	0.58
E	83.68	0.08	7.44	0.24	0.22	1796.77	14.92	0.36	0.09	0.31	0.69
F	3.86	0.14	2.99	0.19	0.17	1313.13	21.94	0.77	0.10	0.51	0.49
G	5.99	0.11	5.58	0.19	0.17	1219.23	24.15	0.93	0.11	0.68	0.32
H	75.46	0.11	8.90	0.19	0.18	1309.58	22.69	0.35	0.11	0.43	0.57
I	22.23	0.13	1.32	0.18	0.16	1196.42	26.90	0.12	0.11	0.31	0.69
				Average							
	36.30	0.13	6.36	0.21	0.19	1479.46	21.78	0.53	0.10	0.47	0.53

The data presented in Table 7, signifies that well 17 reservoirs on average, have a flushed zone saturation of 0.86 (86%), hydrocarbon saturation of 0.53 (53%), movable hydrocarbon saturation of 0.38 (38%), residual hydrocarbon saturation of 0.15 (15%) and hydrocarbon movability index of 0.54 which indicates that hydrocarbon will move out of reservoirs to well head during production. This conclusion corresponds with Hamada (2006), hence well 17 is a prolific well with spiraling hydrocarbon retrieval.

Table 7: Hydrocarbon Movability Summary of Well 17 Reservoirs

Reservoirs	S_{xo}	S_h	MHS	RHS	HMI
B	0.88	0.47	0.35	0.12	0.60
C	0.9	0.41	0.31	0.10	0.65
D	0.84	0.58	0.42	0.16	0.50
E	0.79	0.69	0.48	0.21	0.39
F	0.87	0.49	0.36	0.13	0.59
G	0.93	0.32	0.25	0.07	0.70
H	0.84	0.57	0.41	0.16	0.51
I	0.79	0.69	0.48	0.21	0.39
	Average				
	0.86	**0.53**	**0.38**	**0.15**	**0.54**

Well 18 Analysis

As indicated in Figure 7a and b, well 18 penetrated the thirteen reservoirs (B, C, D, E, F, G, H, I, J, K, L, M, and N) present in the field and ranges in depth from 3001 (9,903.30) m to 3720 m (12,276 ft). Reservoirs in this well are all single-phase reservoirs, the first reservoir is a single-phase oil reservoir, while the remaining twelve reservoirs are single phase gas reservoirs.

(A)

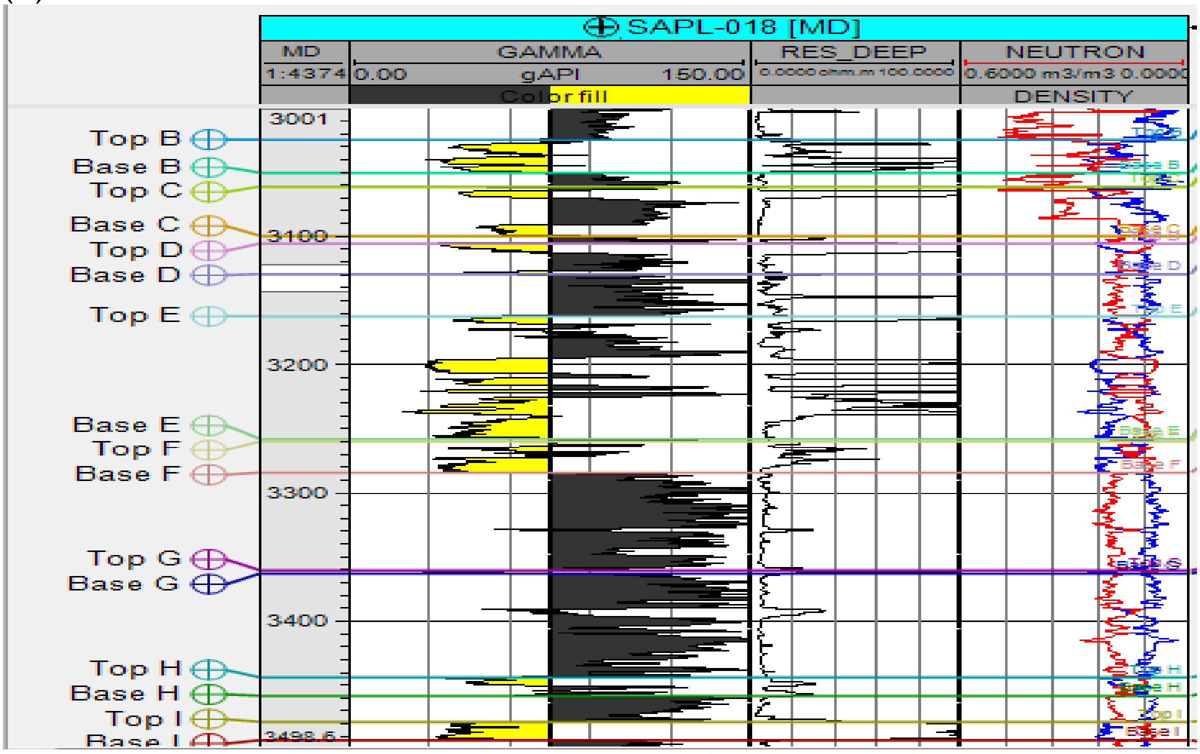

Figure 4a: Well log signature of well 18 from 3001 m to 3498.6 m (Using Petrel®2016).

(B)

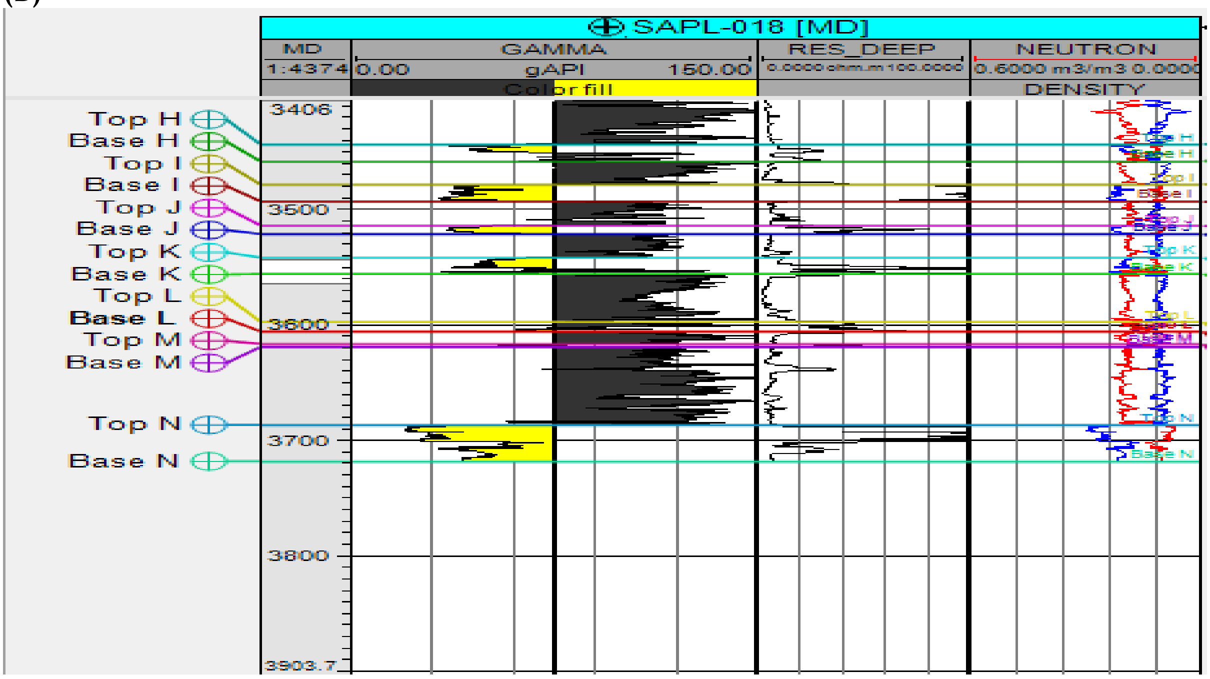

Figure 4b: Well log signature of well 18 from 3406 m to 3720m (Using Petrel®2016)

Hydrocarbon Movability Analysis of well 18 Reservoirs

The petrophysical properties as indicated in Table 8 were used for computation.

Table 8: Petrophysical Summary of Well 18 reservoirs

$Reservoirs$	$Thickness$ (m)	V_{sh}	Net $Sand(m)$	Φ	$Eff\Phi$	$K(mD)$	F	NTG	S_{wirr}	S_w	S_h
B	25.52	0.12	19.29	0.22	0.19	1537.19	21.88	0.76	0.10	0.51	0.49
C	38.48	0.27	5.59	0.23	0.19	1766.02	24.47	0.15	0.11	0.61	0.39
D	23.94	0.09	3.91	0.21	0.19	1508.27	18.55	0.33	0.10	0.4	0.60
E	95.41	0.19	5.71	0.22	0.19	1587.88	21.35	0.36	0.10	0.34	0.66
F	24.73	0.16	14.84	0.21	0.18	1437.18	21.63	0.56	0.10	0.68	0.32
G	2.99	0.23	1.13	0.17	0.13	1108.54	27.28	0.37	0.12	0.5	0.50
H	14.55	0.09	6.24	0.21	0.19	1496.69	18.27	0.43	0.10	0.73	0.27
I	14.95	0.06	12.77	0.23	0.22	1678.61	15.89	0.85	0.09	0.25	0.75
J	7.38	0.06	6.26	0.23	0.21	1660.53	16.35	0.85	0.09	0.49	0.51
K	14.15	0.24	1.94	0.19	0.16	1308.81	24.91	0.14	0.11	0.59	0.41
L	8.37	0.2	0.75	0.18	0.14	1146.87	25.64	0.09	0.11	0.33	0.67
M	2.60	0.22	0.45	0.18	0.14	1131.8	26.49	0.05	0.12	0.44	0.56
N	31.5	0.08	7.8	0.23	0.21	1695.56	17.01	0.74	0.09	0.52	0.48
				Average							
	23.43	0.15	6.67	0.21	0.18	1466.46	21.52	0.44	0.10	0.49	0.51

Table 9 implies that well 18 reservoirs on average, have a flushed zone saturation of 0.86 (86%), hydrocarbon saturation of 0.51 (51%), movable hydrocarbon saturation of 0.37 (37%), residual hydrocarbon saturation of 0.29 (29%) and hydrocarbon movability index of 0.56 which indicates that hydrocarbon will move out of reservoirs to well surface during production. This inference corresponds with Hamada (2006), therefore well 18 is a fecund well with high hydrocarbon recovery.

Table 9: Hydrocarbon Movability Summary of Well 18 Reservoirs

$Reservoirs$	S_{xo}	S_h	MHS	RHS	HMI
B	0.87	0.49	0.36	0.13	0.59
C	0.91	0.39	0.30	0.9	0.67
D	0.83	0.60	0.43	0.17	0.48
E	0.81	0.66	0.47	0.19	0.42
F	0.93	0.32	0.25	0.7	0.74
G	0.87	0.50	0.37	0.13	0.57
H	0.94	0.27	0.21	0.6	0.78
I	0.76	0.75	0.51	0.24	0.33
J	0.87	0.51	0.38	0.13	0.56
K	0.9	0.41	0.31	0.1	0.66
L	0.8	0.67	0.47	0.2	0.41
M	0.85	0.56	0.41	0.15	0.52
N	0.88	0.48	0.36	0.12	0.59
	Average				
	0.86	**0.51**	**0.37**	**0.29**	**0.56**

Well 19 Analysis

This well intercept twelve reservoirs (B, C, D, E, F, G, H, I, J, K, L, and M) out of thirteen reservoirs present in the field and ranges in depth from 30021.72 (9,971.68 ft) m to 3761.55 m (12,413.12 ft). This well contains both single and double-phase reservoirs, it has four single phase gas reservoirs, four double phase (Gas/Oil) reservoirs and four single phase oil reservoirs (Figures 5a, 5b and 5c).

(A)

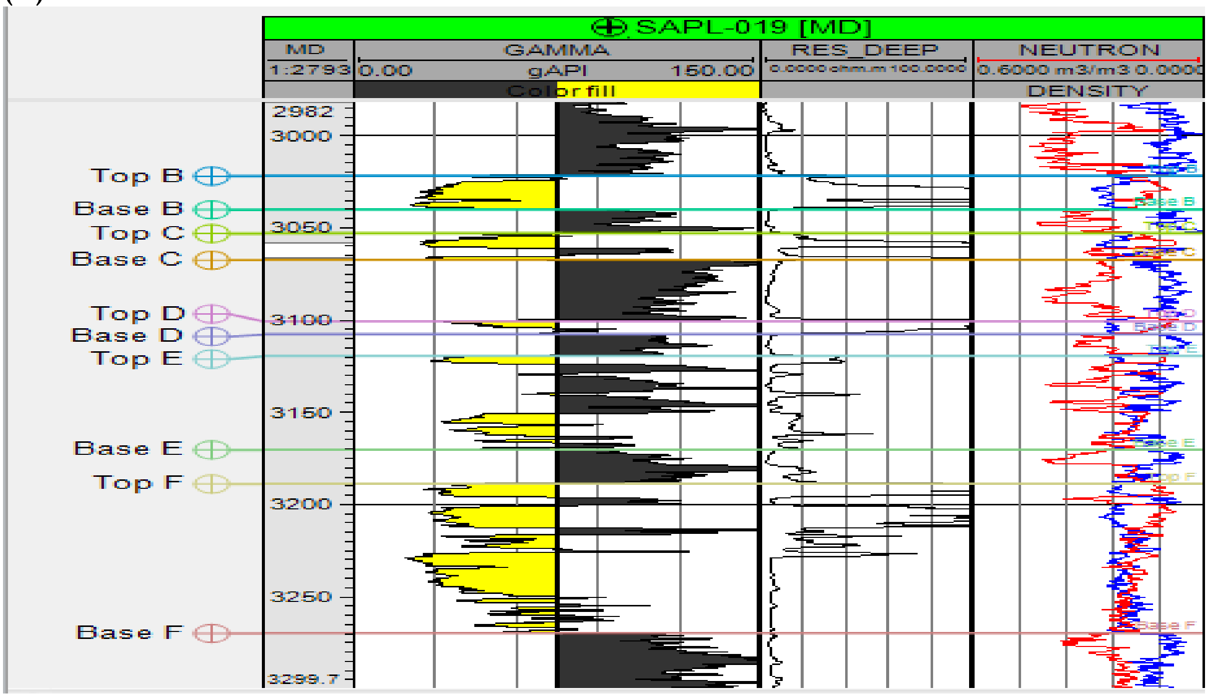

Figure 5a: Well log signature of well 19 from 2982 m to 3299.74 m (Using Petrel®2016).

(B)

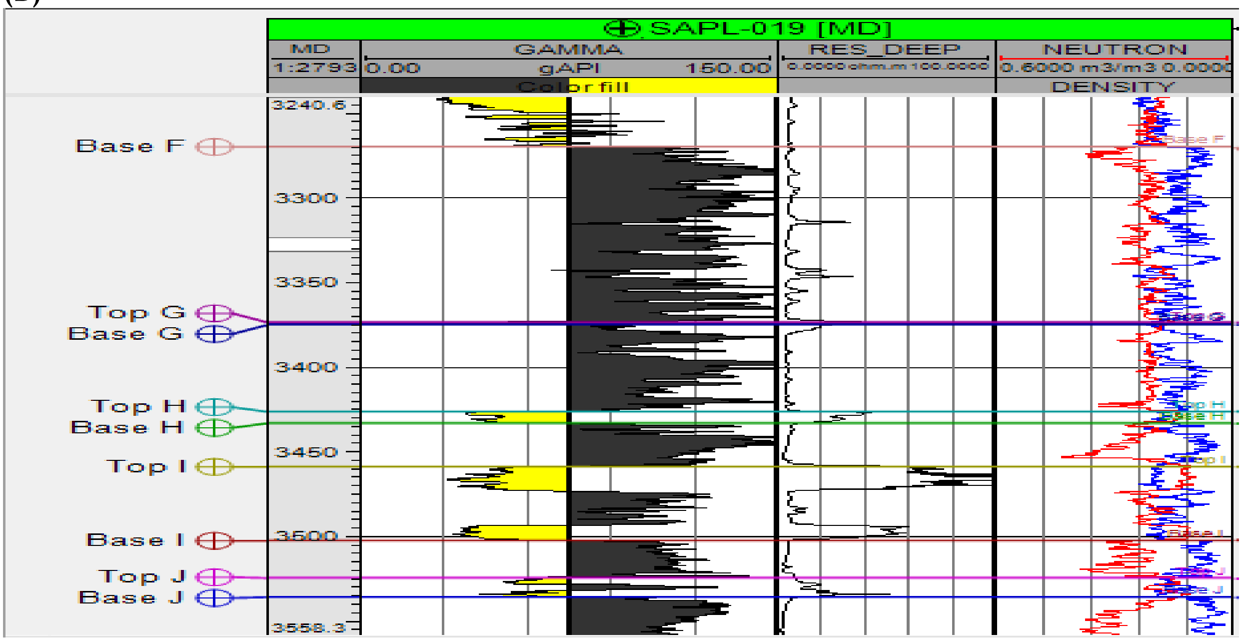

Figure 5b: Well log signature of well 19 from 3240.63 m to 3558.3m (Using Petrel®2016).

(C)

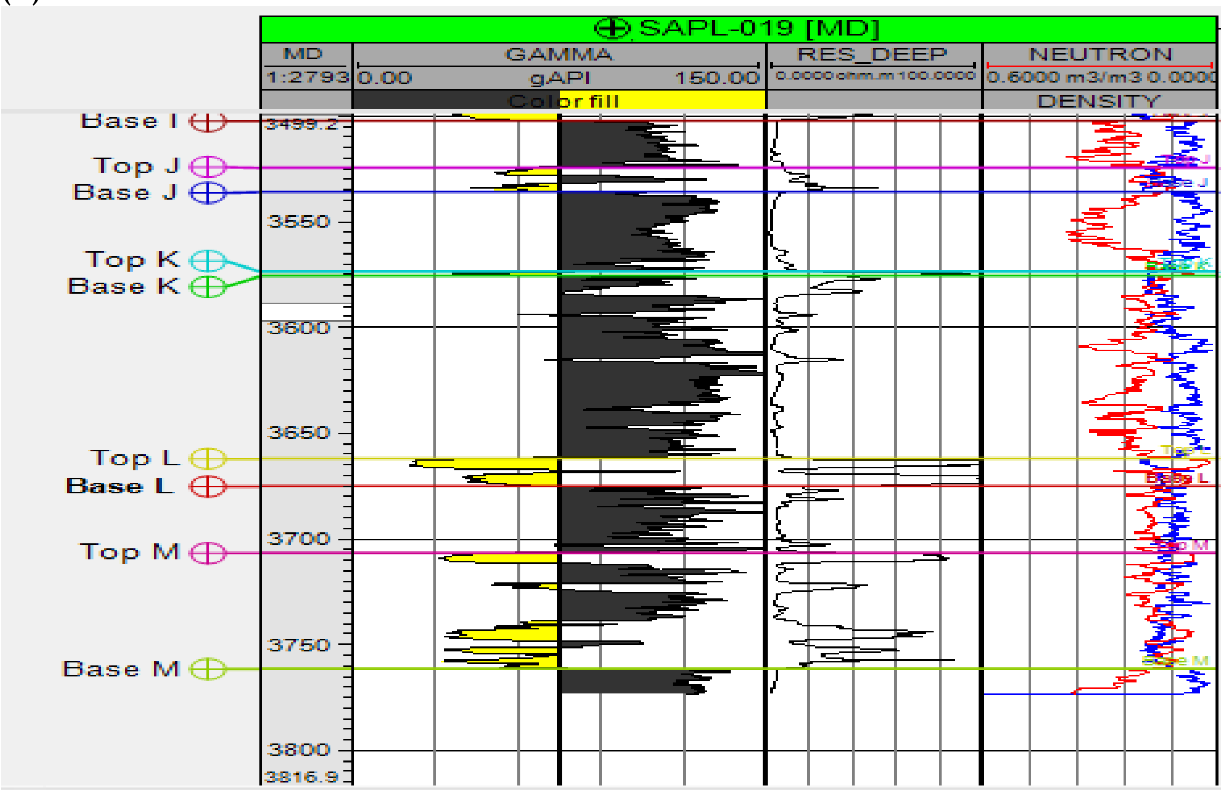

Figure 5c: Well log signature of well 19 from 3499.20 m to 3761.55m (Using Petrel®2016).

Hydrocarbon Movability Analysis of well 19 Reservoirs

The petrophysical properties as indicated in Table 10 were used for computation.

Table 10: Petrophysical Summary of Well 19 Reservoirs

Reservoirs	*Thickness(m)*	V_{sh}	*Net Sand(m)*	Φ	$Eff\Phi$	$K(mD)$	F	NTG	S_{wirr}	S_w	S_h
B	18.25	0.05	15.64	0.25	0.24	1908.34	14.37	0.86	0.09	0.34	0.66
C	14.47	0.3	7.8	0.21	0.17	1435.37	33.67	0.54	0.13	0.56	0.44
D	7.34	0.06	3.23	0.25	0.24	2003.82	12.74	0.44	0.08	0.24	0.76
E	50.92	0.15	4.34	0.21	0.18	1439.96	20.61	0.34	0.10	0.56	0.44
F	80.57	0.3	5.08	0.21	0.15	1503.9	20.08	0.38	0.10	0.53	0.47
G	1.56	0.09	0.95	0.21	0.19	1424.71	19.26	0.61	0.10	0.43	0.57
H	6.45	0.07	6.06	0.18	0.17	1210.39	24.25	0.94	0.11	0.51	0.49
I	43.84	0.06	9.85	0.2	0.19	1364.01	20.93	0.45	0.10	0.37	0.63
J	11.35	0.44	5.18	0.17	0.11	1047.68	33.18	0.46	0.13	0.70	0.30
K	2.00	0.09	1.37	0.18	0.17	1183.17	24.6	0.69	0.11	0.32	0.68
L	12.66	0.14	11.71	0.16	0.14	981.73	36.68	0.92	0.14	0.42	0.58
M	54.97	0.13	6.81	0.15	0.13	924.36	35.91	0.37	0.13	0.42	0.58
			Average								
	25.37	0.16	6.50	0.20	0.17	1368.95	24.69	0.58	0.11	0.45	0.55

The Hydrocarbon movability index of well 19 reservoirs is all less than 0.7 except reservoir "J", whose hydrocarbon movability index is 0.75. This means that hydrocarbon will move out of reservoirs to well surface during production apart from reservoir "J". From Table 11, well 19 reservoirs on average, have a flushed zone saturation of 0.85 (85%), hydrocarbon saturation of 0.55 (55%), movable hydrocarbon saturation of 0.40 (40%), residual hydrocarbon saturation of 0.15 (15%), and hydrocarbon movability index of 0.52. This corollary agrees with Hamada (2006), therefore well 19 is a prolific well with great hydrocarbon retrieval.

Table 11: Hydrocarbon Movability Summary of Well 19 Reservoirs

Reservoirs	S_{xo}	S_h	*MHS*	*RHS*	*HMI*
B	0.87	0.7	0.47	0.19	0.40
C	0.89	0.4	0.33	0.11	0.63
D	0.75	0.8	0.51	0.25	0.32
E	0.89	0.4	0.33	0.11	0.63
F	0.88	0.5	0.35	0.12	0.60
G	0.84	0.6	0.41	0.16	0.51
H	0.87	0.5	0.36	0.13	0.59
I	0.82	0.6	0.45	0.18	0.45
J	0.93	0.30	0.23	0.07	0.75
K	0.80	0.7	0.48	0.20	0.40
L	0.84	0.6	0.42	0.16	0.50
M	0.84	0.6	0.42	0.16	0.50
	Average				
	0.85	**0.55**	**0.40**	**0.15**	**0.52**

Well 27 Analysis

Well 27 comprises of both single and double-phase reservoirs, it has six single phase gas reservoirs, two double-phase (Gas/Oil) reservoirs and three single-phase oil reservoirs (figure 6a and 6b). This well intercepted eleven reservoirs (B, C, D, E, F, G, H, I, J, K, and L) out of thirteen existing reservoirs in the field and ranges in depth from 3008.31 (9,927.42 ft) m to 3468.55 m (11,446.22 ft).

(A)

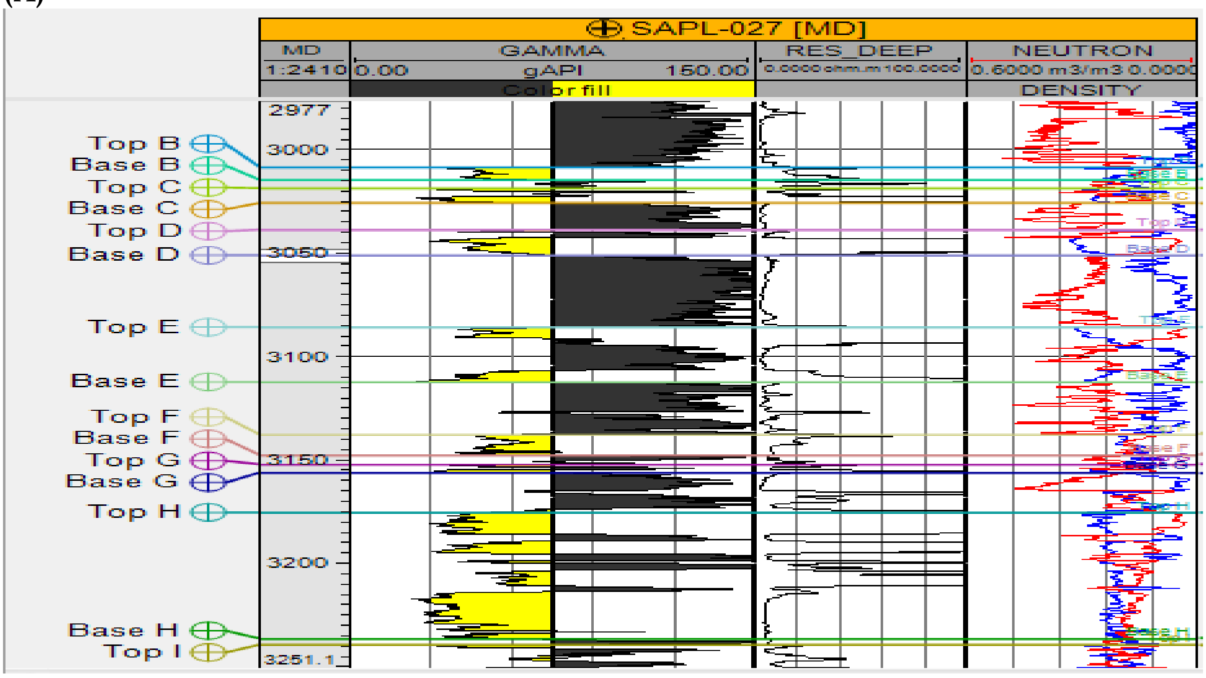

Figure 6a: Well log signature of well 27 from 2977.60 m to 3251.10 m (Using Petrel®2016).

(B)

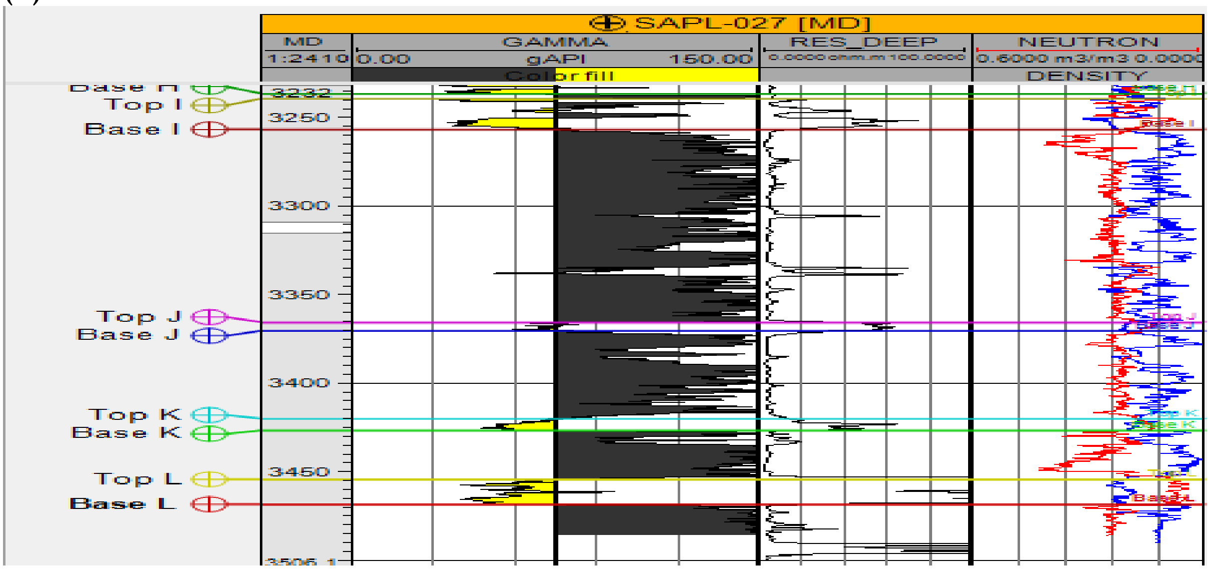

Figure 6b: Well log signature of well 27 from 3232 m to 3506.10 m (Using Petrel®2016).

Hydrocarbon Movability Analysis of well 27 Reservoirs

The petrophysical properties as indicated in Table 12 were used for computation.

Table 12: Petrophysical Summary of Well 27 Reservoirs

Reservoirs	*Thickness (m)*	V_{sh}	*Net Sand(m)*	Φ	$Eff\Phi$	$K(mD)$	F	NTG	S_{wirr}	S_w	S_h
B	6.27	0.25	5.11	0.2	0.16	1393.83	27.77	0.81	0.12	0.59	0.41
C	6.86	0.46	5.5	0.27	0.20	2232.58	23.12	0.80	0.11	0.47	0.53
D	12.24	0.09	3.97	0.31	0.28	2782.08	8.73	0.32	0.07	0.13	0.87
E	26.58	0.06	5.11	0.26	0.24	2056.56	12.66	0.19	0.08	0.39	0.61
F	9.71	0.45	6.34	0.18	0.12	1146.23	37.38	0.65	0.14	0.78	0.22
G	4.03	0.05	4.01	0.26	0.24	2037.52	12.82	0.99	0.08	0.14	0.86
H	71.8	0.25	8.51	0.23	0.18	1703.77	18.2	0.47	0.09	0.47	0.53
I	17.61	0.35	5.97	0.23	0.17	1768.04	16.32	0.34	0.09	0.55	0.45
J	4.93	0.26	2.13	0.21	0.16	1511.37	17.88	0.43	0.09	0.36	0.64
K	6.57	0.14	4.29	0.19	0.16	1244.96	24.41	0.65	0.11	0.47	0.53
L	14.19	0.15	11.19	0.22	0.19	1583.68	17.25	0.75	0.09	0.22	0.78
				Average							
	16.44	0.23	5.65	0.23	0.19	1769.15	19.69	0.58	0.10	0.42	0.58

From Table 13, well 27 reservoirs have hydrocarbon movability index of 0.20 to 0.65 except reservoir "F", whose hydrocarbon movability index is 0.82. This means that hydrocarbon will move out of reservoirs to well surface during production apart from reservoir "J". Well 27 reservoirs on average, have a flushed zone saturation of 0.82 (82%), hydrocarbon saturation of 0.58 (58%), movable hydrocarbon saturation of 0.41 (41%), residual hydrocarbon saturation of 0.18 (18%), and hydrocarbon movability index of 0.49. This outcome corresponds with Hamada (2006), thus well 27 is a prolific well with great hydrocarbon retrieval.

Table 13: Hydrocarbon Movability Summary of Well 27 Reservoirs

$Reservoirs$	S_{xo}	S_h	MHS	RHS	HMI
B	0.90	0.41	0.31	0.10	0.65
C	0.86	0.53	0.39	0.14	0.55
D	0.66	0.87	0.53	0.34	0.20
E	0.83	0.61	0.44	0.17	0.47
F	0.95	0.22	0.17	0.05	0.82
G	0.67	0.86	0.53	0.33	0.21
H	0.86	0.53	0.39	0.14	0.55
I	0.89	0.45	0.34	0.11	0.62
J	0.81	0.64	0.45	0.19	0.44
K	0.86	0.53	0.39	0.14	0.55
L	0.74	0.78	0.52	0.26	0.30
	Average				
	0.82	**0.58**	**0.41**	**0.18**	**0.49**

Table 14: Cumulative Average Hydrocarbon Movability of Sapele Deep

$\boldsymbol{Wells}$	$\boldsymbol{S_{xo}}$	$\boldsymbol{S_h}$	$\boldsymbol{MHS}$	$\boldsymbol{RSH}$	$\boldsymbol{MHI}$
Well 01	0.79	0.62	0.41	0.21	0.42
Well 06	0.85	0.53	0.38	0.15	0.54
Well 17	0.86	0.53	0.38	0.15	0.54
Well 18	0.86	0.51	0.37	0.29	0.56
Well 19	0.85	0.55	0.4	0.15	0.52
Well 27	0.82	0.58	0.41	0.18	0.49
	Average				
	0.84	0.55	0.39	0.19	0.51

Thirteen (13) hydrocarbon sand bodies were delineated and correlated across the study area. Petrophysical analysis reveals that the study area has very good to excellent petrophysical properties with an average gross thickness of 268.60m (886.38 ft), net sand thickness of 6.67 m (22.01 ft), porosity value of 0.21 (21%), permeability of 1493.14 mD, shale volume of 0.16, net-to-gross value of 0.51 and water saturation (S_w) of 0.43 (43%).

CONCLUSION

The petrophysical properties infers that the delineated sand bodies possess good hydrocarbon storage and transmission ability, which are the two main qualities to look out for in a reservoir and from log evaluations, Sapele deep reservoirs were delineated in the Agbada formation. The cumulative hydrocarbon movability summary as shown in Table 4.95, confirms that the field on average has flushed zone water saturation (S_{xo}) of 0.84, hydrocarbon saturation of 0.55, movable hydrocarbon saturation of 0.39, residual hydrocarbon saturation of 0.19, movable hydrocarbon index of 0.51 and a high recovery factor of 81% (0.81) which is due to the presence of gas and appreciable water drive.

Conversely, with the field residual hydrocarbon of 0.19 (19%), it therefore implies that 0.39 (39%) out of 0.51 (51%) field hydrocarbon saturation will move to the surface (wellhead) during production. Hence, we can infer that the reservoir in the field has a high hydrocarbon movability rate, which makes the field a very good prospect.

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