

Petrophysical Analysis of Reservoir Quality using Key Production Parameters: A Case Study of the G-Oil Field within the Niger Delta Basin

*¹Agada, Isaac Owoicho, †¹Igboekwe Magnus Uzoma,
‡²Amos-Uhegbu, Chukwunenyo and *¹Aigba, Paul Igienekepeme

¹Department of Physics, College of Physical and Applied Sciences, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria.

²Department of Geology, College of Physical and Applied Sciences, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria.

*Corresponding author's email: agadaisaac45@gmail.com

ORCID iD: *<https://orcid.org/0000-0002-2483-8938> †<https://orcid.org/0000-0003-2546-3821>

‡<https://orcid.org/0000-0003-2113-7834> *<https://orcid.org/0009-0003-5582-0495>

ABSTRACT

Production parameters of reservoirs such as Porosity (ϕ), Permeability (K) and Water Saturation (Sw) are among the fundamental properties that determine a reservoir's quality, defining its ability to store hydrocarbon and CO₂. The Petrophysical analysis (production parameters) of the G-Oil Field in the Niger Delta basin was aimed at assessing the quality of the reservoirs in supporting hydrocarbon exploitation and carbon sequestration. Interactive Petrophysics (IP) Software was used to analyse 8 well log data in LAS format. 18 geologic reservoirs were delineated using the combination of Basic Logonal, Porosity/Water saturation algorithm and the Cut-off & summation algorithm of the IP software. Production Petrophysical parameters such as Effective Porosity (ϕ_{eff}), Permeability (K) and Water Saturation (Sw) were determined using the Tixier, Wyllie-Rose and Indonesian equations respectively. Results show that ϕ_{eff} is in the range of 14.2% - 27.5% adjudged to be good porosity to very good porosity while Sw values in all 18 reservoirs ranged between 13.1% and 45.7%. K ranged between 181.01mD and 7942.091mD, placing it within the 'Very good - Excellent' permeability classification. Mean value of ϕ_{eff} , Sw and k for the G – Oil field are 22.8%, 31.0% and 1780.941mD respectively. These values as reviewed fell in the quality classification of Very good porosity, Very good Water Saturation and Excellent Permeability. These imply that the G – Oil field has good quality reservoirs which are highly prolific in terms of hydrocarbon production and suitable for Carbon Sequestration.

Keywords:

Petrophysical,
Porosity,
Water Saturation,
Permeability,
Niger Delta,
Hydrocarbon,
Carbon Sequestration.

INTRODUCTION

Geologic reservoirs are subsurface rock formations that are porous and permeable enough to accumulate fluids within its pores and also allow flow within its matrix (Payton *et al.*, 2020). Its systems are fundamental in petroleum geology as it constitutes the birth place and store structure for hydrocarbons (Nelson, 2004; Payton *et al.*, 2020). The best reservoirs are found in sedimentary formations, with examples such as sandstone, limestone and dolomite also known as carbonate reservoirs (Craze, 1950; Burk and Drake, 1974). Beyond hydrocarbon storage, these reservoirs find relevance in carbon sequestration processes of

Enhanced Oil Recovery and permanent/commercial storage of CO₂ (SPE 1987; Payton *et al.*, 2020).

Production parameters of a reservoir are its physical and fluid properties essential for understanding the reservoir's behaviour and ability to store hydrocarbon and CO₂, used predominantly to conduct volumetric estimation of hydrocarbon and CO₂ (Coneybeare, 1967; Ojo and Tse, 2016). They define the reservoir's quality. These parameters include Porosity, Permeability, Compressibility, water/ Oil saturation, fluid viscosity, etc. Reservoirs with highly porous and permeable sedimentary formations, containing up to 30% porosity are considered productive for hydrocarbon and receptive

for CO₂ (Payton *et al.*, 2020; Nelson, 2004) having other parameters within standard cut-offs. This is why most Carbon sequestration projects target sandstone and carbonate reservoirs.

Knowledge of production parameters as major determinants guide decision making for effective execution of hydrocarbon extraction and carbon sequestration processes. Ojo and Tse (2016) noted that in-situ determination of petrophysical properties of reservoirs used for volumetric estimation of hydrocarbon is with the aid of Wireline logs such as Gamma Ray, Density, Neutron, Neutron-Density, Resistivity, Sonic, Neutron-Sonic, Induction and Self-Potential.

In this research, production parameters to be analysed include Porosity, Permeability and Water Saturation, detailing their effect in hydrocarbon and CO₂ reservoirs. The aim of this study is to Petrophysically determine the production parameters of delineated reservoirs within the G-oil field. The parameters shall be used to assess

the quality of the reservoirs in supporting hydrocarbon exploitation and carbon sequestration.

Study Location

The study area (G-Oil Field) is located in the Greater Ughelli depobelt of the Niger Delta Basin between latitude 4°N and 6°N and longitude 5°E and 8°E (Figure 1). The field covers a landmass of 36.9Km². A total of 8 wells within the field were mapped.

The Niger Delta basin comprises the Benin, Agbada and Akata geologic formations (Short and Stauble, 1967). These formations are of the early Tertiary to Recent (Doust and Omatsola, 1989; Umar *et al.*, 2020) in the geological timescale. The basin consists of 5 depobelts which defines the depositional sequence namely: northern delta, greater Ughelli, Central swamp, Coastal swamp and offshore. The geologic make-up of the basin defines its hydrocarbon prolificity and capacity to support carbon sequestration.

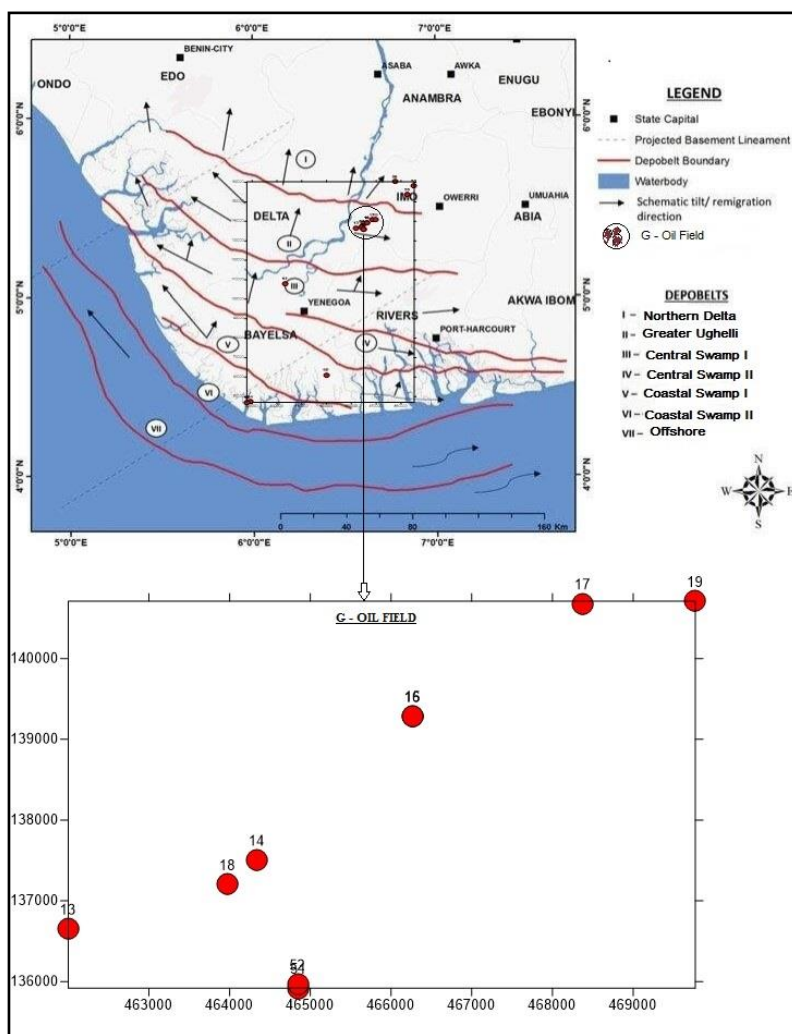


Figure 1: Location map of G – Oil Field within the Niger Delta Basin

MATERIALS AND METHODS

Materials used for this research include log data in LAS format, Interactive Petrophysics (IP) software for well log data analysis, Surfer 13 software for mapping and MS-Excel for data analysis. Eight (8) Well log data within the G-oil field were collated and analysed.

Petrophysical parameters of interest were analysed using the IP software.

Data analysed using IP followed a workflow which allowed for discrete documentation of processes and algorithms implemented based on principles of Physics. The workflow progressed from data import to well setup/normalization and analysis/correlation. Well logs data in (Log ASCII Standard (LAS)) format were uploaded into the Interactive Petrophysics (IP) work environment. The IP work environment was set-up including display columns and other features such as selection of curves required for all types of intended analysis. Well log analysis and correlation ensured reservoirs within each well are delineated using relevant logs and combination of logs. 3 approaches were deployed to achieve this in the IP software: the basic logonal which enable manual delineation, porosity/water saturation algorithm and cut-off/summation algorithm. The last 2 approaches are automated. Applying these 3 approaches ensured precision in the reservoir delineations. The delineations lead to identification of hydrocarbon bearing zones, with porosity/water saturation and cut-off/summation function. Basic logonal provided access to curve settings for necessary adjustments and precise delineation. Petrophysical properties such as total and effective porosities were analyzed using Tixier equations (1) and (2) respectively [Tixier *et al.* (1949), Moradiet *al.* (2016)].

$$\text{Porosity } (\phi) = \frac{\rho_{ma} - \rho_b}{\rho_{ma} - \rho_{fl}} \quad (1)$$

$$\text{Effective Porosity } (\phi_{eff}) = \phi_{total} (1 - V_{sh}) \quad (2)$$

Attoet *al.*, (2025) classified porosity qualitatively into 5 categories: $\phi < 5\%$ is considered negligible while $5\% < \phi < 10\%$ is weak porosity. Porosity in the range $10\% < \phi < 15\%$ is medium porosity while $15\% < \phi < 20\%$ is considered as good porosity. Porosity values greater than 20% ($\phi > 20\%$) constitutes a very good porosity.

Permeability was executed using Wiley-Rose model in equations 3 considering the application of porosity as fraction (Craze, 1950), Tixier (1949).

$$K = a \left[\frac{\phi^b}{S_{wirr}} \right] \quad (3)$$

In the works of Storm et al., (2020) and Glover (2000), qualitative classification of permeability reads: 1-10mD is poor permeability, 10-100mD is fair, 100-1000mD is good while permeability greater than 1000mD ($K > 1000\text{mD}$) is Excellent.

Water saturation utilized the Indonesian model in equation 4 (Buckles (1965), Fozaoet *al.*, 2019),

$$\frac{1}{\sqrt{R_t}} = \left[\frac{1 - V_{sh}}{\sqrt{R_{sh}}} + \frac{\phi_e}{\sqrt{R_t}} \right] S_w \quad (4)$$

Values of $S_w \leq 50\%$ is acceptable as cut-off for water saturation in hydrocarbon reservoirs. Above 50% implies fewer hydrocarbons for extraction which hence reduces the economic viability of the extraction process [Buckles, (1965) and Fozao *et al.*, (2019)].

RESULTS AND DISCUSSION

Well IOA_13

Well IOA_13 a depth profile of 1950.11ft to 2748.99ft. Four (4) reservoirs were delineated within this well, projected to contain hydrocarbon, with capacity to contain CO_2 (Figure 2)

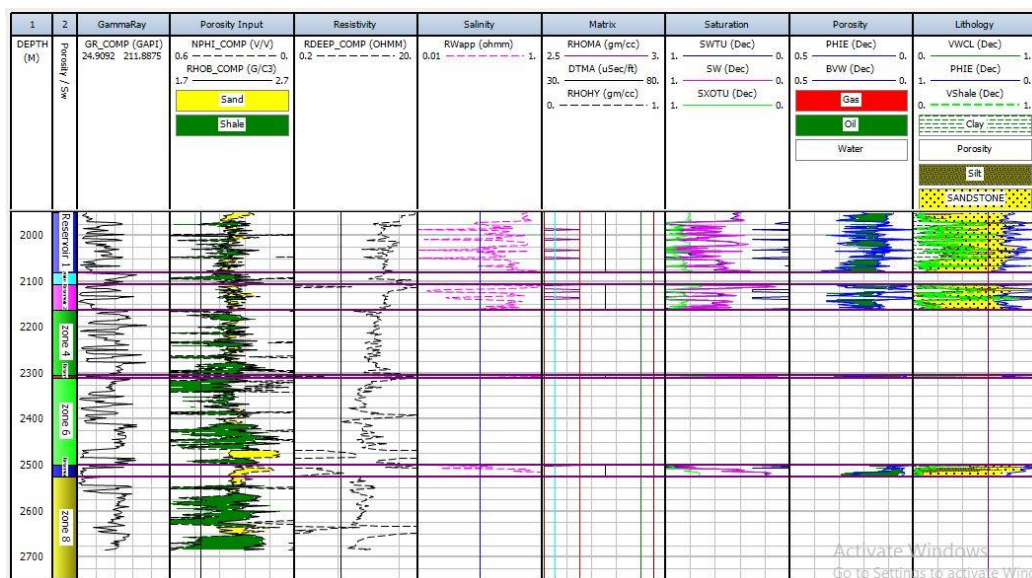


Figure 2: Reservoir Matrix delineation of IOA_13

Table 1: Petrophysical Curve Statistics for Well IOA_13

Well : IOA_13

Date Run : 29-Jul-25 12:05:00 PM

Curve	Units	Top	Bottom	Net	Min	Max	Mean
PHIT	Dec	1950.263	2081.936	131.825	0.035	0.421	0.238
PHIE	Dec	1950.263	2081.936	131.825	0.000	0.406	0.210
SW	Dec	1950.263	2081.936	131.825	0.221	1.000	0.457
VSH	Dec	1950.263	2081.936	131.825	0.000	0.691	0.256
Perm	md	1950.11	1969.77	19.812	0.000	852.711	425.446

Location X	Location Y	Curve	Units	Nulls	Fail	Disc	Top	Bottom	Net	Min	Max	Mean
833978.557	0	PHI	Dec	0	0		2106.473	2162.404	56.083	0.193	0.340	0.272
833978.557	0	PHIT	Dec	0	0		2106.473	2162.404	56.083	0.042	0.364	0.206
833978.557	0	PHIE	Dec	0	0		2106.473	2162.404	56.083	0.000	0.364	0.179
833978.557	0	SW	Dec	0	0		2106.473	2162.404	56.083	0.074	0.513	0.403
833978.557	0	VSH	Dec	0	0		2106.473	2162.404	56.083	0.000	0.859	0.249
833978.557	0	Perm	md	165	0		2107.387	2160.88	30.937	23.096	10725.016	677.581

Location X	Location Y	Curve	Units	Nulls	Fail	Disc	Top	Bottom	Net	Min	Max	Mean
833978.557	0	PHI	Dec	0	0		2305.507	2310.536	5.182	0.130	0.332	0.267
833978.557	0	PHIT	Dec	0	0		2305.507	2310.536	5.182	0.115	0.386	0.264
833978.557	0	PHIE	Dec	0	0		2305.507	2310.536	5.182	0.069	0.385	0.245
833978.557	0	SW	Dec	0	0		2305.507	2310.536	5.182	0.086	0.508	0.198
833978.557	0	VSH	Dec	0	0		2305.507	2310.536	5.182	0.000	0.427	0.169
833978.557	0	Perm	md	0	0		2305.507	2310.536	5.182	3.280	8127.546	2356.494

Location X	Location Y	Curve	Units	Nulls	Fail	Disc	Top	Bottom	Net	Min	Max	Mean
833978.557	0	PHI	Dec	0	0		2499.208	2525.268	26.213	0.123	0.303	0.234
833978.557	0	PHIT	Dec	0	0		2499.208	2525.268	26.213	0.019	0.311	0.166
833978.557	0	PHIE	Dec	0	0		2499.208	2525.268	26.213	0.000	0.311	0.156
833978.557	0	SW	Dec	0	0		2499.208	2525.268	26.213	0.097	0.640	0.246
833978.557	0	VSH	Dec	0	0		2499.208	2525.268	26.213	0.000	0.684	0.098
833978.557	0	Perm	md	40	0		2505.151	2525.116	20.117	65.363	4122.589	831.532

Petrophysical parameters of reservoirs 1, 2, 3, and 4 delineated within the well (Table 1)

Highest value of effective porosity across all reservoirs is 24.5% in Reservoir 3 while lowest value is 15.6% found in Reservoir 4 while Water saturation has its highest value as 45.7% in Reservoir 1 with lowest value

as 19.8% in Reservoir 3. Permeability values across the 4 reservoirs are between 425.446mD and 2356.494mD.

WELL IOA_14

Well IOA_14 has a depth profile of 0.00ft to 2757.22ft. One (1) reservoir was delineated within this well, (Figure 3)

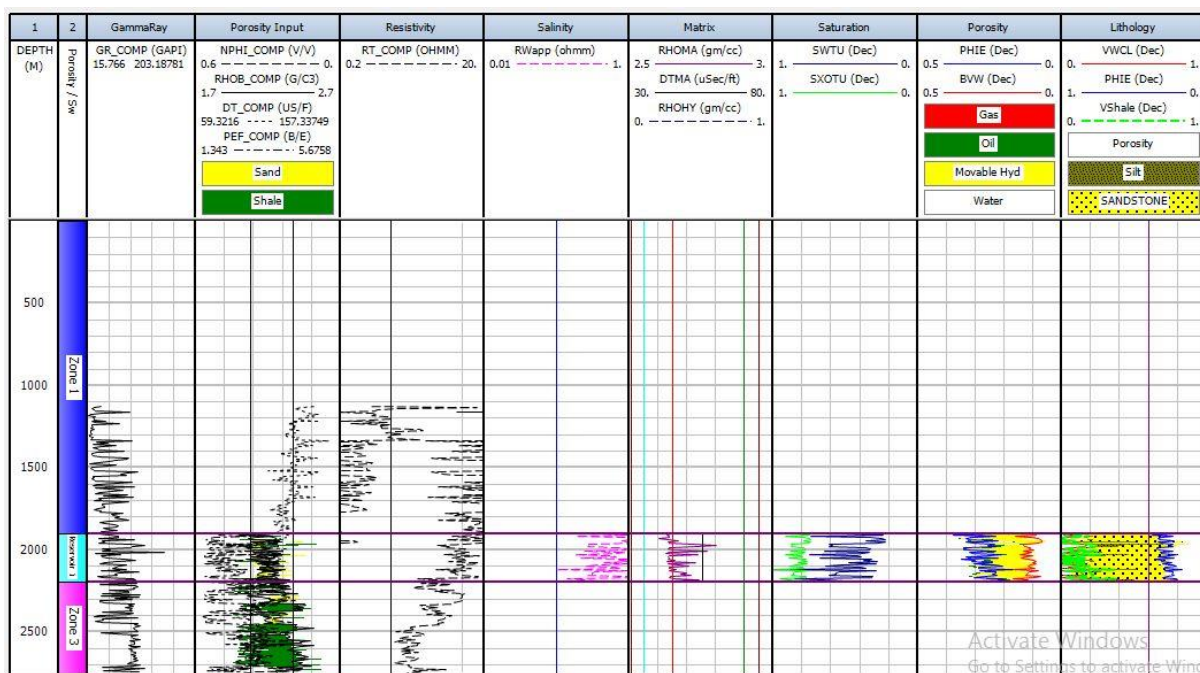


Figure 3: Reservoir Matrix delineation of IOA_14

Table 2: Petrophysical Curve Statistics for Well IOA_14

Well : IOA_14

Date Run : 29-Jul-25 12:21:22 PM

Curve	Units	Top	Bottom	Net	Min	Max	Mean
PHI	Dec	1901.038	2199.742	298.861	0.006	0.600	0.285
PHIT	Dec	1901.038	2199.742	298.861	0.012	0.450	0.288
PHIE	Dec	1901.038	2199.742	298.861	0.000	0.450	0.270
SW	Dec	1901.038	2199.742	298.861	0.151	1.000	0.352
VSH	Dec	1901.038	2199.742	298.861	0.000	1.000	0.322
Perm	md	1917.344	2090.318	107.898	2.342	32368.303	1206.234

Petrophysical parameters of reservoir 1 delineated within the well (Table 2).

Higher value of effective porosity is 27.0% while Water saturation is 35.2%, with Permeability value 1206.234mD (Table 2).

WELL IOA_15

Well IOA_15 has a depth profile of 0.00ft to 2950.48ft. Two (2) reservoirs were delineated within this well, projected to contain hydrocarbon, with same capacity to host injected CO₂. The delineations are as shown in Figure 4.11 and Figure 4.12 below

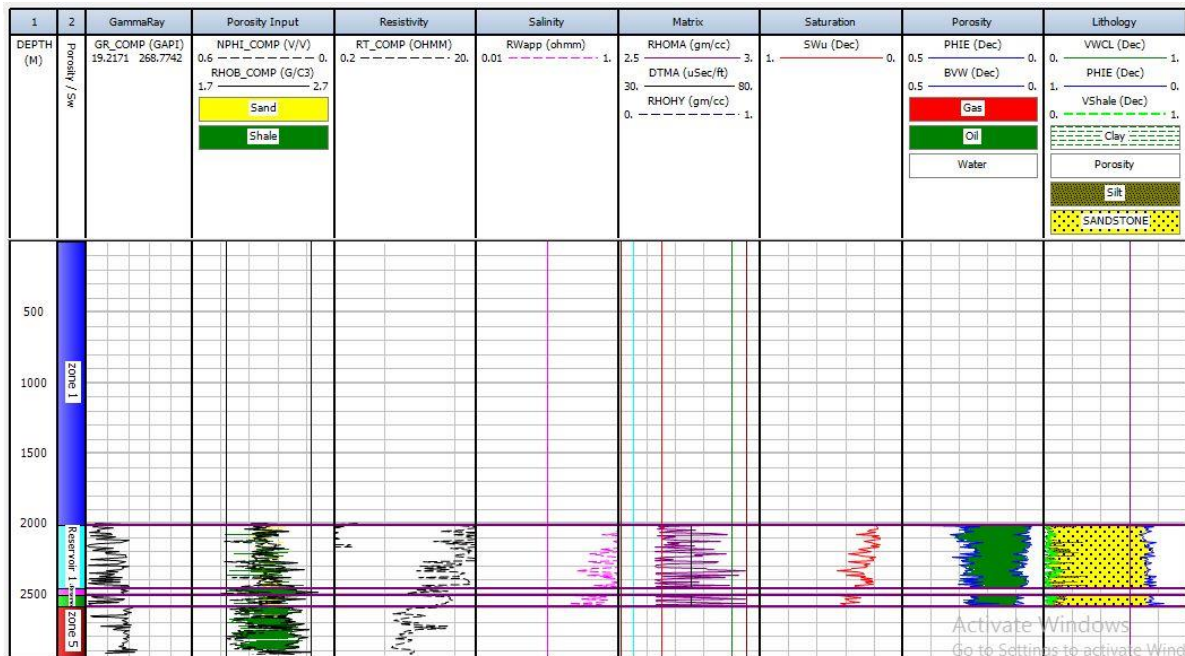


Figure 4: Reservoir Matrix delineation of IOA_15

Table 3: Petrophysical Curve Statistics for IOA_15

Well : IOA_15

Date Run : 29-Jul-25 12:26:58 PM

Curve	Units	Top	Bottom	Net	Min	Max	Mean
PHI	Dec	2013.052	2460.65	447.760	0.042	0.466	0.273
PHIT	Dec	2013.052	2460.65	447.760	0.058	0.438	0.279
PHIE	Dec	2013.052	2460.65	447.760	0.058	0.433	0.275
SW	Dec	2013.052	2460.65	447.760	0.169	0.783	0.326
VSH	Dec	2013.052	2460.65	447.760	0.000	0.136	0.043
Perm	md	2017.776	2167.433	97.688	20.263	4095.324	1114.875

Well : IOA_15

Date Run : 31-Jul-25 2:28:30 AM

Curve	Units	Top	Bottom	Net	Min	Max	Mean
PHI	Dec	2510.79	2590.8	80.162	0.138	0.355	0.257
PHIT	Dec	2510.79	2590.8	80.162	0.167	0.350	0.260
PHIE	Dec	2510.79	2590.8	80.162	0.160	0.350	0.255
SW	Dec	2510.79	2590.8	80.162	0.214	0.467	0.340
VSH	Dec	2510.79	2590.8	80.162	0.000	0.122	0.045
Perm	md	2510.79	2590.8	80.162	0.003	1342.388	190.287

Petrophysical parameters of reservoirs 1 and 2 delineated within the well (Table 3).

Highest value of effective porosity across all reservoirs is 27.5% in Reservoir 1 while lowest value is 25.5% found in Reservoir 2. Water saturation has its highest value as 34.0% in Reservoir 2 with lowest value as

32.6% in Reservoir 1. Permeability delineated reservoirs have permeability values above 100mD (Table 3).

WELL 4 (IOA_16)

Well IOA_16 has a depth profile of 0.00ft to 2954.73ft. Two (2) reservoirs were delineated within this well (Figure 5)

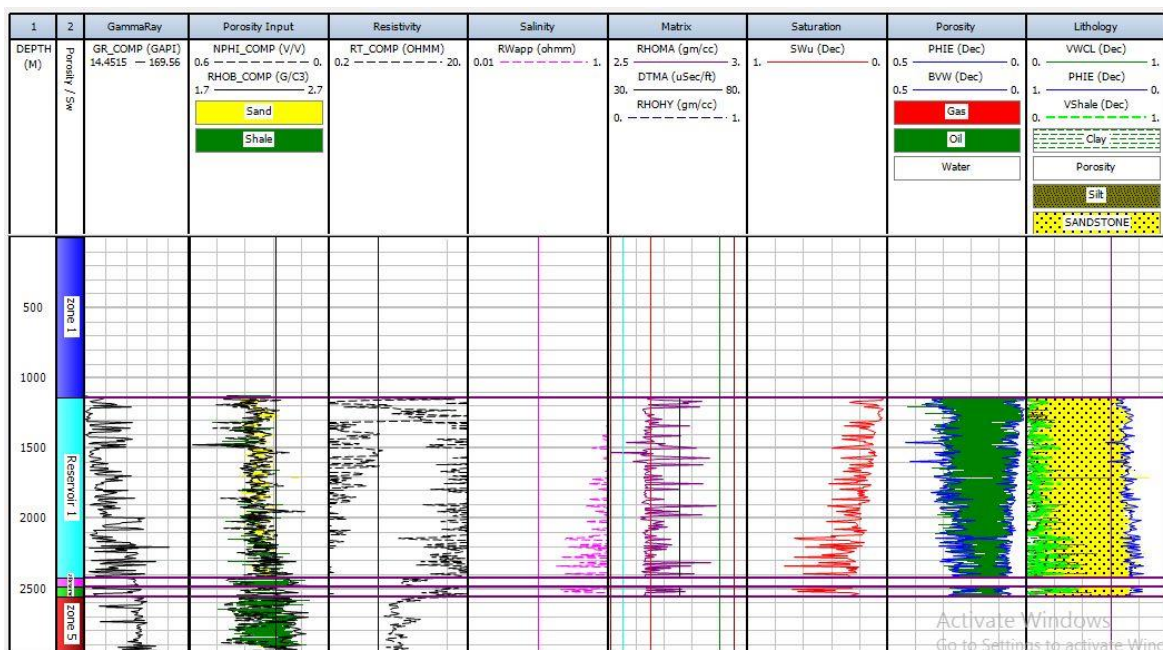


Figure 5: Reservoir Matrix delineation of IOA_16

Table 4: Petrophysical Curve Statistics for IOA_16

Well : IOA_16

Date Run : 29-Jul-25 12:53:58 PM

Curve	Units	Top	Bottom	Net	Min	Max	Mean
PHI	Dec	1144.067	2423.922	1279.940	0.000	0.600	0.315
PHIT	Dec	1144.067	2423.922	1279.940	0.015	0.450	0.288
PHIE	Dec	1144.067	2423.922	1279.940	0.000	0.450	0.274
SW	Dec	1144.067	2423.922	1279.940	0.020	1.000	0.200
VSH	Dec	1144.067	2423.922	1279.940	0.000	0.458	0.080
Perm	md	1144.067	2121.713	977.824	0.000	295009.50	6497.094

Well : IOA_16

Date Run : 31-Jul-25 2:38:27 AM

Curve	Units	Top	Bottom	Net	Min	Max	Mean
PHI	Dec	2483.51	2558.339	74.981	0.152	0.329	0.257
PHIT	Dec	2483.51	2558.339	74.981	0.144	0.353	0.255
PHIE	Dec	2483.51	2558.339	74.981	0.111	0.318	0.232
SW	Dec	2483.51	2558.339	74.981	0.191	0.748	0.360
VSH	Dec	2483.51	2558.339	74.981	0.000	0.396	0.128
Perm	md	2483.51	2558.339	74.981	5.227	1419.320	311.567

Petrophysical parameters of reservoirs 1 and 2 delineated within the well (Table 4).

Effective porosity value of in reservoir 1 is 27.4% while it is 23.2% in Reservoir 2 while Water saturation values are pegged at 20.0% in Reservoir 1 and 36.0% in

Reservoir 2. Delineated reservoirs have permeability values above 100mD (Table 4).

WELL 5 (IOA_17)

Well IOA_17 has a depth profile of 1084.48ft to 2540.66ft. Three (3) reservoirs were delineated within this well (Figure 6).

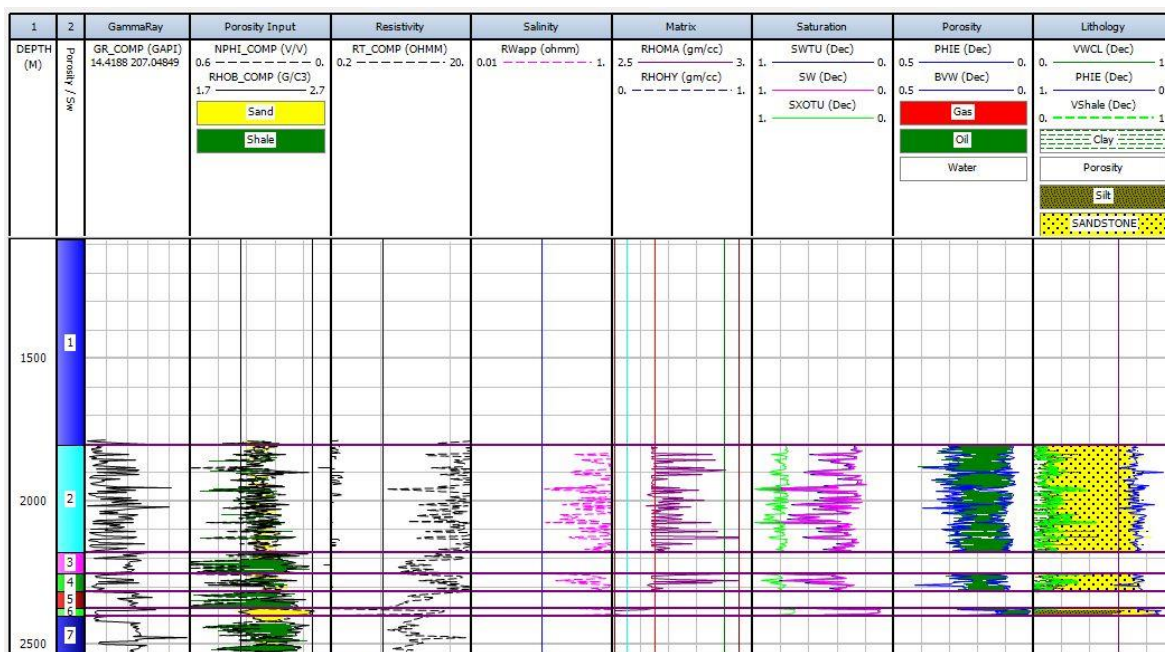


Figure 6: Reservoir Matrix delineation of IOA_17

Table 5: Petrophysical Curve Statistics for IOA_17

Well : IOA_17

Date Run : 29-Jul-25 2:58:15 PM

Curve	Units	Top	Bottom	Net	Min	Max	Mean
PHI	Dec	1803.044	2180.539	377.654	0.012	0.560	0.269
PHIT	Dec	1803.044	2180.539	377.654	0.037	0.428	0.285
PHIE	Dec	1803.044	2180.539	377.654	0.031	0.419	0.274
SW	Dec	1803.044	2180.539	377.654	0.118	1.000	0.325
VSH	Dec	1803.044	2180.539	377.654	0.000	0.527	0.119
Perm	md	1803.044	2179.472	125.881	0.231	42861.504	967.861

Well : IOA_17

Date Run : 31-Jul-25 2:44:00 AM

Curve	Units	Top	Bottom	Net	Min	Max	Mean
PHI	Dec	2256.13	2319.223	63.246	0.125	0.490	0.245
PHIT	Dec	2256.13	2319.223	63.246	0.180	0.450	0.266
PHIE	Dec	2256.13	2319.223	63.246	0.167	0.450	0.255
SW	Dec	2256.13	2319.223	63.246	0.278	0.859	0.439
VSH	Dec	2256.13	2319.223	63.246	0.000	0.413	0.125
Perm	md	2256.13	2319.223	63.246	2.515	4502.858	181.010

Well : IOA_17

Date Run : 29-Jul-25 3:01:30 PM

Curve	Units	Top	Bottom	Net	Min	Max	Mean
PHI	Dec	2377.897	2403.043	25.298	0.196	0.588	0.277
PHIT	Dec	2377.897	2403.043	25.298	0.096	0.315	0.168
PHIE	Dec	2377.897	2403.043	25.298	0.096	0.315	0.168
SW	Dec	2377.897	2403.043	25.298	0.036	0.496	0.131
VSH	Dec	2377.897	2403.043	25.298	0.000	0.169	0.005
Perm	md	2380.031	2403.043	23.165	100.322	32818.813	7942.091

Petrophysical parameters of reservoirs 1, 2 and 3 delineated within the well (Table 5).

Reservoir 1 has the highest effective porosity value of 27.4% while reservoir 3 is least with 16.8% within the well. Reservoir 2 has highest Water saturation value of 43.9% while the least value of 13.1% is in Reservoir

3. Delineated reservoirs have permeability values above 100mD (Table 5).

WELL 6 (IOA_18)

Well IOA_18 has a depth profile of 0.00ft to 2799.99ft. Two (2) reservoirs were delineated within this well (Figure 7).

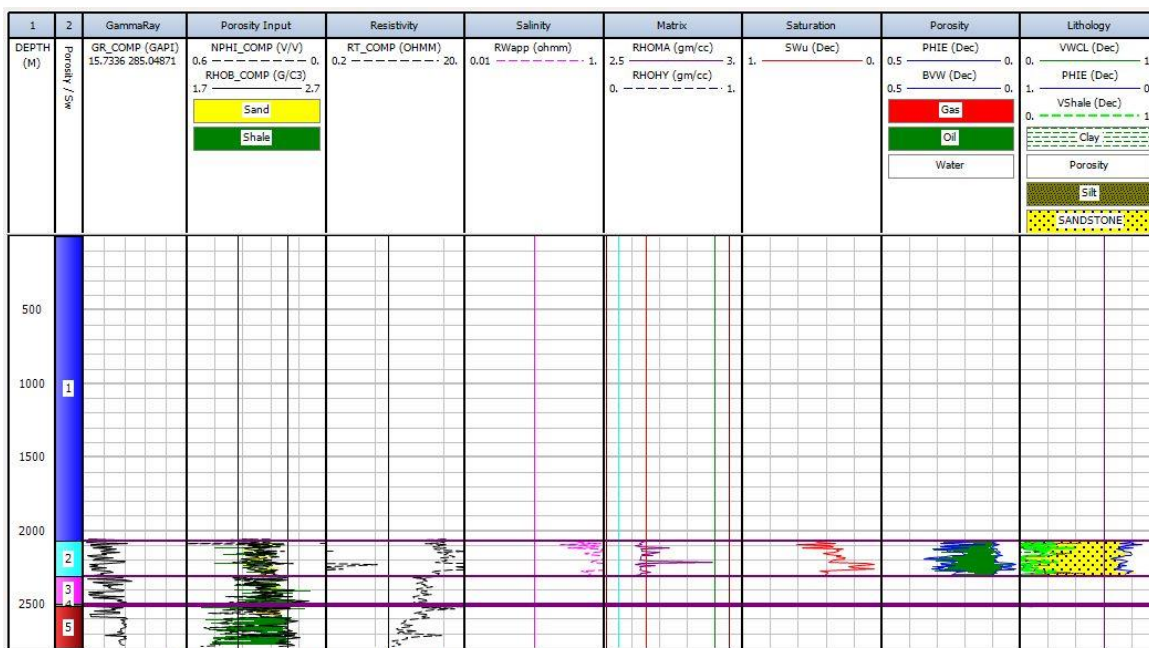


Figure 7: Reservoir Matrix delineation of IOA_18

Table 6: Petrophysical Curve Statistics for IOA_18

Well : IOA_18

Date Run : 29-Jul-25 3:10:15 PM

Curve	Units	Top	Bottom	Net	Min	Max	Mean
PHI	Dec	2066.849	2312.67	245.976	0.032	0.600	0.271
PHIT	Dec	2066.849	2312.67	245.976	0.026	0.423	0.268
PHIE	Dec	2066.849	2312.67	245.976	0.012	0.400	0.251
SW	Dec	2066.849	2312.67	245.976	0.045	0.997	0.339
VSH	Dec	2066.849	2312.67	245.976	0.000	0.514	0.115
Perm	md	2222.144	2265.883	43.891	0.002	24371.471	3058.104

Well : IOA_18

Date Run : 29-Jul-25 3:11:16 PM

Curve	Units	Top	Bottom	Net	Min	Max	Mean
PHI	Dec	2499.665	2516.429	16.916	0.087	0.339	0.266
PHIT	Dec	2499.665	2516.429	16.916	0.083	0.335	0.258
PHIE	Dec	2499.665	2516.429	16.916	0.069	0.322	0.252
SW	Dec	2499.665	2516.429	16.916	0.042	0.578	0.156
VSH	Dec	2499.665	2516.429	16.916	0.000	0.308	0.035
Perm	md	2499.665	2516.429	16.916	0.615	21872.791	4459.963

Petrophysical parameters of reservoirs 1 and 2 delineated within the well (Table 6).

Reservoir 1 has effective porosity value of 25.1% while reservoir 2 is 25.2% within the well. Reservoir 1 has highest Water saturation value of 33.9% while the least

value of 15.6% is in Reservoir 2. Delineated reservoirs have permeability values above 1000mD (Table 6).

WELL IOA_19

Well IOA_19 has a depth profile of 0.00ft to 2731.47ft. Two (2) reservoirs were delineated within this well (Figure 8).

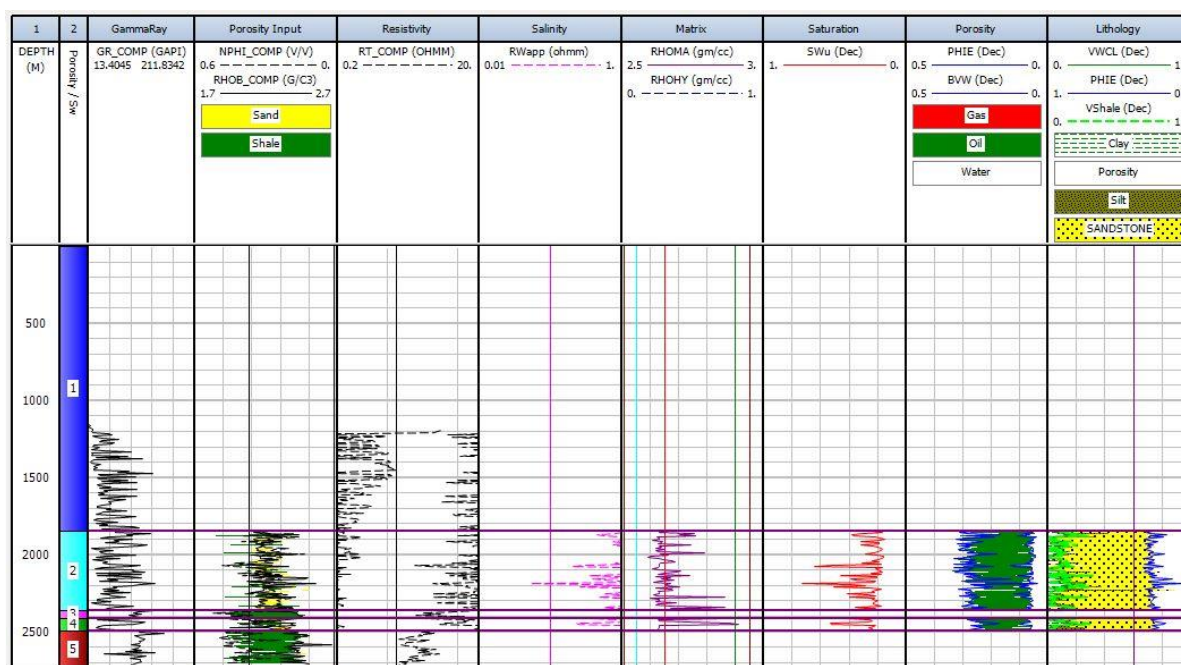


Figure 8: Reservoir Matrix delineation of IOA_19

Table 7: Petrophysical Curve Statistics for IOA_19

Well : IOA_19

Date Run : 29-Jul-25 3:21:32 PM

Curve	Units	Top	Bottom	Net	Min	Max	Mean
PHI	Dec	1848.917	2365.4	516.647	0.029	0.382	0.266
PHIT	Dec	1848.917	2365.4	516.647	0.040	0.374	0.270
PHIE	Dec	1848.917	2365.4	516.647	0.034	0.374	0.266
SW	Dec	1848.917	2365.4	516.647	0.147	1.000	0.289
VSH	Dec	1848.917	2365.4	516.647	0.000	0.442	0.101
Perm	md	1882.445	2330.958	246.738	8.558	5114.240	848.053

Well : IOA_19

Date Run : 31-Jul-25 3:10:08 AM

Curve	Units	Top	Bottom	Net	Min	Max	Mean
PHI	Dec	2417.216	2492.502	75.438	0.082	0.461	0.249
PHIT	Dec	2417.216	2492.502	75.438	0.162	0.426	0.256
PHIE	Dec	2417.216	2492.502	75.438	0.152	0.422	0.252
SW	Dec	2417.216	2492.502	75.438	0.142	0.663	0.297
VSH	Dec	2417.216	2492.502	75.438	0.000	0.443	0.105
Perm	md	2417.216	2492.502	75.438	0.857	12575.422	513.630

Petrophysical parameters of reservoirs 1 and 2 delineated within the well (Table 7)

Reservoir 1 has effective porosity value of 26.6% while reservoir 2 has 25.2% within the well. Water saturation is higher in reservoir 2 with a value of 29.7% while the least value of 28.9% is in Reservoir 1. Delineated

reservoirs have permeability values above 100<K<1000mD (Table 7).

WELLIOA_52

WELL IOA_52 has a depth profile of 1550.06ft to 3909.97ft. Two (2) reservoirs were delineated within this well (Figure 9).

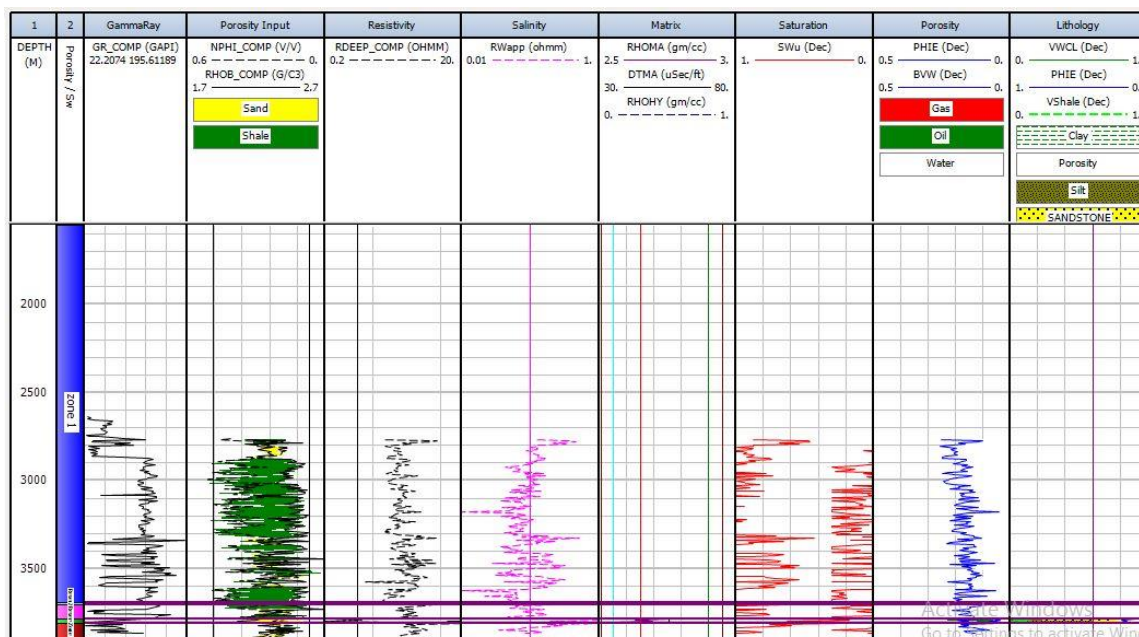


Figure 9: Reservoir Matrix delineation of IOA_52

Table 8: Petrophysical Averages Report

Well : IOA_52

Date Run : 29-Jul-25 3:32:43 PM

Curve	Units	Top	Bottom	Net	Min	Max	Mean
PHI	Dec	3691.738	3706.52	14.935	0.079	0.279	0.192
PHIT	Dec	3691.738	3706.52	14.935	0.051	0.263	0.155
PHIE	Dec	3691.738	3706.52	14.935	0.051	0.263	0.149
SW	Dec	3691.738	3706.52	14.935	0.132	1.000	0.401
VSH	Dec	3691.738	3706.52	14.935	0.000	0.237	0.077
Perm	md	3693.719	3701.948	8.382	3.860	1252.955	259.919

Well : IOA_52

Date Run : 29-Jul-25 3:33:12 PM

Curve	Units	Top	Bottom	Net	Min	Max	Mean
PHI	Dec	3783.025	3811.524	28.651	0.053	0.247	0.184
PHIT	Dec	3783.025	3811.524	28.651	0.043	0.243	0.144
PHIE	Dec	3783.025	3811.524	28.651	0.043	0.243	0.142
SW	Dec	3783.025	3811.524	28.651	0.086	1.000	0.304
VSH	Dec	3783.025	3811.524	28.651	0.000	0.160	0.030
Perm	md	3783.33	3811.524	28.346	0.315	1471.121	215.204

Petrophysical parameters of reservoirs 1 and 2 delineated within the well (Table 8).

Reservoir 1 has the highest effective porosity value of 14.9% while reservoir 2 has the least with 14.2% within the well. Reservoir 1 has highest Water saturation value of 40.1% while the least value of 30.4% is in Reservoir

2. Meanwhile, delineated reservoirs have permeability values within the range of $100 < K < 1000 \text{ mD}$ (Table 8)..

Summary of Petrophysical Parameters

Key production petrophysical parameters within all 18 reservoirs (Figure 9) reveal the quality of the reservoirs being studied.

Table 9: Petrophysical Parameters across Depobelts

Well code	Reservoir	Effective Porosity (ϕ_{eff})	Water Saturation (Sw) (Indonesian)	Permeability (K) (mD)
IOA_13	Reservoir 1	0.210	0.457	425.446
	Reservoir 2	0.179	0.403	677.581
	Reservoir 3	0.245	0.198	2,356.494
	Reservoir 4	0.156	0.246	831.532
IOA_14	Reservoir 1	0.270	0.352	1,206.234
IOA_15	Reservoir 1	0.275	0.326	1,114.875
	Reservoir 2	0.255	0.340	190.287
IOA_16	Reservoir 1	0.274	0.200	6,497.094
	Reservoir 2	0.232	0.378	311.567
IOA_17	Reservoir 1	0.274	0.325	967.861
	Reservoir 2	0.255	0.439	181.010
	Reservoir 3	0.168	0.131	7,942.091
IOA_18	Reservoir 1	0.251	0.339	3,058.104
	Reservoir 2	0.252	0.156	4,459.963
IOA_19	Reservoir 1	0.266	0.289	848.053
	Reservoir 2	0.252	0.297	513.630
IOA_52	Reservoir 1	0.149	0.401	259.919
	Reservoir 2	0.142	0.304	215.204
Mean values		0.228	0.310	1780.941

Results obtained from 18 reservoirs in 8 wells put Effective Porosity (ϕ_{eff}) in the range of 0.142 – 0.275 (14.2% - 27.5%) adjudged to be good porosity to very good porosity according to Atto *et al.*, (2025). Water Saturation values in all 18 reservoirs ranged between 0.131 (13.1%) and 0.457 (45.7%). The works of Buckles, (1965) and Fozao *et al.*, (2019) reveal that water saturation below the 0.5 (50%) cut-off portends a reservoir that has a hydrocarbon potential and CO_2 storage capacity that is economically viable if other parameters are okay. Permeability (k) values ranged between 181.01mD and 7942.091mD across all 18 reservoirs studied. These K values fall within the 'Very good - Excellent' permeability classification according to the works of Bachu (2007).

CONCLUSION

Overall Mean value of Effective porosity, Water Saturation and Permeability for the G – Oil field stood at 22.8% for ϕ_{eff} , 31.0% for Sw and 1780.941mD for k. These values as reviewed fell in the quality classification of Very good porosity, Very good Water Saturation and Excellent Permeability. These imply that the G – Oil field has good quality reservoirs which are

highly prolific in terms of hydrocarbon production and suitable for Carbon Sequestration.

REFERENCES

- Atto, Y. D. S, Yao, N. F, Kouadio, K. E, Ilbuodo, M and Monde, S (2025). Petrophysical Evaluation and Reservoir Quality of the Upper Cretaceous Sedimentary Formations of Block CI-M in the Ivorian Offshore Basin; *Open Journal of Geology*.15(6), 331-341. <https://dio.org/10.4236/ojg.2025.156016>
- Bachu, B. (2007). 'Screening and Ranking of hydrocarbon Reservoir for CO_2 Storage in Alberta Canada; *https://pdfs.semanticscholar.org*> accessed February 2025. <https://www.researchgate.net/publication/237408831>
- Coneybeare, C. E. B. (1967). Influence of Compaction on Stratigraphic Analysis. *Canadian Petroleum Geology Bulletin*, 15: 331-345. <https://dio.org/10.35767/gscpgbull.15.3.331>
- Craze, R. C. (1950). Performance of limestone reservoirs. *Petroleum Branch*, vol. 189. <https://dio.org/10.2118/950287-G>

- Doust, H. and Omasola, E. (1989). Niger Delta. Edited in Edwards, J. D., and Sandtoggrossi, P. A., Divergent/passive Margin Basins; *American Association of Geologists*, 48: 239-248. <https://doi.org/10.1306/M48508C4>
- Fozao, K. F., Djieto-Lordon, A. E., Ali, E. A. A., Agying, C. M., Ndeh, D. M. and Zebaze-Djuka M. K. (2019). Analysis of shaly sand reservoir rocks in the eastern Niger Delta Basin using geophysical well logs. *Journal of Petroleum and Gas Engineering*. Vol. 10(1), pp. 1-13. <https://doi.org/10.5897/JPG2018.0300>
- Burk, C. A and Drake, C. L. (1974). The Geology of Continental Margins, New York, *Springer-Verlag*, pp. 137-155. <https://doi.org/10.1017/S0016756800043120>
- Glover, P. W. J. (2000). Petrophysics – MSc Petroleum Geology; *University of Aberdeen, UK*. Pp270. <https://pdfcoffee.com/paul-glover-petrophysics-pdf-free.html>
- Moradi, S., Moeini, M., Al-Askari, M. K. G. and Mahvelati, E. H. (2016). Determination of shale volume and distribution patterns and effective porosity from well log data based on cross-plot approach for a shaly carbonate gas reservoir: *Earth and Environmental Science*, v. 44, Paper 042002, 7 p. <https://doi.org/10.1088/1755-1315/44/4/042002>
- Nelson, P.H. (2004). Permeability–porosity data sets for sandstones. *Leading Edge*; 23, 1143–1144, <https://doi.org/10.1190/1.1813360>
- Ojo, A. C. and Tse, A. C. (2016). Geological Characterisation of Depleted Oil and Gas Reservoirs for Carbon Sequestration Potentials in a Field in the Niger Delta, Nigeria. *J. Appl. Sci. Environ. Manage.* Vol. 20 (1) 45 – 55. <https://doi.org/10.4314/jasem.v20i1.6>
- Payton, R.L., Fellgett, M., Clark, B., Chiarella, D., Kingdon, A. and Hier- Majumder, S. (2020). UKGEOS PNM Supporting Data. *Royal Holloway University of London*. Dataset, <https://doi.org/10.17637/rh.13401059.v1>
- Short, K. C. and Stauble, A. J. (1967). Outline of the Geology of the Niger Delta. *AAPG Bulletin*, 51, 761-779. <https://doi.org/10.1306/5D25C0CF-16C1-11D7-8645000102C1865D>
- Society of Petroleum Engineers (SPE) (1987). Definitions for oil and gas reserves; *Journal of Petroleum Technology*, edited in Onyekonwo M.; Reservoir Engineering Volume 1. *Laser Engineering Consultants*. <https://www.scribd.com/document/600262124/SPE-1987-Definitions-of-Oil-and-Gas-Reserves>
- Storms, J., Weltje, G. J. And Geel, K (2020). Reservoir Rock Properties. *TU Delft*. Pp 41. <https://ocw.tudelft.nl>
- Tixier, M. P. (1949). Evaluation of Permeability from Electric Log Resistivity Gradients. *Oil and Gas Journal*. 8, pp. 75 - 90. <https://www.semanticscholar.org/paper/Evaluation-of-permeability-from-electric-log-Pierre/6326da9fdf97b066c4d8ab553bba082175576438>
- Ugbor, C.C., Obumselu, C.A. and Ogboke, J.O. (2022). Evaluation of the Influence of Shale on the Petrophysical Properties of Hydrocarbon-Bearing Reservoir Sand in ‘CAC’ Field in the Niger Delta, Nigeria. *International Journal of Geosciences*, 13, 71-92. <https://doi.org/10.4236/ijg.2022.131005>
- Umar, B. A., Gholami, R., Nayak, P., Shah, A. A. and Adamu, H. (2020). Regional and Field Assessments of Potentials for Geological Storage of CO₂: A case study of the Niger Delta Basin, Nigeria. *Journal of Natural Gas Science and Engineering*, 77 pp 35. <https://doi.org/10.1016/j.jngse.2020.103195>