

PETROPHYSICAL EVALUATION OF LOWER AGBADA FORMATION, DELTA-FRONT RESERVOIRS OF THE AWEN FIELD, NIGER DELTA BASIN

Chinagorom Ogonnaya Okorie ^{1*} , Kelechi Noble Asiegbu ², Onyinyechukwu Onyemaechi ³, Eugenia Ezinneamaka Chukwu ², Chibuike Martins Anyaezu ²

¹ Department of Geology, University of Port Harcourt, Choba, Nigeria

² Department of Geology, University of Nigeria, Nsukka, Nigeria

³ Alex Ekwueme Federal University Ndufu-Alike Ikwo, Ebonyi State, Nigeria

* Email (corresponding author): chinagorom_okorie@uniport.edu.ng

DOI: 10.51865/JPGT.2026.02.04

ABSTRACT

The Niger Delta Basin is rich with hydrocarbons but some of these deeper intervals in many fields are not fully explored due to limited petrophysical characterization. Despite extensive seismic and structural studies across the basin, integrated well log-based evaluation of deeper reservoir quality particularly in the Coastal Swamp Depobelt remains sparse, restricting informed development decisions for deeper targets.

In this study, a comprehensive petrophysical study of deeper reservoir sections in the Awen Field of the Coastal Swamp Depobelt, Niger Delta Basin was carried out. Wireline logs (caliper, gamma ray, resistivity, neutron, and density) from two exploration wells (Awen_1 and Awen_2) were used to define reservoir quality and fluid distribution. Eight stratigraphic sand packages were identified and correlated across the well. However, detailed evaluation was focused on Reservoirs A and B, the deeper productive horizons. The volume of shale was estimated based on the nonlinear model of Larionov for Tertiary rocks and the total porosity was obtained from the crossplots of density and neutron logs. Pickett plot analyses were used to get the formation water resistivity and the cementation exponents, which were used to estimate water saturation from Archie's equation. The relatively clean nature of the sands was considered in the calculation of permeability using the Timur correlation with irreducible water saturation of 0.1. Net-to-gross ratios were computed based on shale volume and porosity cut-offs.

Results indicate shale volume ranges from 0.11 to 0.28, average porosity from 0.25 to 0.27, water saturation from 0.30 to 0.41, and permeability from 946 to 1,223 mD, with net-to-gross values between 0.64 and 0.97. Reservoir A in Awen_1 is water-bearing, whereas Reservoir B contains hydrocarbons; both reservoirs in Awen_2 are oil-bearing. The low shale volume, favourable porosity, high permeability, and good net-to-gross ratios collectively indicate viable reservoir quality at deeper intervals within the Awen Field. These findings provide a petrophysical benchmark for deeper reservoir assessment in analogous Niger Delta fields and support future development planning in underexplored Depobelts.

Keywords: Petrophysical evaluation, volume of shale, porosity, water saturation, permeability, Niger Delta, reservoir characterization, wireline log analysis

INTRODUCTION

The Niger Delta Basin is renowned for its vast hydrocarbon reserves and has been the subject of numerous petroleum exploration and production-based studies and reports [1-3]. The Awen Field has been the focus of significant interest over time for its hydrocarbon potential because of its geologically complex and heterogeneous nature and its large hydrocarbon reserves. This presents difficulties when it comes to precisely assessing the petrophysical properties of its reservoir intervals. Previous studies in the Awen Field have mainly focused on seismic interpretation, stratigraphy and structural analysis [4],[5]. The results of these studies have been of great value in understanding the regional geology, depositional environments and tectonic evolution of the field. There is, however, a very limited type of petrophysical evaluation, which combines well log data and geological interpretation. This assessment is critical to comprehend the characteristics of the fluid and rock in the reservoir and to make proper estimates of hydrocarbon reserve within the field. Lack of understanding of the distribution of porosity, permeability and fluid saturation within reservoir intervals creates difficulties in the development of reservoir strategies. Thus, the need for a detailed petrophysical analysis to address the challenges and maximize hydrocarbon production from the Awen field has been the motivation for this study.

The petrophysical properties of reservoir intervals, however, such as porosity, permeability, and hydrocarbon fluid saturation, are important factors for the reservoir productivity and the efficiency of hydrocarbon recovery methods. Accurate assessment of these properties is essential to a decision on drilling and completion decisions and reservoir management. According to Anumah *et al* [6] and Fagbemigun *et al* [7], reliable assessment of the petrophysical properties of hydrocarbon-bearing reservoirs is key for the estimation of hydrocarbon reserves, identification of good production zones, and assessing the need for hydro-fracturing jobs.

The aim of this study is to assess different petrophysical parameters (volume of shale, porosity, permeability, water saturation and net to gross) of the wells and their effects on reservoir quality. The objectives include:

- (a) Correlation of stratigraphic sand packages across the two wells,
- (b) Estimate the petrophysical parameters across the reservoirs,
- (c) Identify the quality of the reservoirs across the two wells,
- (d) Analyse the fluid saturation profiles to identify potential hydrocarbon zones.

This communication therefore presents an evaluation of reservoir properties, specifically porosity, permeability, volume of shale, and water saturation, derived from wireline logs obtained from Awen_1 and Awen_2 within the Awen field.

The scope of this study work only focuses on the petrophysical studies of the reservoir interval within the Awen Field where the deeper reservoir intervals (A and B) is our core focus. Only two wells (Awen_1 and Awen_2) are evaluated and use a set of wireline logs: gamma ray, caliper, resistivity, neutron, and density logs. Analysis includes estimation of volume of shale, total and effective porosity, water saturation from Archie's equation, prediction of permeability using the Timur equation, and net-to-gross. The scope is intentionally limited to deeper intervals to be able to evaluate their potential as hydrocarbon bearing reservoirs, as shallower reservoirs have been explored more in the field.

Despite the considerable attention given to seismic interpretation and structural analysis in the Awen Field, comprehensive petrophysical evaluation integrating well log data with reservoir quality assessment remains limited. Existing studies in the Niger Delta have largely focused on either seismic-based structural mapping or generalized petrophysical analyses of multiple fields [8], without field-specific, well-to-well correlation of deeper reservoir intervals. Furthermore, there is a paucity of published data on the petrophysical properties of deeper reservoirs in the Coastal Swamp Depobelt [9], particularly regarding the integration of Pickett plot-derived formation water resistivity with Archie-based saturation modeling and Timur permeability estimation. This gap restricts the ability of operators to make informed development decisions for deeper targets in analogous fields.

The novelty of this work lies in its integrated approach to petrophysical evaluation of deeper reservoir intervals in a relatively underexplored field within the Coastal Swamp Depobelt. Specifically, this study:

- (i) presents a detailed well-to-well correlation and petrophysical analysis of Reservoir A and B in the Awen Field using a consistent methodology,
- (ii) combines Pickett plot analysis for formation water resistivity and cementation exponent and Archie's saturation model and the Timur permeability correlation to obtain a robust and internally consistent dataset for reservoir estimation,
- (iii) challenges the assumption that the deeper intervals in the Awen Field are predominantly water-bearing as the Awen Field demonstrates favourable reservoir quality (porosity 0.25 – 0.27, permeability 946 – 1,223 mD, net-to-gross 0.64–0.97),
- (iv) provides a petrophysical benchmark for the Awen Field which can help guide future drilling, completion and reservoir management practices in geologically similar Niger Delta fields.

GEOLOGIC SETTING

The Niger Delta Basin, situated at the apex of the Gulf of Guinea on the west coast of Africa, covers an area of approximately 140,000km². Positioned at the southern terminus of the Benue Trough, the basin originated as a failed third arm during the rifting process associated with the South Atlantic that commenced in the early Jurassic and ceased in the late Cretaceous [10-12]. Following the cessation of rifting, gravity tectonics became the dominant deformational process [13]. The Niger Delta Basin has been affected by both pre-sedimentary and syn-sedimentary tectonic activities during its evolutionary path [14],[15]. These tectonic events played a vital role in shaping the development of the basin. Furthermore, the structural framework exerted fundamental control over paleogeographic boundaries, both in the present and in the past, during the evolution of the Niger Delta Basin.

The study area is located within the proximal part of the coastal swamp depo-belt of the Niger Delta Basin (Figure 1). This portion of the Niger Delta Province is delineated by the geology of southern Nigeria and southwestern Cameroon. The province encompasses the geological extent of the Tertiary Niger Delta (Akata-Agbada) Petroleum System. The formation of reservoirs in the Awen Field can be attributed to interaction of various geological processes [16]. The Basin has undergone many cycles of sedimentation which have been eroded from the inland and transported by the rivers (fluvial process) into the deltaic environment. This process has resulted in the formation of extensive sequences of sand and shale, serving as principal

reservoir, source, and seal rocks respectively. The structural style within the study area primarily consists of normal faults that predominantly trend in the northwest-southeast (NW-SE) direction [17].

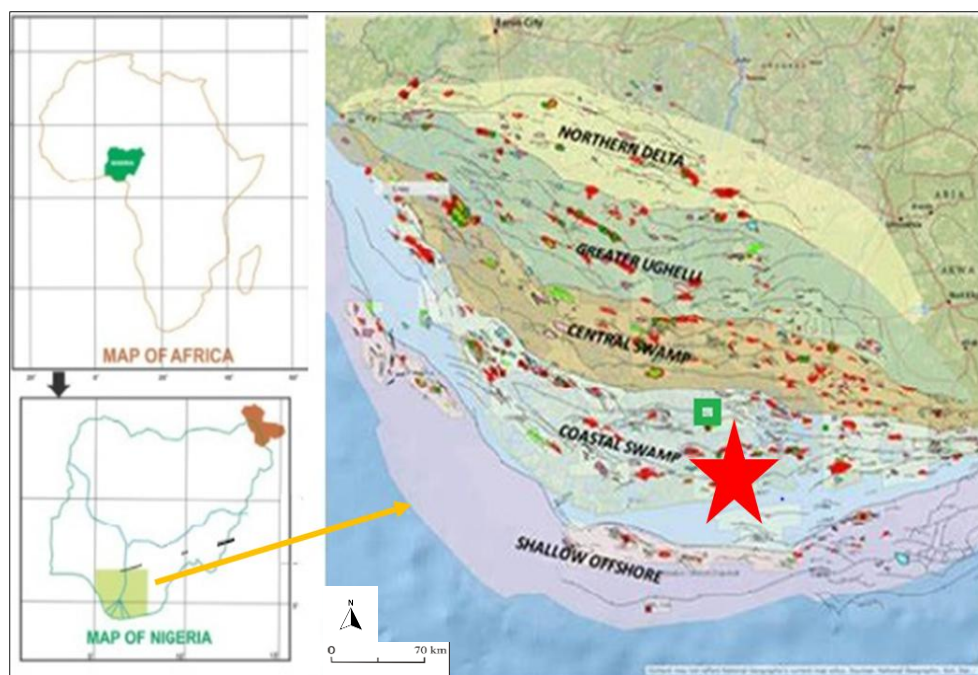


Figure 1. Map showing the depobelts of the Niger Delta and the location of the study area [19].

The reservoir intervals studied in this work is associated with the Agbada Formation which is the principal petroleum bearing unit of the Niger Delta Basin. The Agbada Formation is composed of over 3700 meters of paralic siliciclastics, which represents the true deltaic section of the sequence, that were deposited in delta-front, delta-topset and fluvio-deltaic environments [16],[18]. The Awen reservoirs occur in the lower section of the Agbada Formation which is made up of shale and sandstone deposits in almost equal proportions. The environment of deposition in the lower section of the Agbada formation is delta front to prodelta. This is the transition from shallow-marine deltaic sedimentation to deeper subaqueous environment; the upper part of the Agbada Formation is a mixture of sand and minor shale interbeds [18]. The facies association consists of interbedded sequences of sandstone and shale formed by mouth bar processes of the distributaries and turbidity currents in a paralic environment [1]. Sandstone units are delta-front mouth bar and distributary channel deposits, with blocky gamma-ray log signatures, and moderate to good lateral continuity. Prodelta shale intervals serve as intra-reservoir baffles and possible flow barriers between these sands. The upper part of the Agbada Formation, on the other hand, grades into more fluvio-deltaic continental deposits, consisting largely of alluvial sands of the Benin Formation [18]. The depositional environment of the lower Agbada then created the primary reservoir structure observed in this study, clean well sorted delta front sand and shale interbedding which also serve as a local seal and source rock. The Agbada Formation is underlain by the marine Akata Formation, a thick (up to 2000 m) shale formation that is the main source rock, and overlain by the continental Benin Formation, alluvial and upper coastal plain sand up to 2000 m thick [18],[13]. The presence of faulting and

fracturing further adds to its geologic complexity, influencing fluid flow and reservoir connectivity. So far, only two wells have been drilled, Awen_1 and Awen_2. Two hydrocarbon-bearing reservoir levels were identified across both wells.

METHODOLOGY

The workflow is categorized into 6 parts with each workflow performing its own task using the petrophysical software Techlog. The well logs available for this study were caliper logs, gamma ray logs, resistivity logs, neutron, and density logs. Estimated petrophysical parameters are porosity, volume of shale, permeability, Net to gross and water saturation. Figure 2 shows the workflow used for the study.

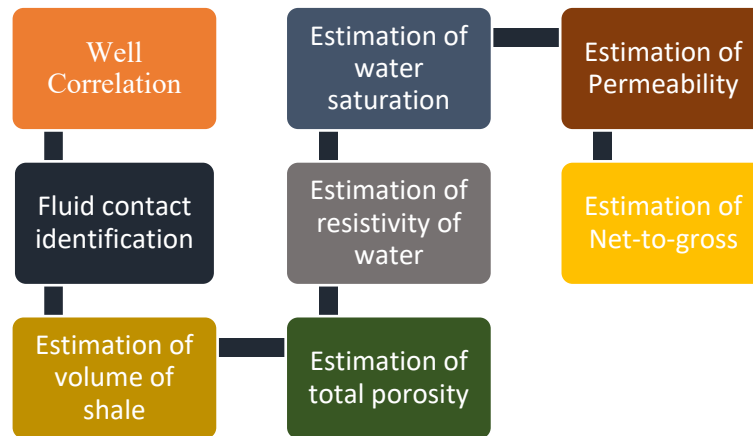


Figure 2. Study workflow.

Sand intervals were identified and correlated across both wells using gamma ray logs [20],[21]. The Volume of shale (VSH) was estimated using Gamma ray which has two empirical responses; linear and nonlinear. The Larionov model for Tertiary rocks [22] was used for volume of shale estimation (Equation 2). Fluid contacts were identified using a combination of resistivity, neutron, and density logs [23].

Porosity is a very important petrophysical parameter that gives us the amount of available pore spaces within the reservoir. For this study, we estimated porosity using density log (Equation 3). However, the water saturation within the Awen Field was estimated using the Archie's model given in Equation 4 [24],[25].

Permeability is one of the key parameters in determining reservoir quality. This explains the interconnectivity of the pore spaces within the reservoir. The permeability of the reservoir of interest was estimated using the Timur correlation for permeability. Irreducible water saturation of 0.1 was used for permeability estimation as the sands were relatively clean [26],[27].

Linear response ($V_{sh} = I_{GR}$):

$$V_{sh} = I_{GR} = \frac{GR_{log} - GR_{matrix}}{GR_{shale} - GR_{matrix}} \quad (1)$$

where: I_{GR} = linear response to shaliness or clay content,

GR_{log} = log reading at the depth of interest,

GR_{matrix} = Gamma ray value in a nearby clean zone,

GR_{shale} = Gamma ray value in a nearby shale.

For Linear Gamma ray, clay volume relationship is given as: $V_{sh} = I_{GR}$. And for nonlinear Gamma ray, clay volume relationships are given as [31]:

$$V_{sh} = 0.083 \times (2^{(3.7 \times I_{GR})} - 1) \quad (2)$$

$$\phi_T = \frac{\rho_{ma} - \rho_b}{\rho_{ma} - \rho_f} \quad (3)$$

where: ϕ = porosity

ρ_{ma} = matrix density (2.65g/cm³)

ρ_b = formation bulk density (log value)

ρ_f = fluid density.

$$S_w = \left\{ \frac{a \times R_w}{\Phi^m \times R_t} \right\}^{1/n} \quad (4)$$

where: R_t = formation resistivity (containing hydrocarbon and water with a saturation of S_w)

R_w = formation water resistivity,

Φ = porosity,

n = saturation exponent,

a = numerical coefficient depending on lithology and pore geometry,

m = cementation factor.

From water saturation S_w , hydrocarbon saturation (S_H) can be estimated as;

$$S_H = 1 - S_w \quad (5)$$

$$k = k_w \times \frac{\Phi^d}{S_{wi}^e} \quad (6)$$

where: k = permeability in millidarcy (mD),

Φ = porosity,

S_{wi} = irreducible water saturation,

$d = 4.4$; $e = 2$; $k_w = 3400$ for oil; $k_w = 340$ for gas.

RESULTS AND DISCUSSION

Petrophysical evaluations were carried out from Awen_1, and Awen_2 wells, utilizing a comprehensive set of logging data, including gamma ray, neutron-density, and resistivity logs. Eight reservoir intervals were identified and correlated across the field. This was delineated using the gamma-ray log which measures the amount of radioactive content in the reservoir [27]. Moreover, for this study, petrophysical evaluation was restricted to reservoirs A and B (Figure 3).

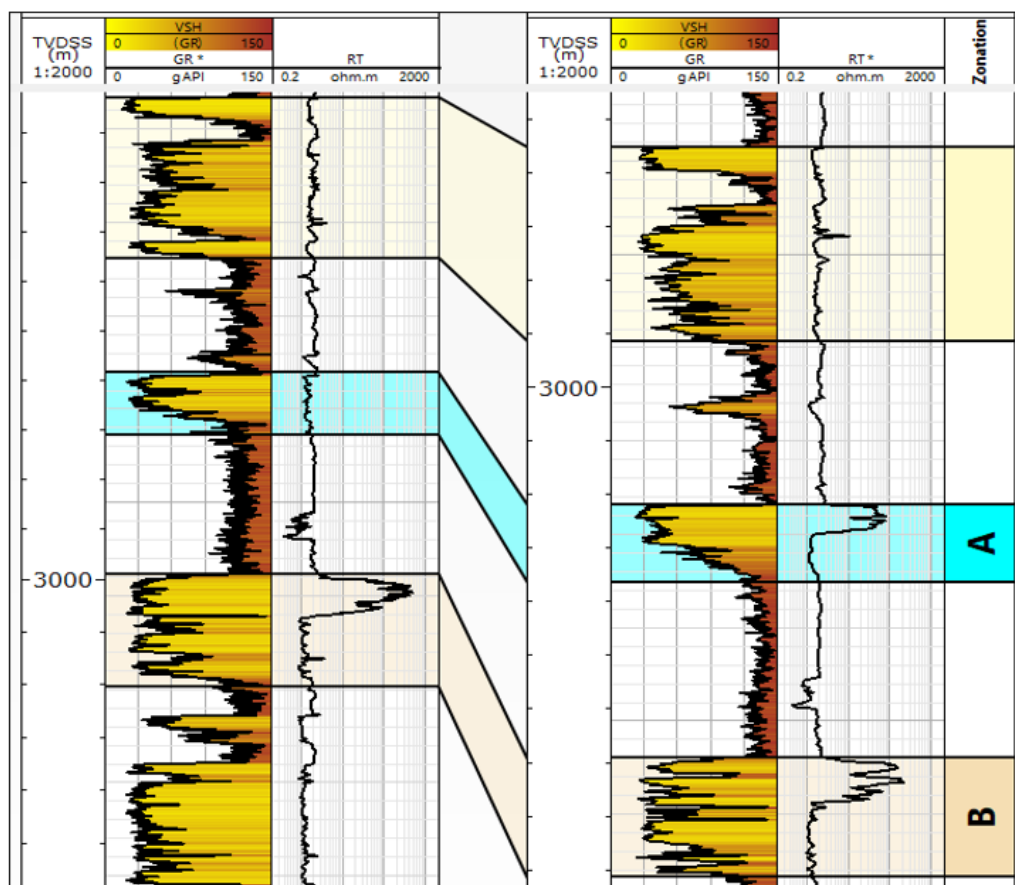


Figure 3. Well correlation/zonation across Awen_1 and Awen_2.

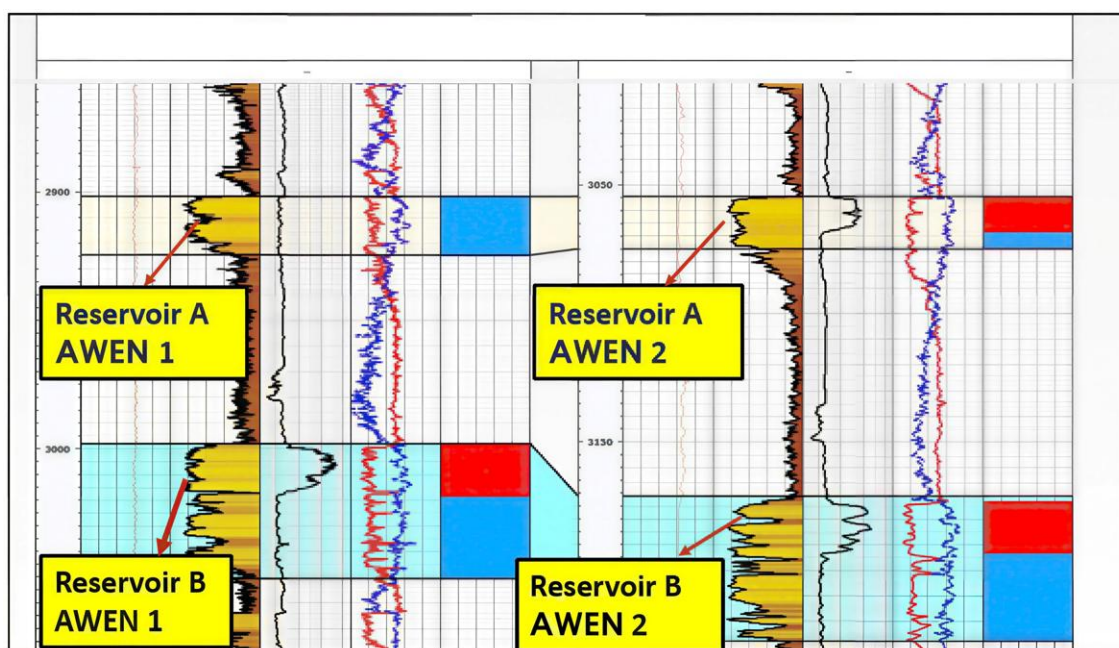


Figure 4. Fluid identification (Blue = water, Red = Oil).

Table 1. Fluid contact results.

Wells	Reservoir	Contact (OWC, mTVDSS)
Awen_1	A	Wet
Awen_1	B	3017.49
Awen_2	A	3068.34
Awen_2	B	3193.68

The volume of shale and lithology were estimated using gamma ray log (Figure 5). This accounts for the effect of shale contents within the reservoir intervals in the Awen field [29]. A summary of values of the various reservoir parameters is presented in Table 2. Porosity of each zone was determined using neutron, and density logs (Figure 6). A general observation from the wells indicates a decrease in total porosity values with increasing depth. The average estimated porosity for the two wells ranged from 0.25 to 0.27, indicating a favorable porosity range for hydrocarbon saturation.

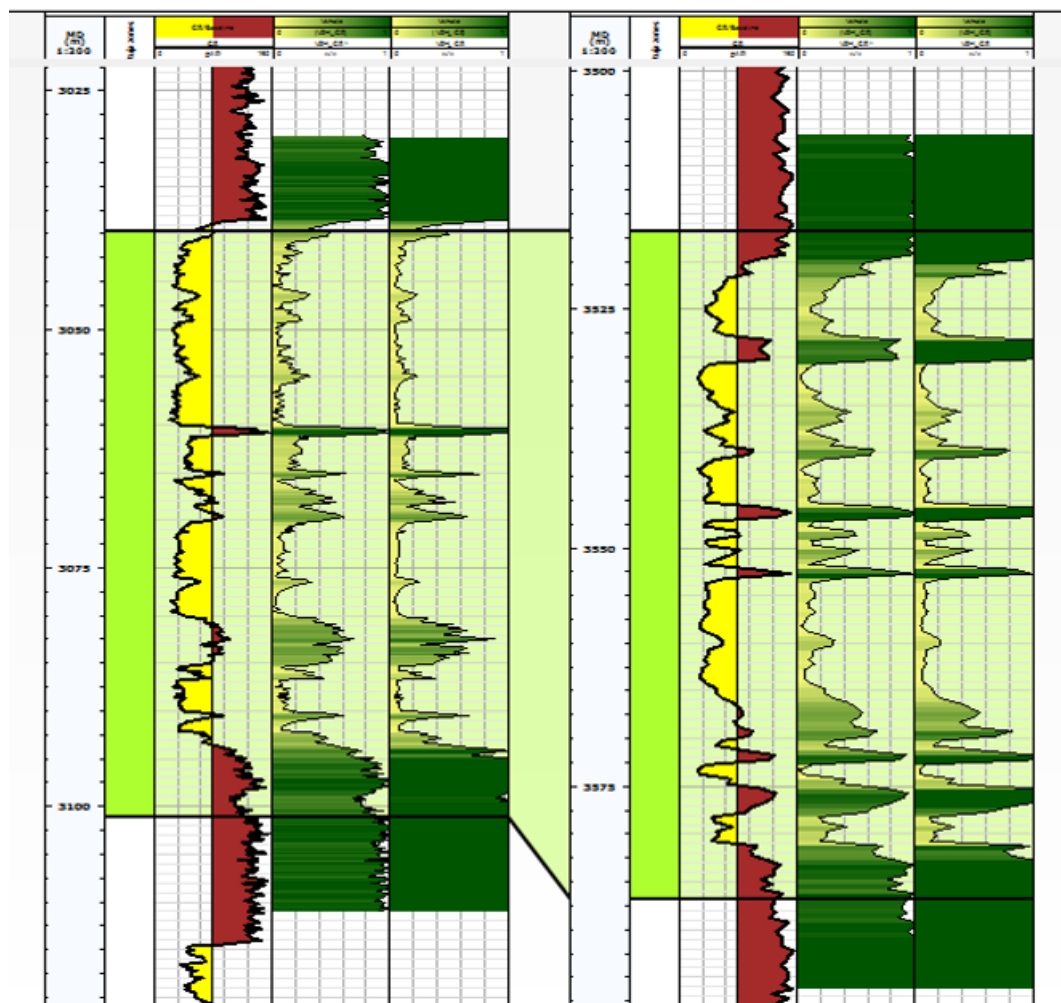


Figure 5. Volume of shale computation using Gamma ray log.

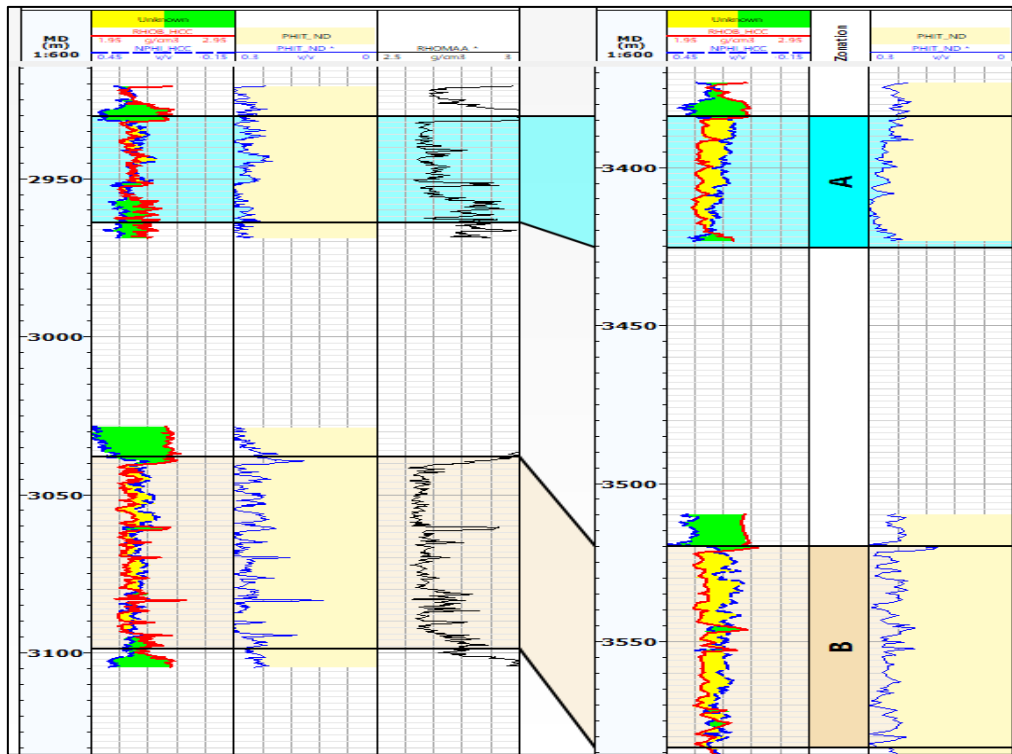


Figure 6. Total porosity estimation using neutron-density log.

Resistivity of formation water was estimated using Pickett plot. For each reservoir, clean sand zones were carefully selected in both wells and utilized in the construction of the Pickett plot. Figure 7a and 7b show the Pickett plots of the reservoirs A and B which have corresponding values of $R_w = 0.115$, $m = 1.911$, and $R_w = 0.129$, $m = 1.676$ respectively.

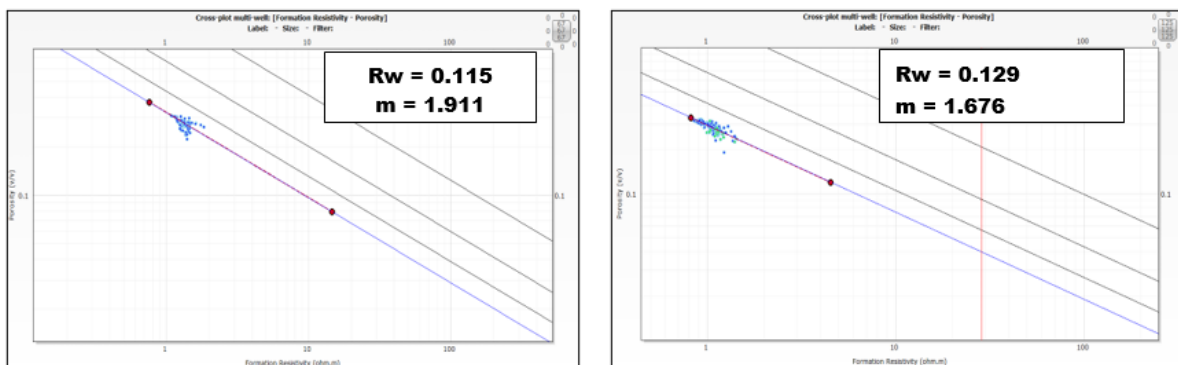


Figure 7. Pickett plot for: a) Reservoir A; b) Reservoir B.

Water saturation was estimated using the Archie's saturation model [30], which suggests the sand were of good quality (Figure 8). The estimated water saturation in these reservoirs ranges from 0.30 to 0.41, as illustrated in Table 2. The permeability of the reservoir was estimated between 946.938 and 1222.93 millidarcy (mD), pointing to a highly favourable permeability level. Overall, the low shale volume and corresponding fair to good porosity, favourable

permeability (Figure 9) and good net-to-gross (Table 2) is an indication of viable reservoirs at deeper intervals within the Awen field.

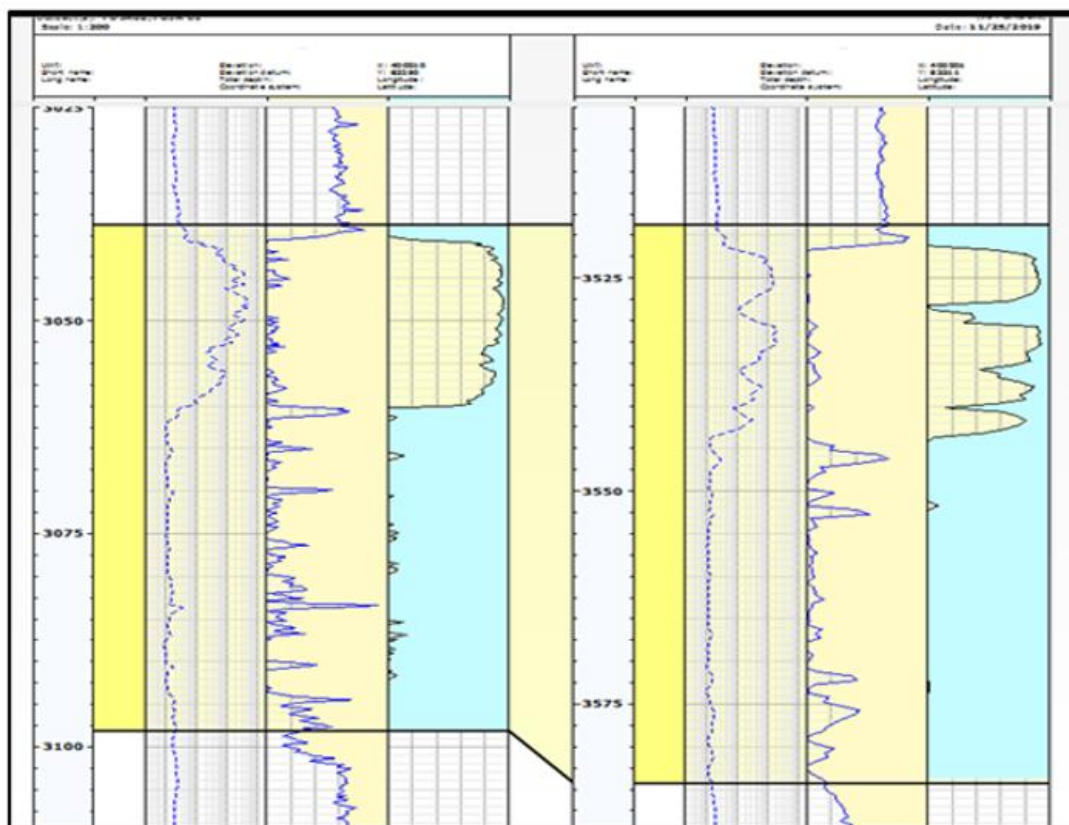


Figure 8. Water saturation (S_w) computed using Archie's model.

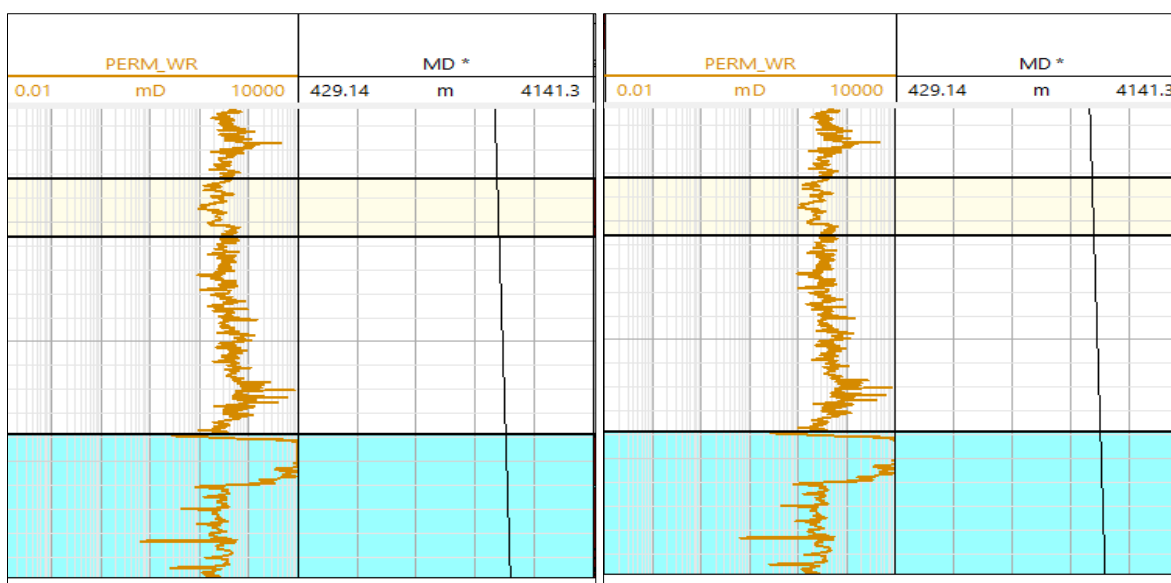


Figure 9. Permeability estimation.

Table 2. Average petrophysical properties.

<i>Well</i>	<i>Reservoir</i>	<i>Average volume of shale (v/v)</i>	<i>Average Porosity (%)</i>	<i>Average Water Saturation (%)</i>	<i>Average Permeability (mD)</i>	<i>Net to Gross (v/v)</i>
Awen_1	A	0.168	0.270	Wet	1142.76	0.97
Awen_1	B	0.166	0.270	0.380	1222.93	0.64
Awen_2	A	0.155	0.267	0.303	1102.14	0.78
Awen_2	B	0.280	0.259	0.410	946.938	0.81

Well log correlation shows the same sand facies in both wells, but significant reservoir compartmentalization has been identified from the fluid distribution. Awen_1, being at a higher structural position (up-dip, about 3,017 m TVDSS), is water-bearing while Awen_2 (down-dip, about 3,068 m TVDSS) is oil-bearing. This pattern of inversion of what was expected a down-dip sequence of water and up-dip sequence of oil suggests a tectonic or stratigraphic barrier preventing communication of fluids between the wells. Likewise, the oil-water contacts (OWC) are different between Awen_1 (3,017.49 m TVDSS) and Awen_2 (3,193.68 m TVDSS), with a variation of 176.19 m between them. The NW-SE trending normal faults mapped in the study area [17] probably provide sealing barriers to the faults, forming discrete fault blocks separated by fluid columns. This compartmentalization reveals that Reservoirs A and B in Awen_1 and Awen_2 are not a single connected reservoir and as such must be assessed separately.

CONCLUSIONS

Detailed petrophysical evaluation of reservoir intervals within the Awen Field has been conducted using wireline logs (gamma ray, neutron/density, and resistivity logs) obtained from two drilled wells in the field. Eight stratigraphic sand packages were correlated across the two wells. The results obtained from the evaluation (Awen_1 and Awen_2) indicated good reservoir qualities, with favourable values observed for volume of shale, porosity, permeability, net-to-gross, and water saturation. These findings suggest the potential for hydrocarbon accumulation and production in the Awen Field.

It is important to note that the two important reservoirs of this study were carefully selected to include their distinctive fluid properties which were obtained from the two wells in the Awen field (Awen_1 and Awen_2). This is a good indication that more work needs to be done to explore and collect more data to understand the reservoir properties of the entire field. Furthermore, the core analysis and geological interpretation would also increase the accuracy and reliability of the petrophysical evaluation.

The research findings from this study provides information that will be used in reservoir development and production planning for the Awen Field in the future. Moreover, detailed reservoir characterization, such as further petrophysical analysis, reservoir modelling, and dynamic simulation, will be essential in optimizing drilling, completion, and reservoir production and management strategies. Concerted efforts in petrophysical analysis and further data acquisition will contribute to much-improved reservoir characterization and the maximization of hydrocarbon recovery from the Awen Field, Niger Delta Basin.

ACKNOWLEDGEMENTS

We would like to express our profound gratitude to the following scholars for their guidance to ensure a successful work done; Ishoma Oshilike, Daniel Fadokun, Kelechi Osime, Orrelo Athoja, and Robinson Madu. More so, we want to extend our honest gratitude to all the researchers whose wonderful contributions helped to improve knowledge in this field of study.

REFERENCES

- [1] Okwoli E., Obiora D., Adewoye O., Chukudebelu J., Ezema P., Reservoir characterization and volumetric analysis of Lona field, Niger Delta, using 3-D seismic and well log data, *Petroleum and Coal*, vol. 57, no. 2, pp. 108–119, 2015.
- [2] Dim P.I.C., Onuoha K.M., Ozumba B.M., Hydrocarbon leads and prospects opportunities across a cluster of fields in parts of onshore Niger Delta Basin, *Journal of African Earth Sciences*, vol. 164, p. 103804, 2020.
- [3] Ogbe O.B., Okoro A.U., Ogagarue D.O., Osokpor J., Overare B., Ocheli A., Aghogho A.O., Oluwajana O.A.I., Oluwajana O.A., Reservoir hydrocarbon prospectivity and productivity evaluations of sands S-600 and S-700 of Fega field, onshore Niger Delta Basin, Nigeria, *Journal of African Earth Sciences*, vol. 184, p. 104311, 2021.
- [4] Toba A., Ideozu R.U., Ibe A.C., Modelling of reservoirs in Awe-Field, Eastern Niger Delta, Nigeria, *IOSR Journal of Applied Geology and Geophysics*, vol. 6, no. 1, pp. 36–46, 2018.
- [5] Osaji A.G., Chiazor F.I., Patta A.L., Evaluation of petrophysical properties of a field in deep offshore Niger Delta Basin, *International Journal of Engineering Research & Development*, vol. 21, no. 8, pp. 89–109, 2025.
- [6] Anumah P., Mohammed S., Sarkodie-Kyeremeh J., Aggrey W.N., Morgan A., Petrophysical evaluation of the reservoir in the K-Field, offshore Ghana, in *SPE Nigeria Annual International Conference and Exhibition*, 2019.
- [7] Fagbemigun T.S., Fajana A.O., Odebunmi O.D., Oyanameh O.E., Tsado J., Osisanya W.O., Petrophysical parameters analysis and reservoir correlation of Atinuk field, Niger Delta Basin, Nigeria, *Scientific Journal of Basic and Applied Sciences*, vol. 12, no. 1, pp. 1–15, 2023.
- [8] Onyekuru S.O., Oluoma C.F., Ikoru D.O., Okoro E.M., Selemo A.O., Okoli E.A., Depositional sequences and petrophysical evaluation to predict potential prospects of clastic reservoirs of Olu field, onshore Niger Delta, *Arabian Journal of Geosciences*, vol. 15, p. 1566, 2022.
- [9] Oluwajana O.A., Petrophysical analysis of reservoirs in Well-Y, Coastal Swamp Depobelt, Niger Delta Basin, Nigeria, *Achievers Journal of Scientific Research*, vol. 4, no. 1, pp. 11–20, 2022.
- [10] Lehner P., De Ruiter P.A.C., Structural history of Atlantic margin of Africa, *AAPG Bulletin*, vol. 61, no. 7, pp. 961–981, 1977.
- [11] Klett T.R., Ahlbrandt T.S., Schmoker J.W., Dolton G.L., Ranking of the World's Oil and Gas Provinces by Known Petroleum Volumes, U.S. Geological Survey, Open-File Report 97-463, 1997.

- [12] Pochat S., Castelltort S., Van Den Driessche J., Besnard K., Gumiaux C., A simple method of determining sand/shale ratios from seismic analysis of growth faults: An example from upper Oligocene to lower Miocene Niger Delta deposits, AAPG Bulletin, vol. 88, no. 10, pp. 1357–1367, 2004.
- [13] Tuttle M.L., Charpentier R.R., Brownfield M.E., The Niger Delta Petroleum System: Niger Delta Province, Nigeria, Cameroon, and Equatorial Guinea, Africa, U.S. Geological Survey, Open-File Report 99-50, 1999.
- [14] Knox G.J., Omatsola E.M., Development of the Cenozoic Niger Delta in terms of the 'escalator regression' model and impact on hydrocarbon distribution, in Coastal Lowlands: Geology and Geotechnology, H. J. Oertli, Ed. Rotterdam, Netherlands: A.A. Balkema, pp. 181–202, 1989.
- [15] Stacher P., Present understanding of the Niger Delta hydrocarbon habitat, in Geology of Deltas, M.N. Oti and G. Postma, Eds. Rotterdam, Netherlands: A.A. Balkema, pp. 257–267, 1995.
- [16] Short K.C., Stauble A.J., Outline of geology of the Niger Delta, AAPG Bulletin, vol. 51, no. 5, pp. 761–779, 1967.
- [17] Opara A.I., Okoro E.M., Onyekuru S.O., Njoku I.O., Onyenegecha C.P., Asedegbega J.E., Ekwe A.C., Okoli A.E., Ezekiel J.C., Fault seal integrity and strati-structural studies of reservoirs in parts of the onshore Niger Delta, using deterministic and stochastic techniques, NAPE Bulletin, vol. 30, no. 2, pp. 9–22, 2021.
- [18] Reijers T.R.A., Stratigraphy and sedimentology of the Niger Delta, Geologos, vol. 17, no. 3, pp. 133–162, 2011.
- [19] Lucas F.A., Omodolor Hope E., Lithofacies characterization of sedimentary succession from Oligocene to Early Miocene age in X2 well, Greater Ughelli Depo Belt, Niger Delta, Nigeria, Journal of Geosciences and Geomatics, vol. 6, no. 2, pp. 77–84, 2018.
- [20] Asquith G., Gibson C., Basic Well Log Analysis for Geologists. Tulsa, OK, USA: American Association of Petroleum Geologists, 1982.
- [21] Rider M.H., The Geological Interpretation of Well Logs. Glasgow, UK: Blackie, 1986.
- [22] Larionov V.V., Radiometry of Boreholes. Moscow, Russia: Nedra, 1969.
- [23] Crain E.R., Visual analysis rule for water saturation, Petrophysical Handout, 2016.
- [24] Philip C.I., Formation-resistivity theory: How Archie equations, shaly-reservoir models, conductive rock-matrix model and dual-triple-porosity model are related, SPE Reservoir Evaluation & Engineering, 17 (3), 314–325, 2014.
- [25] Onyekuru S.O., Maduka R.C., Anyanwu T.C., Njoku I.O., Ikoro D.O., Amadi C.C., Agbasi O.E., Fagorite V.I., Integrated stratigraphic and petrophysical assessment of the Maduky field, Niger Delta, Nigeria: implications for reservoir architecture and hydrocarbon prospectivity. Romanian Journal of Petroleum & Gas Technology, vol. 7, no. 1, pp. 219–241, 2026.
- [26] Timur A., Effective porosity and permeability of sandstones investigated through nuclear magnetic resonance principles, in Proc. SPWLA 9th Annual Logging Symposium, 1968.
- [27] Etu-Efeotor J.O., Fundamentals of Petroleum Geology. Port Harcourt, Nigeria: Jeson Services, 1997.

-
- [28] Bridge J., Demicco R., *Earth Surface Processes, Landforms and Sediment Deposits*. Cambridge, UK: Cambridge University Press, 2008.
 - [29] Adeoti L., Ayolabi E.A., James P.L., *An integrated approach to volume of shale analysis: Niger Delta example, Orire Field*, 2009.
 - [30] Archie G.E., The electrical resistivity log as an aid in determining some reservoir characteristics, *Transactions of the AIME*, vol. 146, no. 1, pp. 54–62, 1942.
 - [31] Ojo, O.A., Oluwadare O.A., Balogun J.A., Akinterinwa K.O., *Geopressure prediction and intensity characterization based on fuzzy inference system in Barbados Field of the Niger Delta, Nigeria*. *Romanian Journal of Petroleum & Gas Technology*, vol. 6, no. 2, pp. 139-156, 2025.

Received: May 2026; Revised: June 2026; Accepted: July 2026; Published: July 2026