Engineering and Technology Journal e-ISSN: 2456-3358

Volume 11 Issue 03 March-2026, Page No.-9151-9158

DOI: 10.47191/etj/v11i03.03, I.F. – 8.595

A Geological Interpretation of Depositional Environments from "NIK Field" Niger Delta Using Well Logs

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ABSTRACT: The geological interpretation of depositional environments is fundamental for understanding reservoir heterogeneity and optimizing hydrocarbon recovery in the Niger Delta. This paper focuses on the "NIK" Field, utilizing wireline log data obtained from the Nigerian Agip Oil Company (NAOC) to delineate lithofacies and reconstruct the sedimentary environment of the Agbada Formation. A suite of Gamma Ray (GR) and Resistivity logs from two wells (NIK 1 and NIK 2) within "NIK Field" were analyzed to identify electrofacies motifs and stratigraphic continuity. The well logs reveal a transition from distal marine shales to proximal deltaic deposits. NIK-1 is characterized by approximately 30m thick, blocky shaped distributary channel sand, while NIK-2 exhibits approximately 19m thick, funnel-shaped prograding shoreface sequence. Stratigraphic correlation demonstrates a lateral facies transition and structural thinning toward the east, influenced by the field's location within a rollover anticline. This paper provides a localized depositional model that enhances the prediction of reservoir geometry and connectivity, offering a robust framework for further field development and target identification within the "NIK" Field.

KEYWORDS*:* Depositional environment, well log, Gama Ray, paleo-deposition, sequence stratigraphy

INTRODUCTION

The Niger Delta stands as one of the world's most prolific hydrocarbon provinces, characterized by a complex interplay of deltaic, shallow marine, and deep-water depositional systems (Asaah 2011; Short and Stäuble, 1967). For decades, the pursuit of energy resources in this region has driven the need for high-resolution subsurface characterization (Asaah 2011; Oghonyon et al 2025). Understanding the depositional environment is not merely an academic exercise; it is the cornerstone of predicting reservoir geometry, connectivity, and quality (Erhire et al 2025; Osaki and Oghonyon 2025). Deciphering the spatial and temporal distribution of lithofacies within the Agbada Formation tends to offer challenges in NIK Field (Osaki and Oghonyon 2025). This formation is a classic example of a prograding deltaic sequence where rapid sedimentation and growth faulting create high stratigraphic complexity (Laurence et al 2002).

While seismic data provides a structural framework, well log analysis offers the vertical resolution necessary to identify specific depositional sub-environments (Ideozu et al., 2024; Osaki and Oghonyon 2025). By analyzing the characteristic shapes of Gamma Ray (GR) and Resistivity logs, geologists can distinguish between various architectural elements (Erhire et al 2025; Ochoma 2024).

According to Friday et al (2022), these log trends represent specific depositional energy regimes such as; progradational sequences (represented by "funnel" shapes, indicating a transition from low energy muds to high-energy shorefaces or delta fronts), aggradational units (Indicated by cylindrical or blocky shapes, typical of braided stream channels or thick eolian sands), and retrogradational packages (Marked by bell shapes, suggesting a fining-upward sequence common in fluvial channels or transgressive marine cycles).

Despite the general understanding of the Niger Delta's stratigraphy, local variations in the "NIK" Field present unique uncertainties regarding reservoir compartmentalization and sand body continuity (Abraham et al., 2020; Oghonyon et al 2025). A lack of precise environmental interpretation can lead to suboptimal well placement and inaccurate reserve estimations. This paper aims to bridge this gap by integrating petrophysical data to: identify and correlate key stratigraphic markers across the "NIK" Field, interpret the various lithofacies and their corresponding depositional environments using log signatures, reconstruct a localized depositional model that explains the evolution of the field's sedimentary architecture. By synthesizing these elements, this manuscript provides a robust geological framework that enhances our understanding of the "NIK" Field's reservoir potential and contributes to the broader knowledge of Niger Delta sedimentology.

MATERIALS AND METHODS

Description of the Study Area: The "NIK" Field is situated within the Niger Delta Basin, located on the continental margin of the Gulf of Guinea (Short and Stäuble, 1967). The field is positioned within the Cenozoic depobelt system, which formed as a result of the progradation of the Niger Delta onto the Atlantic crust (Hospers, 1965). Geologically, the area (see fig. 1 below) is characterized by a tripartite stratigraphic sequence which is the undercompacted marine shales of the Akata Formation, the paralic, sand shale alternations of the Agbada Formation, and the continental sands of the Benin Formation (Laurence et al 2002; Short and Stäuble, 1967; Doust and Omatsola, 1990). The structural architecture of the study area is dominated by syn-sedimentary growth faults and rollover anticlines, which act as the primary traps for the hydrocarbon accumulations within the Agbada Formation (Kame 1978).

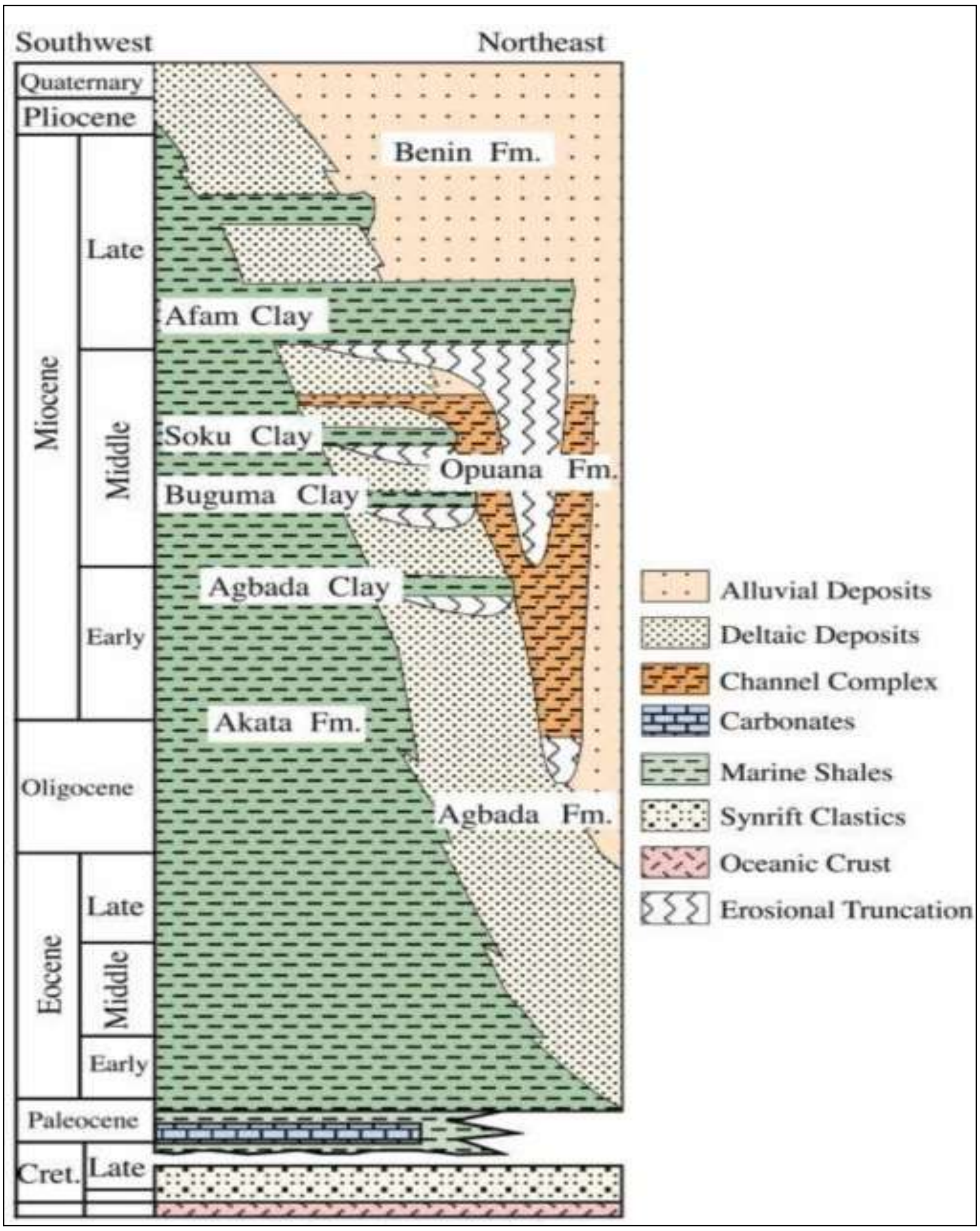

Fig. 1: Stratigraphic column showing the formations of the Niger Delta (modified from Lawrence et al., 2002).

The base map (in fig.2 below) illustrates the spatial distribution of the study wells, NIK-1 and NIK-2 within a structured 3D seismic grid. The grid is defined by a series of north-south trending Inline (5577-5847) and east-west trending Xline (1495-1745), which provide the coordinate framework for subsurface mapping and data integration.

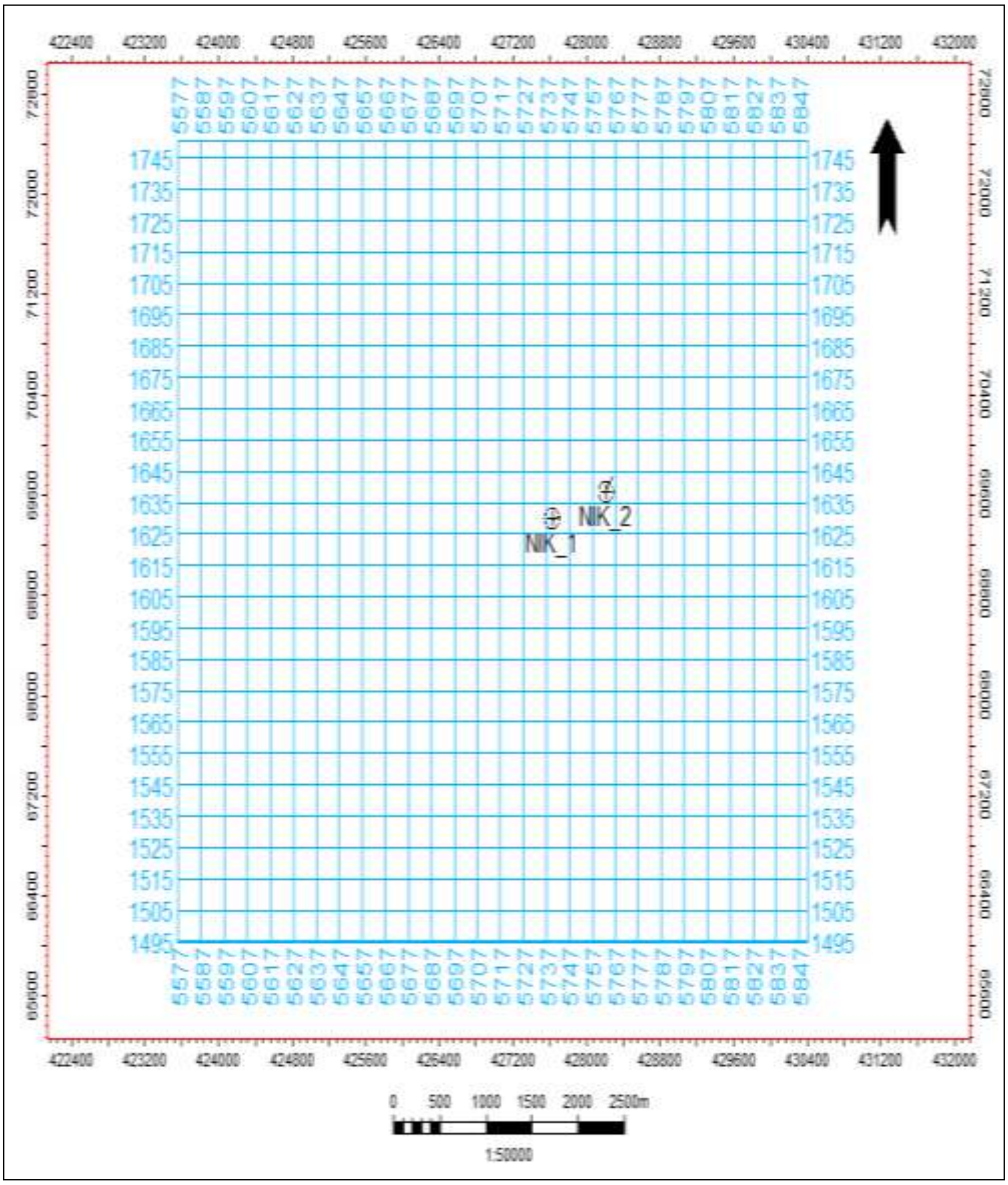

Fig. 2: Base map of the study area showing the spatial distribution of the various wells within the NIK field Niger Delta

Data Acquisition: This study is based on secondary data originally acquired and provided by the Nigerian Agip Oil Company (NAOC). The dataset consists of a suite of wireline logs from two wells within the "NIK" Field. The specific logs utilized for the geological and environmental interpretation include Gamma Ray (GR) For lithology identification and facies sequencing and resistivity (LLD) For fluid discrimination and permeability assessment.

Data Quality Control and Pre-processing: The secondary data underwent a rigorous quality check to ensure log integrity. This involved depth-matching and the normalization of Gamma Ray logs to a common baseline to minimize effects from tool calibration or hole conditions.

Lithofacies Delineation: Lithological units were identified by analyzing the Gamma Ray log response. Decrease in log signature signifies sandy units, while increase in log signature signifies impermeable shale units (Oghonyon et al 2025).

Electrofacies Analysis and Interpretation: The core methodology involved electrofacies analysis, where depositional environments were inferred from log motifs (shapes). The primary log motiffs include; Funnel Shape (Coarsening Upward), signifying prograding shorefaces or delta front deposits, Bell Shape (Fining Upward) signifying fluvial or tidal channel fills. Cylindrical Shape (Blocky).

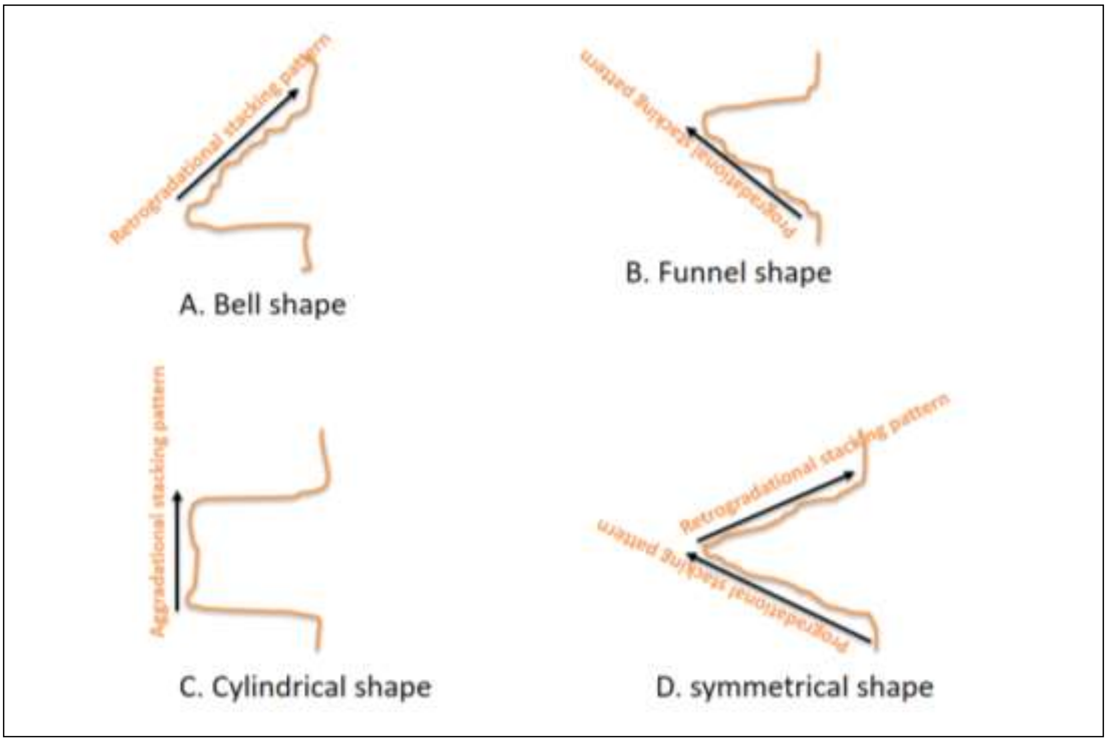

Fig. 3: Log motiffs for interpretation of Depositional Environments

Stratigraphic Correlation and Environmental Reconstruction: Well-to-well correlation was conducted using marine shale markers as chronostratigraphic datums. This allowed for the spatial mapping of sand bodies across the "NIK" Field, enabling a reconstruction of the ancient depositional system within the Agbada Formation.

RESULTS AND DISCUSSION

The stratigraphic evolution of the NIK-1 well (see fig. 4 below), interpreted from the base at 3095SSTVD to the top at 2885SSTVD, reveals a transition from a wave-dominated marine setting to a high-energy deltaic distributary system. From 3095SSTVD to approximately 2992SSTVD, the Gamma Ray (GR) log displays a highly serrated, high-API baseline characteristic of distal marine shales and silts of the Akata-Agbada transition (Short and Stäuble, 1967). Above this, at the 2992SSTVD to 2962SSTVD interval, "Reservoir A" appears as a prominent blocky to cylindrical electrofacies; this sharp decrease in GR values signifies a sudden influx of coarse-grained sediments, characteristic of a distributary channel fill. This unit reflects a high-energy depositional regime where the rate of sediment-supply significantly outpaced accommodation space, creating a massive, relatively clean sand body. Above the reservoir top at 2962m, the log returns to a serrated shale-dominated motif, suggesting a return to lower-energy floodplain or interdistributary bay conditions as the local delta lobe shifted (Laurence et al 2002).

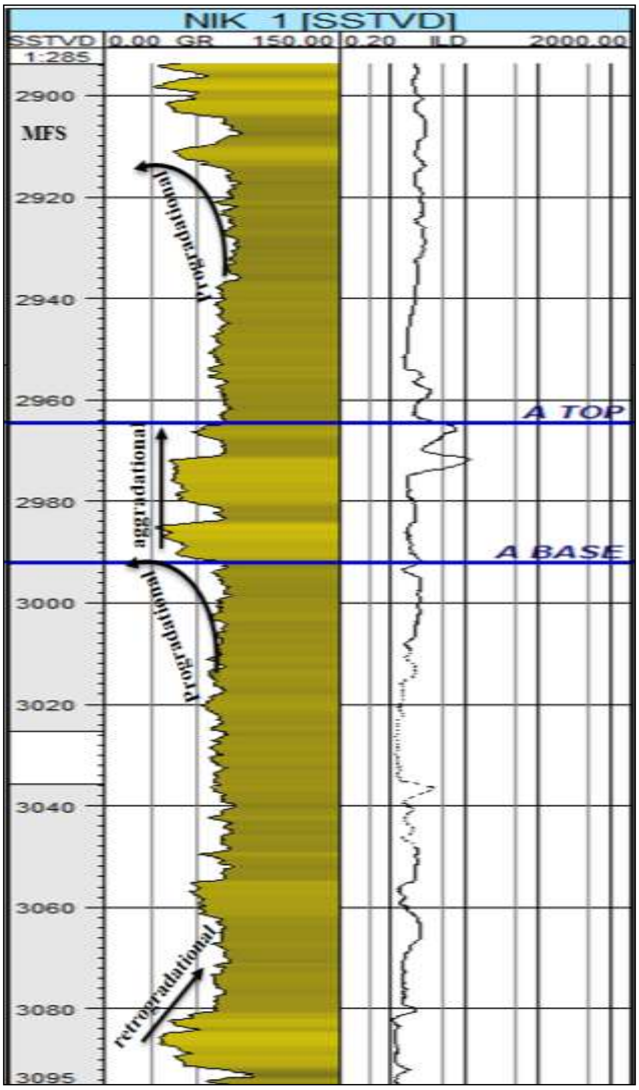

Fig. 4: NIK field composite well log-1 showing the stacking patterns and sequence boundaries.

In the NIK-2 well (see fig.5 below), the depositional sequence from 3097SSTVD upward shows a gradual increase in environmental energy culminating in a shoreface complex. The lower section (3097SSTVD to 2972SSTVD) consists of thick, low energy marine shales with occasional thin, silty laminations, indicating a distal shelf or prodelta environment (Laurence et al 2002). At the 2972SSTVD to 2953SSTVD interval, the "Reservoir A" sequence exhibits a distinct funnel-shaped (coarsening-upward) motif, where the GR values progressively decrease upward from a shaly base to a clean sandy top. This electrofacies transition is a classic signature of a prograding shoreface or delta front, representing the gradual seaward migration of the shoreline over deeper marine muds. The top of the reservoir at 2953SSTVD is capped by a sharp return to higher GR values, indicating a transgressive event or a shift in the depocenter that halted sand deposition and reintroduced quieter, mud-rich conditions

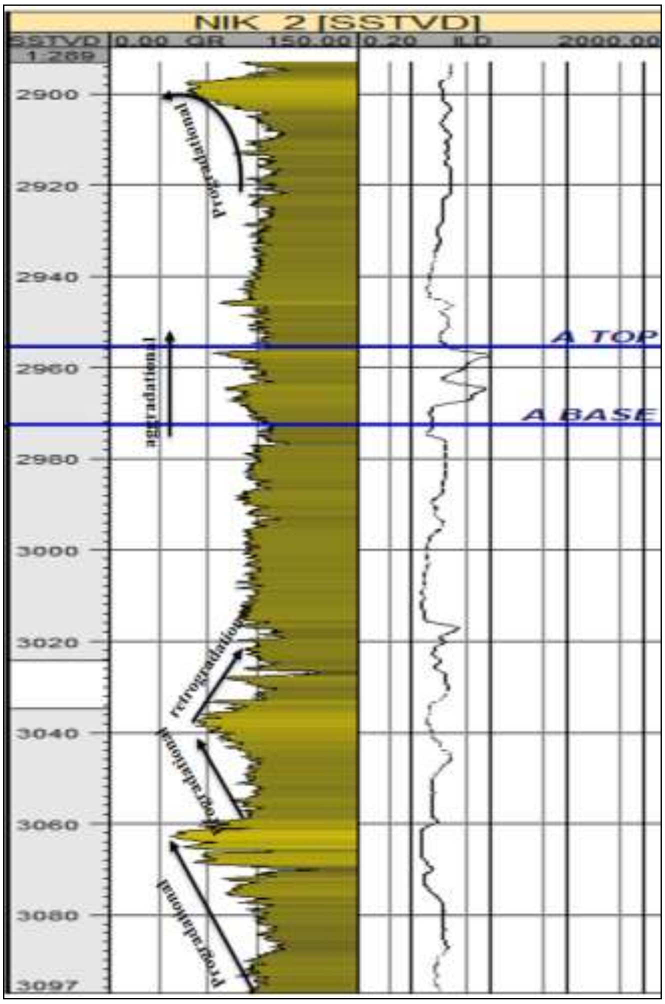

Fig. 5: NIK field composite well log-2 showing the stacking patterns and sequence boundaries.

The correlation of the "NIK" Field wells (as shown in fig.6 below) provides a spatial interpretation of the depositional architecture, illustrating a proximal to distal environmental transition within the Agbada Formation. When correlated from the base upward, it is evident that "Reservoir A" represents a continuous sand body that varies in both thickness and depositional energy across the field. In NIK-1, the 30m thick blocky sand suggests a proximal distributary channel axis, whereas the lateral equivalent in NIK-2 is thinner (approximately 19m thick) and displays a funnel .

motif, indicating a transition into a marginal marine shoreface. This lateral facies change reflects the inherent complexity of the Niger Delta's paralic sequences, where channelized sands often interdigitate with wave-reworked shoreface deposits (Laurence et al 2002). Structurally, the rise of the "A Top" marker from 2962SSTVD in NIK-1 to 2953SSTVD in NIK 2 confirms the field's position on a structural high or rollover anticline, which is critical for hydrocarbon entrapment in this region

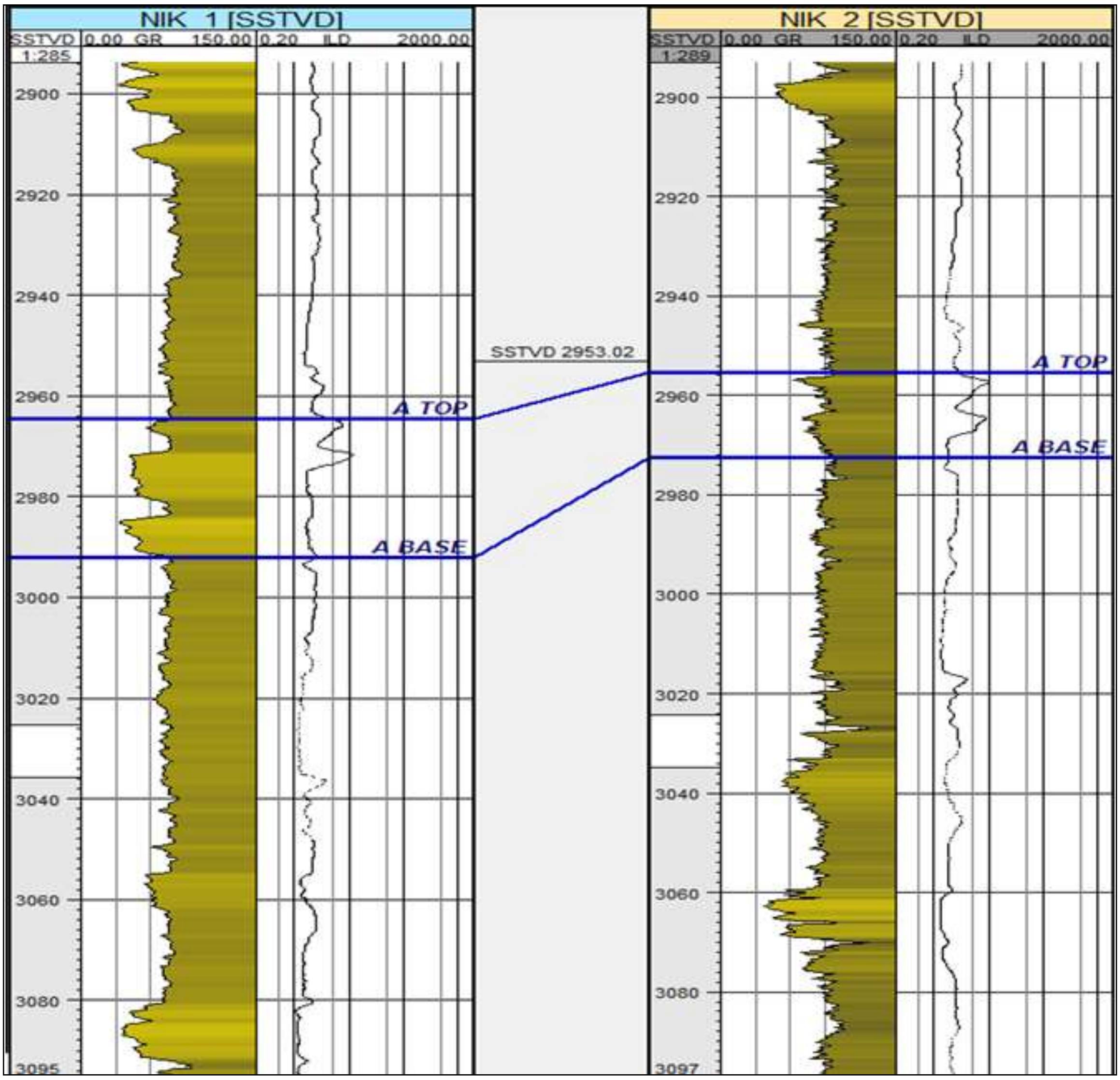

Fig. 6: Structural correlation panel between wells NIK-1 and NIK-2, showing the lateral continuity and structural position of clean sand.

Conclusion: This paper successfully integrates petrophysical data to establish a localized depositional framework for the "NIK" Field, contributing a high-resolution facies model to the existing knowledge of the Niger Delta’s Agbada Formation. By identifying the transition from distributary channel axes to marginal marine shorefaces, this research provides critical insights into the lateral variability and compartmentalization of reservoir sands, which are often overlooked in regional studies. To maximize the economic potential of the field, it is recommended that 3D seismic attributes be integrated with these electrofacies interpretations to map the precise spatial boundaries of the identified channel systems. Additionally, further core analysis is advised to calibrate log-derived facies with physical sedimentary structures, ensuring higher precision in future reservoir simulation and well-placement strategies.

DECLARATIONS

Ethical Approval: This study involved the analysis of secondary geophysical data and did not involve human or animal subjects.

Disclaimer (Artificial Intelligence): The authors declare that no Large Language Model was used to assist in the formatting and structural editing of this manuscript.

Conflict of Interest: The authors declare no conflict of interest regarding this work.

Data Availability: This study is based on secondary data which are proprietary. Access to the raw well log data may be granted by the original data owners upon reasonable request.

REFERENCES

1. Abraham, C. U., Clement, E. B., Aniete, E. E., Monday, U. U., (2020). Sequence stratigraphic study of 'X' field in eastern offshore of Niger Delta, Nigeria. Journal of Geology and Mining Research, 12(2), 65-69. DOI: https://dx.doi.org/10.5897/jgmr2019.0322
2. Asaah, A. V. (2011). Geology and Mineral Resources of Nigeria. *Eco. Geol.* 106(3), 523. DOI: https://doi.org/10.2113/econgeo.106.3.523.
3. Erhire, ER; Ideozu, RU; Oghonyon, R (2025). Integrated Petrophysical Characterization of the WABI Field: Delineation and Volumetric Assessment

of Shallow and Deep Hydrocarbon Reservoirs. *Sci. Africa.* 24(4) 95-102.
DOI: https://doi.org/10.4314/sa.v24i4.8

4. Friday, U; Kenneth; Anthony, U. O; (2022). Analysis of depositional Environments of UK Field Reservoir Sands in Niger Delta Basin, Nigeria. U.S.A. J. App. Sci. 4(12), 5-32.
DOI:https://doi.org/10.37547/tajas/volume04issue12-02
5. Hospers, J. (1965). Gravity Field and Structure of the Niger Delta, Nigeria, West Africa. Geological society of American Bulletin. 76(4): 407
DOI:https://doi.org/10.1130/0016-7606(1965)76[407:gfasot]2.0.co;2
6. Ideozu, R. U; Chiazor, F. I; Sam, E (2024). Seismic Stratigraphy of and Petrophysical Properties in KALA Field, Niger delta. Scientia Africana. 23(5): 271-292.
DOI: https://dx.doi.org/10.4314/sa.v23i5.22
7. Kame, B. (1978). Hydrocarbon Habitat of Tertiary Niger Delta. AAPG Bulletin. 62(1).
DOI: https://doi.org/10.1306/c1ea47ed-16c9-11d7-86450001021865d.
8. Laurence, SR; Munday, S; Bray, R (2002). Regional Geology and Geophysics of the Eastern Gulf of Guinea (Niger Delta to Rio Muni) The leading Edge. 21(11) 1112-1117.
DOI: https://doi.org/10.1190/1.1523752
9. Loke, MH; Barker, RD (1996). Rapid least-squares inversion of apparent resistivity pseudosections by a quasi-Newton method1. *Geo. Pros.* 44(1), 131–152.
DOI: https://doi.org/10.1111/j.1365-2478.1996.tb00142.x
10. Oghonyon, R; Osaki, LJ; Nnurum, EU (2025). Geophysical Extraction of Subsurface Parameters Using Seismic While Drilling (SWD) Technique for Formation Evaluation. *Sci. Africa.* 24(3) 173-182.
DOI: https://dx.doi.org/10.4314/sa.v24i3.17.
11. Osaki, LJ; Oghonyon, R (2025). Synthesizing Geophysical Well Logging and Spatial Modelling for Reservoir Analysis Optimization: A Dynamic Approach. *Africa. J. Engr. Environ. Rees.* 7(2) 22-44.
https://ajoeer.org.ng/otn/ajoeer/qtr-2/2025/02
12. Short, K.C.; Staeuble, A.J. (1967). Outline of geology of Niger delta. AAPG Bulletin. 51 (5): 761–799. DOI: https://dx.doi.org/10.1306/5d25c0cf-16c1-11d7-8645000102c1865d.
13. Wagoner, JCV; Mitchum, RM; Campion, KM; Rahmanian, VD (1990). Siliciclastic Sequence Stratigraphy in Well Logs, Cores, and Outcrops. DOI: *U.S.A. Ass. Petro. Geol*.
DOI: https://doi.org/10.1306/mth7510.