# GEOLOGICAL MODELLING AND FAULT SEAL ANALYSIS FOR OPTIMISING $CO_2$ STORAGE, NIGER DELTA

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The negative impacts of $CO_2$ and Greenhouse Gases (GHG) have immensely affected the environment and the earth's sustainability. The Paris Agreement stipulates that emissions must be reduced to 45% by 2030 to attain the net zero goal by 2050, resulting in the decrease of global warming to 1.5°C. This study aims to identify and characterize subsurface formation's structural integrity and capacity potentials for $CO_2$ storage in the Aida field Niger Delta Basin. It assesses, the risk of leakage and migration of gasses stored in the reservoir as a result of a breach in the fault and cap rock of the reservoir unit.

To optimally characterize the reservoirs, well logs and 3D seismic data were utilized in the Petrel interphase with an emphasis on characterizing subsurface structural configuration and explaining the petrophysical parameters of the reservoirs. Five reservoirs were mapped; F_70- B5, G_02, G_10, G_40 and H _03 with thicknesses of 18.2m, 105m, 50.64m, 23.19m and 48.4m respectively.

Normal faulting was observed in the field. A total of forty (40) faults were identified; seven (6) major faults and thirty-four (34) intermediate faults or minor faults. The major faults act as closures or traps for the reservoirs drilled at the Aida 004ST1well. The G_02 reservoir was picked as a target for carbon storage because it had the largest area was and suited the criteria depth of 800m and thickness 10m. The results of the static model and petrophysics estimated values for the G-02 reservoir as; a porosity range of 20-24%, permeability (>100mD), shale volume >30% and carbon dioxide storage capacity of 25.5852 x 10^6kgm^3. T7 software was used to determine fluid flow parameters of throw juxtapositions and the Shale Gouge Ratio was (>40%). This implies the faults in this region have good sealing capacity.

Consequently, the G_02 reservoir is suitable for carbon storage, has a low leakage risk and good sealing capacity because it exceeds the cut off values of (15% -20) %. Core data and pressure data is recommended to be incorporated in the research, to further analyse the field for fault reactivation and slip tendency within the reservoir and stress regimes of the field. The results contribute valuable information for the planning and implementation of carbon capture and storage projects, aligning with global efforts to mitigate climate change.

**Key Words**: Petrophysics, Geological Model, Shale Gouge Ratio, Fault Seal Capacity

# ICHNOLOGY, SEDIMENTOLOGY AND PALEODEPOSITIONAL RECONSTRUCTION OF THE CRETECEOUS SEQUENCE, KOUM BASIN, NORTHERN CAMEROON

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In the context of sequence stratigraphy, trace fossil assemblages in a fluvial-lacustrine setting provide important new information about environmental controls and the history of continental basin filling. The Cretaceous sediments in the Kali and Mbissiri members of the Koum Basin were analyzed to identify their sedimentary characteristics and differences in ichnogenera. The goal of this study was to identify the paleo-depositional environment and situate it within a sequence stratigraphic framework which had been constraint by limited recovery of low polymorphs, particularly specific spores and pollen commonly utilized as environmental indicators.

Lithologic logging was carried out to gather sedimentological and ichnological data. Twelve sedimentary facies were studied and grouped into eight facies associations, revealing a tripartite sequence of deposition, comprising fluvial/alluvial, lacustrine, and fluvio-deltaic environments. While18 ichnospecies from 11 ichnogenera identified, the ichnological data showed a well-established climax community mostly made up of dwellers (domichnia) and feeders (fodinichnia). Analysis of the ichnofossil association identified three ichnofacies: Skolithos, Scoyenia, and Termitichnus. Skolithos ichnofacies were present in both active and abandoned fluvial channels, characterized by low-diversity assemblages dominated by simple vertical burrows and escape traces. Scoyenia ichnofacies occurred in floodplain and shallow lacustrine areas, exhibiting a high diversity of simple ormented burrows, arthropod trackways, vertebrate trackways, and soft sediment deformational structures. Termitichnus, a predominantly fluvial ichnofacies, consisted of nest structures as well as J, Y, and U-shaped burrows.

The lacustrine sequence displayed a balanced filled lake structure, features hypersaline conditions during lowstand systems tract (LST) and freshwater intrusion during transgressive systems tract (TST) to highstand systems tract (HST). Due to desiccation, LST observed the deposition of thin aggradational parasequences including a high concentration of Scoyenia ichnofacies. Significant erosion in nearby locations led to high deposition of clastic materials during HST. Similar TST-HST-LST stacking patterns were seen in the fluvial sequences; HST was identified by paleosols and sandstones with a greater density, LST by combined channel deposits, and TST by deposits on the floodplain encircled by solitary channel sand bodies.

KEY WORDS: trace fossils, ichnofacies, paleo depositional environments, sequence stratigraphy, cretaceous, Koum basin

# SEISMIC AND PETROPHYSICAL DATA ANALYSIS FOR GEOLOGICAL INTERPRETATION AND SUBSURFACE MODELING OF KEVA FIELD, ONSHORE NIGER DELTA, NIGERIA

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Seismic and petrophysical data have been integrated in this research to evaluate the subsurface geological information of Keva Field, located in the onshore part Niger Delta, with the primary objective of generating 3D geological subsurface model of the field and estimate the volume of recoverable hydrocarbons in the field. The overarching goal is to optimize hydrocarbon production while concurrently preserving the environment.

Well log interpretation, stratigraphic analysis and well correlation were carried out using petrophysical log signatures of six wells drilled in the field. Petrophysical studies were also employed to determine reservoir thickness, net-to-gross, net pay sands, volume of shale, porosity, permeability and hydrocarbon saturation. Structural interpretation involves fault mapping from seismic data, with seismic-to-well tie for horizon mapping. Time and depth structure maps generated to address structural complexity. A 3D grid was constructed using Pillar Gridding technique which integrates faults into the model. The grid employed an orthogonal lattice with a spacing of 50m x 50m and a cell height of 0.5ft for accurate reservoir heterogeneity representation. Depositional environments were finally interpreted using a combination of log motifs and seismic responses.

Six wells analyzed in this research identified three hydrocarbon bearing horizons corresponding to three key reservoirs (C500, D200, and E900). The delineated reservoirs presented characteristic high net-to-gross, excellent porosity, high hydrocarbon saturation comprising of oil and gas. The reservoir units were deposited in tidal/fluvial-dominated shoreface environments, comprising of sheet sands in a distributary splay environment. The delineated reservoirs had Gas Initially in Place (GIIP) values of 156.37; 28.44 and 27.89 BSCF and Estimation Ultimate Recovery (EUR) values are 104.77, 19.06 and 18.69 for C500, D200, and E900 respectively and Stock Tank Original Oil in Place (STOOIP) values of 24.43; 91.29 and 86.41 MMSTB and Estimation Ultimate Recovery (EUR) values are 7.32; 27.4 and 25.92 for C500, D200, and E900, respectively. The cumulative GIIP totals 212.72 BSCF and EUR GIIP is 142.52 BSCF, and the cumulative STOOIP 202.13 MMSTB and EUR STOOIP is 60.64 MMSTB. The average porosity across the three reservoirs was 22.62%, while the average Gas saturation and Oil saturation were 84.66% and 73%, respectively. Average NTG is 55.62%.

**Key Words**: Porosity, Permeability, Hydrocarbon saturation, 3D geological modeling, Keva, Niger Delta

# DEPOSITIONAL AND POST-DEPOSITIONAL ARCHITECTURAL ELEMENTS OF THE DAR ES SALAAM PLATFORM, CENTRAL COASTAL TANZANIA: DISTRIBUTION OF PETROLEUM SYSTEM ELEMENTS AND THEIR IMPLICATIONS FOR PETROLEUM PROSPECTIVITY

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The Dar es Salaam Platform (DSP) and Mafia Basin are within the Bigwa-Rufiji-Mafia (BRM) hydrocarbon exploration block of the coastal Tanzania basins. The DSP has insignificant hydrocarbon discovery despite some exploration campaigns that involved acquisition of reflection seismic data and exploration drilling. This study used 2D seismic interpretation technique and well logs analysis to establish depositional and post-depositional architectural elements of the DSP for the purpose of contributing to the understanding of petroleum prospectivity of the area. Based on well logs analysis, correlation has been made to Mafia Basin in order to be able to assess any spatial variability in depositional conditions and processes which may be key in understanding the petroleum potential of the DSP. Results have shown that formation of the DSP was mostly controlled by tectonics, sea level changes and sediment supply. Different tectonic events have created hydrocarbons migration pathways from deep buried source rocks to shallow seated reservoirs and formed possible petroleum prospects. The revealed petroleum prospects are fault-controlled and have not been tested by drilling; some of the prospects have been fractured by subsequent faulting. Faulting of the petroleum prospects within the DSP caused hydrocarbon leakages revealed by the mapped gas chimneys. These gas chimneys are reported for the first time in the study area. The hydrocarbon leakage from the DSP prospects may be one of the reasons as to why the previous exploration campaigns ended with some dry wells.

**Keywords**: Dar es Salaam Platform, coastal Tanzania basins, seismic, petroleum prospects, hydrocarbon migration, flowering faults, sea-level changes

# PETROPHYSICAL ANALYSIS AND 3D STRUCTURAL MODELING OF PALEOGENE SOKOR-1 FORMATION, FANA FIELD IN AGADEM BLOC, TERMIT BASIN, NIGER REPUBLIC

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The Termit Basin in Niger Republic stands out as a hydrocarbon-producing basin. The Agadem bloc has been a focal point of previous studies. However, certain areas within the basin, like the Fana Field, lack comprehensive information regarding hydrocarbon reservoirs. This study aims to assess the petrophysical characteristics of the reservoirs in the Fana Field of the Paleogene Sokor_1 system of the Termit Basin and also generate a structural model for the field. This study seeks to determine and delineate the promising reservoir formations; deduce different properties of the reservoir; and understand its hydrocarbon potential; trapping system, and proposed potential prospects.

In this study, all the available data, well logs from six exploratory wells, and a 3D seismic section were integrated. The petrophysical analysis of well logs was done using Interactive Petrophysics software. In addition, cross-plots (Dia-porosity, M-N, and Pickett plots) have been generated for mineralogical discrimination and fluid content identification. The seismic interpretation integrated with well logs was used to identify clean, porous, permeable sandstone interbedded with claystone/shale, volumetric estimation of the reservoirs, and build structural and 3D static models.

The five hydrocarbon-bearing units (E_1, E_2, E_3, E_4, and E_5) has been identified. The M-N cross-plots show the presence of limestone and dolomite in the reservoir. The average petrophysical values of the reservoir in the Paleogene Sokor-1 revealed that E_5 is the best reservoir with 97.51m thick, shale volume (34.76%), permeability (157.74 mD), total computed porosity (25.76%), and hydrocarbon saturation (84.84%). Stratigraphically, the shale thickness below and above each reservoir can also act as seals for trapping the hydrocarbon accumulation. The seismic interpretation shows 33 normal fault trends NW-SW and NNW-SSE, which can serve structurally as the trapping systems of hydrocarbon. The calculated STOIIP values from the 3D static model range between 43.58 MMbbl, 5.29 MMbbl, and 23.16 MMbbl of reserves. The seismic surface attributes show six potential prospects in the Fana Field. This study showed that the Paleogene Sokor_1 Formation in Termit Basin is an exceptionally promising reservoir with strong indications of significant hydrocarbon-bearing zones.

**Key Words**: Porosity, Permeability, Hydrocarbon saturation, 3D modeling, Fana Field, Termit Basin

# HYDROCARBON POTENTIAL OF THE LIBERIAN BASIN: A QUALITATIVE AND QUANTITATIVE APPROACH

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The Liberian offshore Basin is connected to the opening of the Atlantic Ocean and it represents a rifted and subsided region that developed during the breakup of the supercontinent Pangaea. However, the current study focuses on the assessment of potential for undiscovered, technically recoverable oil and gas resources within the Liberian offshore Basin. This study will integrate predrill data, exploration and Well reports, together with 2D and 3D seismic survey report to quantitatively and qualitatively evaluate the hydrocarbon potential of the Liberian Basin with emphasis on the Nighthawk-1 and Carmine Deep-1 Wells.

The 2D and 3D seismic reports were used to generate and evaluate the reservoir systems of the basin, and the syn-rift section. The results show that sediments were deposited during relative sea level fall along the shoreline.

Pyrolysis results indicated a TOC of 2.6wt% across the basin. However, Carmine Deep-1 has a TOC range of 1.3-2.55wt%, as well as Nighthawk-1 shows a TOC range of 0.52-3.68wt%. This is an indication of mature source rock. The vitrinite reflectance from predrill data analysis (Rock-Eval analysis) has a range of 0.77R% for Carmine Deep-1 and 0.97R% for Nighthawk-1 well. This also shows that the source rock is in the early mature stage and the type of organic matter present in Carmine-1 formation is different compared to Nighthawk formation. Geochemical analysis from predrill and exploration data on the biomarker shows the presence of an extended tricyclic terpanes in Carmine Deep-1 well, which indicates that marine upwelling took place during the Aptian-Upper Albian/Cenomanian-Turonian interval. This shows that the Aptian-upper Albian/Cenomanian-Turonian interval experienced favorable conditions for organic matter productivity and the development of a good hydrocarbon source rocks.

The results imply that the basin has a good source rock quality and quantity with Nighthawk-1 and Carmine Deep-1 indicating good source potential, hence, has provided a framework for future prediction of good source rock performance. This study demonstrated the usefulness of the well and exploration reports as a tool for better understanding and for evaluating major source rock properties vis-a-vis to Total organic carbon, Vitrinite Reflectance, Biomarkers and Depositional settings.

**Keywords:** West African Transform margin, Liberian Basin, Hydrocarbon Potential, Pyrolysis

# PALEODEPOSITIONAL ENVIRONMENT AND RESERVOIR QUALITY ASSESSMENT OF THE JEL FIELD, OFFSHORE NIGER DELTA BASIN, NIGERIA

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Exploration of hydrocarbons and field development require knowledge of the depositional environment and petrophysical properties of reservoirs to discover more petroleum accumulation and meet the growing demand for hydrocarbon resources. In Nigeria, there is still an increasing demand for hydrocarbon resources as oil and gas remain the main source of revenue for the government, regardless of advocacy for clean energy sources. This study aims to evaluate the paleodepositional environment and reservoir quality of the JEL Field in the eastern offshore Niger Delta Basin.

Well logs were analysed using sequence stratigraphy method and qualitative and quantitative petrophysical analysis; a 3D seismic volume was analysed using seismic interpretation and seismic facies analysis. Sequence stratigraphic analysis delineated depositional sequences underlaid and overlaid by two sequence boundaries and composed of lowstand system tract (LST), transgressive system tract (TST) and highstand system tract (HST). The sands of LST and HST act as reservoir rocks, whereas the shales of TST and HST act as source and seal rocks in the study area.

Through qualitative analysis of gamma rays combined with resistivity density and neutron logs, three reservoir sand units (Reservoirs A, B, and C) were identified and correlated across the five wells, demonstrating the lateral continuity of the delineated reservoirs. The petrophysical properties of the identified reservoirs showed the following average values: volume of shale (14.7 to 17.2%), net-to-gross (82.2 to 85.3%), effective porosity (22.62 to 25.90%), permeability (1957.55 to 2498.76 mD) and hydrocarbon saturation (55.39 to 58.06%). The results demonstrate good reservoir quality. The reservoir sands fall within the prograding delta, delta distributary channel, transgressive marine, shoreface delta, fluvial to deltaic settings, and near-shore to shallow marine environments. Seismic interpretation revealed growth and antithetic faults, oriented in the NE-SW and NW-SE directions. Structural maps showed a faulted anticline, implying a possible hydrocarbon prospect that could be targeted during further exploration.

Findings revealed that the JEL Field, falls within the marginal marine to shoreface or shallow marine paleodepositional environment with good reservoir sand quality. Knowledge from this study will aid in understanding subsurface geological complexities and enhance hydrocarbon prospectivity.

**Keywords:** Paleodepositional environment, reservoir quality, depositional sequence, Offshore Niger Delta