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Research Article

Reservoir Characterization of KD Field Located Onshore of Akwa-Ibom State, Niger Delta, Nigeria Using Well Logs Property Comparison to Seismic Amplitude Analysis

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Abstract

Characterization of reservoirs defines how well they can generate and store hydrocarbon, reservoir parameters are used to determine the behavior of reservoir fluids under various conditions and to identify the best production practices that can optimize hydrocarbon production, the objective is to identify and map reservoir sand zones using basic logs, provide information about the reservoir depth and thickness using well log data, interpret faults and sealing system using the seismic data and generate amplitude maps and model basic reservoir facies, the method applied was sectioned into three distinct parts that encompasses qualitative well log analysis, seismic interpretation and cross plotting of basic well logs versus amplitude for reservoir characterization, the well data analyzed shows well number 5, 6 and 8 have incomplete GR logs resulting in missing lithology while well 10 have some missing logs, such as, density (DEN) log, neutron porosity (NEU) log and porosity (POR) log, five logs needed for this study were available in the remaining complete wells. These logs include gamma ray (GR) log, resistivity (RES) log, density (DEN) log, neutron porosity (NEU) log, and porosity (POR) log. This study looks at a possible change in log signal due to an increase or decrease in seismic amplitude in characterizing a reservoir sand and how logs are influence with Amplitude peaks and trough.

Keywords

Reservoir, Seismic Interpretation, Well Logs, Hydrocarbon

1. Introduction

Reservoir characterization is the process of assessing a reservoir's capacity to produce and hold hydrocarbons [1]. Reservoir characteristics are utilized to ascertain how reservoir fluids behave under different circumstances and to pinpoint the most effective production techniques for maximizing hydrocarbon output [2]. Characterizing the reservoir is the first step towards quantifying reservoirs with a lower risk of uncertainty, which is connected to geological models of various exploration and production of interest [3]. Applications of well-log measurements include the evaluation of the porosity and saturation of reservoir rocks as well as depth correlations [4].

The need of log information records for a thorough understanding of geology is becoming increasingly apparent. In fact,

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geologists have discovered that well logs may be to rocks what optical and geological devices are to surface outcrop [5, 14]. Through logging, we recorded several parameters related to the petrophysical and geological properties of the accessible strata; these properties are usually studied with the use of rock samples [6]. Moreover, logs display the fluids found in the pores of reservoir rocks (Hampson & Russell, 2012). The distinct picture that logs offer is sometimes distorted or lacking, but it is always permanent, unwavering, and unbiased [7].

As a consequence of the physical, chemical, and biological circumstances that existed during deposition as well as the evolution of the rock throughout geological time, the morphological traits represented by log data are comparable to the "signature" of the rock [8].

2. Study Area

In the Nigerian Niger Delta's Akwa-Ibom State, the field is known as KR field. It is in the southern section of OML 138, around 55 kilometers south of Abia. It is located in the Niger Delta depobelt's coastal marsh region (Figure 1). Numerous writers have written on the well-known Niger Delta's geology [9-12].

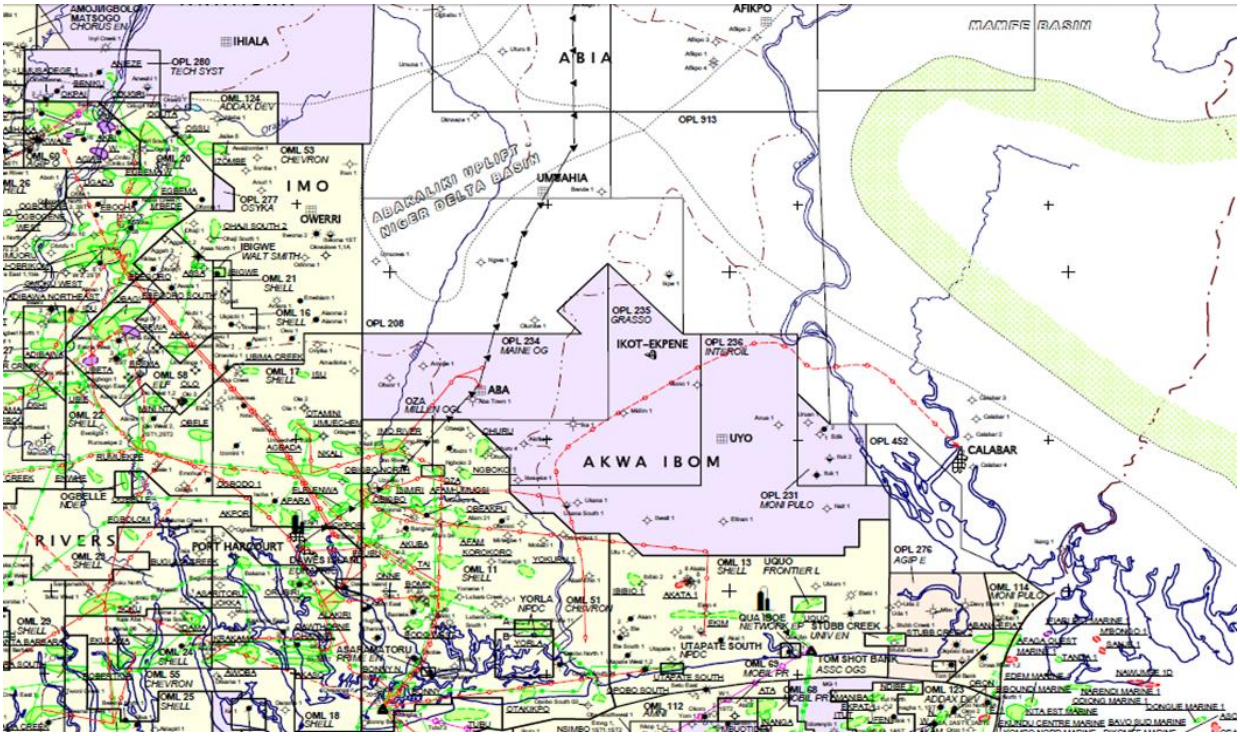

Figure 1. *Map of Niger Delta showing the study area.*

The Niger Delta clastic wedge originated about the late Jurassic plate fracturing of South America and Africa, and it developed within a futile sector of an aulacogen triple linked system [13-16].

2.1. Aim and Objectives of the Study

This research is aimed at comparatively analyzing log properties and seismic amplitudes to provide a more reasonable and dependable data for reservoir characterization. The objectives are to identify lithology and thickness of rock strata using well logs data, identify and Map reservoir sand zones using basic logs, provide information about the reservoir depth and thickness using well log data, interpret Faults and sealing systems using the seismic data, generate amplitude maps and model basic reservoir facies, and cross-plot well logs with seismic amplitude to provide reservoir characteristics.

2.2. Significance of the Study

In order to support well management and reservoir monitoring, the data from this study can be used to enhance research on reservoir features. Furthermore, this study will help eliminate false log responses caused by changes in temperature, pore fluid concentration and lithology contrast.

3. Methodology

The method applied in this research encompasses three distinct separate sections. The first section covers qualitative well-log analysis, also known as petrophysical analysis. Identifying the reservoir's top and base as well as delineating its lithology are the main objectives of the qualitative study.

The second half of the study focuses on seismic interpretation, which involves facie modeling and the third section of this research project consists of cross-plots of basic well logs vs. amplitude for reservoir characterisation.

In this research, the sources of data were obtained from Total Energies EP Nigeria Limited which consist a set of well information and 3D post-stack seismic volume acquired from the Niger Delta. Total Energies EP Nigeria Limited also known as TEPNG is a subsidiary of Total Energies France which is an integrated energy company with its headquarters in Courbevoie, France, near Paris. More than 100,000 workers from various nations make up the company. The Data set consists of Ten (10) wells that cut across the Agbada formation and four (4) of the wells have incomplete information needed for this study. The well log suites consist of gamma ray log (GR), Resistivity (RES), Porosity (POR), Neutron (NEU) and Density (DEN) logs. The seismic volume comprises of in-lines ranging from 100 and 1600, X-lines (crosslines) 110 and 800. Then, certain software such as Word, Excel and Petrel 2014 version are used. Petrel is an open-source seismic determination system that is licenced from Schlumberger and can be used to visualize analyse, and interpret 2D, 3D, and 4D seismic data. For the interpretation of Geo-Radar, it is also widely used. All of the tools you would expect to find in a seismic interpretation system are supported by Petrel, including but not limited to: cross-plots, log viewers, well-tie module, Time-Depth Conversion, 3D bodies, Mapping (via GMT), modelling, and more. Horizon trackers (auto-tracking, manual, gridding, etc.) and fault interpretation (sticks and planes) are also supported.

4. Results and Discussion

From the results analyzed, Seismic data from KR Field, South-South, Niger Delta, reveals an intense amplitude horizon in the Agbada formation. Every well that was interpreted reached the reservoir's top.

4.1. Well Data

A total number of 10 Well data (Table 1) were provided for this research work From the data provided, well numbers 5, 6, and 8 have incomplete GR logs resulting in missing lithology while well 10 have some missing logs; density (DEN) log, neutron porosity (NEU) log, and porosity (POR) log. Five logs needed for this study were available in the remaining complete wells. These logs include gamma ray (GR) log, resistivity (RES) log, density (DEN) log, neutron porosity (NEU) log, and porosity (POR) log.

4.2. Petrophysical Evaluation

Qualitative Interpretation

The typical well log responses for all ten wells named KR-1, KR-2, KR-3, KR-4, KR-5, KR-6, KR-7, KR-8, KR-9 and KR-10 in discrimination of lithology and formation boundary is displayed in Figure 2 & 3 and discussed below.

Table 1. *Summary of Results of well log Analysis of KR wells for zone 1 – 3.*

Zones	1				2				3			
	Depth (m)		Thickness	Lithology	Depth (m)		Thick-ness	Lithology	Depth (m)		Thickness	Lithology
	Top	Base			Top	Base			Top	Base		
KR-1	3575	3676	101	shale	3676	3802	126	shale	3802	4000	198	Sandstone
KR-2	3575	3699	124	Sandstone	3699	3803	104	shale	3803	3899	96	shale
KR-3	3568	3675	107	Sandstone	3675	3797	122	shale	3797	4000	203	Sandstone
KR-4	3596	3735	139	Sandstone	3735	3850	115	Sandstone	3850	3910	60	Clean sand
KR-5	-	-	-	NA	-	-	-	NA	-	-	-	NA
KR-6	-	-	-	NA	-	-	-	NA	-	-	-	NA
KR-7	3727	3875	148	Sandstone	3875	4005	130	Shale	4005	4110	105	sandstone
KR-8	-	-	-	NA	-	-	-	NA	-	-	-	NA
KR-9	3625	3725	100	Shale	3725	3850	125	shale	3850	3950	100	Sandstone
KR-10	3900	4025	125	Sandstone	4025	4100	75	Clean sand	4100	4200	100	Clean Sand

The typical well log responses for all ten wells named KR-1, KR-2, KR-3, KR-4, KR-5, KR-6, KR-7, KR-8, KR-9 and KR-10 in discrimination of lithology and formation boundary is displayed in Figure 2 & 3 and discussed below.

Resistivity log play an important role in identifying a reservoir rock. In this study, the ten wells were correlated from north to south and the resistivity log of KR wells are displayed on track 3 alongside the Gamma ray log to identify lithology and sand zones.

One reservoir unit labelled HRA was identified at depths ranging from 3625 – 4700 m across all wells. Reservoir HRA consist of five (5) smaller zones that occurred in a paralic sequence. In well KR-1, Reservoir zone 1 consists of Shale unit and it was identified at a depths of 3575 – 3676 m with thickness of 101 m. Reservoir zone 2 consists of Shale unit and it was identified at a depths of 3676 – 3802 m with thickness of 126 m.

Table 2. *Summary of Results of well log Analysis of KR wells for zone 4 – 5.*

Zones	**4**				**5**			
	Depth (m)		**Thickness**	**Lithology**	**Depth (m)**		**Thickness**	**Lithology**
	Top	**Base**			**Top**	**Base**		
KR-1	4000	4151	151	Sandstone	4151	4325	174	Clean sand
KR-2	3899	3975	76	Clean sand	3975	4100	125	Clean sand
KR-3	4000	4150	150	Sandstone	4150	4300	150	Clean sand
KR-4	3910	4010	100	Clean sand	4010	4125	115	Sandstone
KR-5	-	-	-	NA	-	-	-	NA
KR-6	-	-	-	NA	-	-	-	NA
KR-7	4110	4290	180	Sandstone	4290	4410	120	Sandstone
KR-8	-	-	-	NA	-	-	-	NA
KR-9	3950	4175	225	Sandstone	4175	4362	187	Sandstone
KR-10	4200	4375	175	Clean Sand	4375	4550	175	Clean sand

Reservoir zone 3 consists of Sand stone unit and it was identified at a depths of 3802 – 4000 m with thickness of 198 m. Reservoir zone 4 also consists of Sand stone unit and it was identified at a depths of 4000 – 4151 m with thickness of 151 m. Reservoir zone 5 consists of clean sand unit and it was identified at a depths of 4151 – 4325 m with thickness of 174 m.

In well KR-2, Reservoir zone 1 consists of Sand Stone unit and it was identified at a depths of 3575 – 3699 m with thickness of 124 m. Reservoir zone 2 consists of Shale unit and it was identified at a depths of 3699 – 3803 m with thickness of 104 m. Reservoir zone 3 consists of Shale unit and it was identified at a depths of 3803 – 3899 m with thickness of 96 m. Reservoir zone 4 also consists of Clean Sand unit and it was identified at a depths of 3899 – 3975 m with thickness of 76 m. Reservoir zone 5 consists of clean sand unit and it was identified at a depths of 3975 – 4100 m with thickness of 125 m.

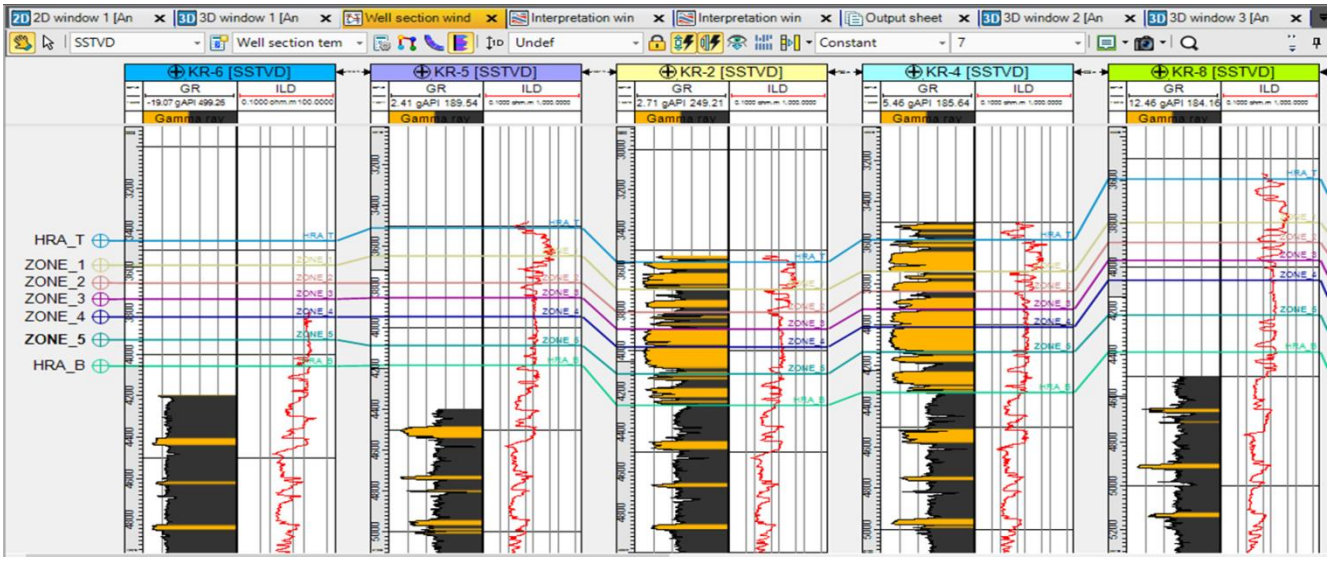

Figure 2. *Correlation of KR wells from north to south.*

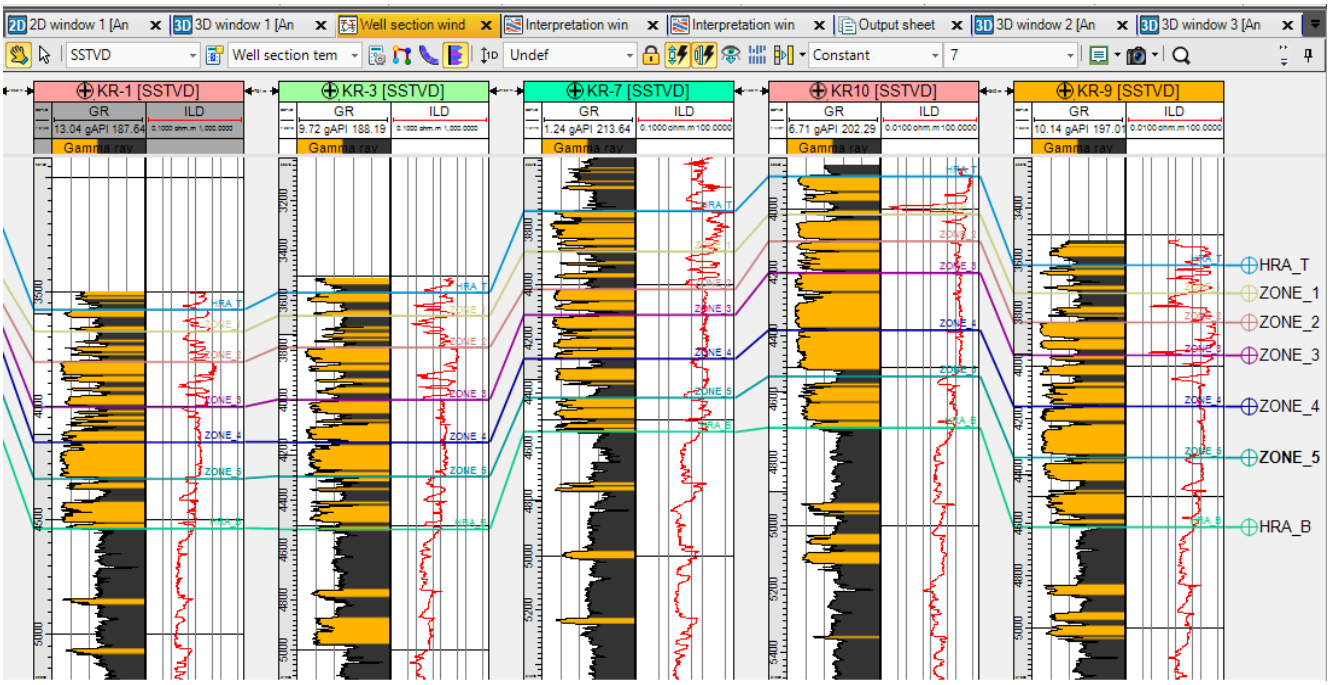

Figure 3. *Correlation of KR wells from north to south cont'd.*

5. Conclusions

Accurate evaluation of the formation is essential to access the economic viability of reservoir wells in the Niger Delta oilfield. Reflection amplitude plays a vital role in reservoir characterization and its importance cannot be over-emphasized. Over the Years, reservoir characterization has taken diverse forms and shapes and each result has proven to be very effective. Using an innovative method, this study has effectively evaluated and characterised reservoir sand. The data showed some trends, but the majority of cross plots showed only a broad trend and weak correlation.

Abbreviations

OML: Oil Mining Lease
GR: Gamma Ray Log
RES: Resistivity
POR: Porosity
NEU: Neutron
DEN: Density Logs
KR: Oil Field or Well

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Conflicts of Interest

The authors declare no conflict of interest.

References

[1] Richardson, A. A. M. (2013). Well Correlation and Petrophysical Analysis, a Case Study of "Rickie" Field Onshore Niger Delta. The International Journal of Engineering And Science, 2319–1813. Retrieved from www.theijes.com

[2] Emujakporue, G. O., & Faluyi, T. O (2015). Evaluation of Hydrocarbon Volume in 'TRH' Field, Onshore Niger Delta, Nigeria. Intern. J. of Geophys. and Geochem. 2(5): 113-123. https://orcid.org/10.4314/jasem.v23i12.16

[3] Knut, B (2010). Petroleum Geoscience: From Sedimentary Environments to Rock Physics. Springer, New York. https://orcid.org/10.1007/978-3-642-34132-8

[4] Lyaka, A. L; Mulibo, G. D (2018). Petrophysical Analysis of the Mpapai Well Logs in the East Pande Exploration Block, Southern Coast of Tanzania: Geological Implication on the Hydrocarbon Potential. Open J. of Geol. 8: 781–802. https://orcid.org/10.4236/ojg.2018.88046

[5] Obiora, D. N., Gbenga, D., & Ogobiri, G. (2016). Reservoir characterization and formation evaluation of a "Royal onshore field", Southern Niger Delta using geophysical well log data. Journal of the Geological Society of India, 87(5), 591–600. https://doi.org/10.1007/s12594-016-0433-6

[6] Okwoli, E; Obiora, D. N; Adewoye, O; Chukudebelu, J. U; & Ezema, P. O., (2015). Reservoir characteriztion and volumetric analysis of Lona Field, Niger Delta, using 3-D seismic data and well log data. Petroleum and Coal, 57(2): 108-119. https://orcid.org/10.9734/ajee/2024/v23i3533

[7] Hampson D. P, Russell B. (2012). HRS-9 software suite for reservoir characterization. Calgary, Canada. https://orcid.org/10.1007/s13202-020-00917-1

[8] Ahmad M. N, & Rowell P. (2012). Application of spectral decomposition and seismic attributes to understand the structure and distribution of sand reservoirs within tertiary rift basins of Gulf of Thailand. Lead Edge 31: 630–634. https://orcid.org/10.1190/tle31060630.1

[9] Abdel-Fattah, M. and Tawfik A., (2015). 3D Geometric Modeling of the Abu Madi Reservoirs and Its Implication on the Gas Development in Baltim Area (Offshore Nile Delta, Egypt). Int. J. Geoph., 2015, 1-11. https://doi.org/10.1155/2015/369143

[10] Dembicki-Jr., H. (2017). Practical petroleum geochemistry for exploration and productions. Elsevier, 341pp. https://doi.org/10.1016/j.jhsb.2006.10.005

[11] Asadu, A. N., Omo-Irabor, O. O., and Ibe, K. A. (2015). Source Rock Characterisation of AGBADA Formation in Well Z, Offshore, Niger Delta, Nigeria. International journal for research in emerging science and technology. Vol. 2, 92-100.

[12] Eteh D. R, Francis O., & Jonathan L. E., (2021). Site Suitability Study for Solid Waste Dumpsite Selection Using Geospatial-Based Multi-Criteria Analysis in Yenagoa, Bayelsa State Nigeria. Annals of Geographical Studies. Volume 4, Issue 1, PP 1-12 ISSN 2642-9136 https://doi.org/10.22259/2642-9136.0401001

[13] Adaeze, I. U., Samuel, O. O., & Chukwuma, J. I., (2012). Petrophysical evaluation of uzek well using well log and core data, Offshore Depobelt, Niger Delta, Nigeria. Advances in Applied Science Research, 2012, 3 (5): 2966-2991.

[14] Ogbesejana, A. B., Bello, O. M., Uduma, A. U. (2018). Characterization of Source Rocks from Off-shore Niger Delta Basin. J. Appl. Sci. Environ. Manage. Vol. 22 (3), 356–361. https://dx.doi.org/10.4314/jasem.v22i3.11

[15] Najime T, Eduvie M. O & Jolly B., (2017). Evolution of the Niger Delta, present dynamics and the future. African Journals Online (AJOL). ISSN: 1118-1931.

[16] Francis O. & Edeye E. (2020). AVO fluid inversion (AFI) technique as a tool to predict reservoir fluid content using data from FD field, Onshore Niger Delta Nigeria. IJCIRAS | ISSN (O) - 2581-5334. Vol. 3 Issue. 2.