Reservoir Evaluation and Depositional Environment of Sand Bodies in Welder Field - Northern Depobelt of the Niger Delta Basin

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Abstract: ***In this work, reservoir sands from four oil wells in Welder Field Niger Delta, was evaluated petrophysically to determine the impact of reservoir properties to the environment of deposition. Results from the petrophysical analysis showed that the average petrophysical properties obtained for the reservoir W700 includes porosity (23%), permeability (78mD), water saturation (39%), net - to - gross ratio (9%), pay thickness of 98m and STOOIP (Stock tank original oil in place) of 84mmstb. While sand body W800 includes porosity (21%), permeability (12mD), water saturation (42%), net - to - gross ratio (9%), pay thickness of 85m and STOOIP (Stock tank original oil in place) of 62mmstb. The STOOIP value for reservoir W700 is higher than that of reservoir W800 because of the presence of thick shales at top of W800. W700 and W800 reservoirs generally show a prograding to aggradational stacking pattern as seen from the gamma ray log. Based on standard log motifs, from the gamma ray log, the environments of deposition of the reservoirs are interpreted as mouth bar, deltaic front and shore face respectively.***

Keywords: Sand bodies, porosity, log motif and shoreface

1. Introduction

In every prospect evaluation venture, characterizing the subsurface geometry, stratigraphy, and determining the hydrocarbon trapping potential as well as interpreting the depositional environments across a field is key. Major improvements in seismic and well logs have made it possible to map such structural and stratigraphic architectures with high degree of accuracy and exactness. Seismic profiles provide a continuous lateral view of the subsurface by defining its geometry. However, vertical details are limited due to lengthy duration of the individual seismic wavelets and the occurrence of overlapping wavelets from closely spaced reflectors. Thus, the extent of accuracy in mapping complicated facies architectural plays would be improved greatly by combining seismic data with well logs (Adejobi and Olayinka, 1997). A reservoir model is an idealized sequence of facies which is defined as a general summary of specific sedimentary environment in a reservoir. Available information on a depositional environment is used to derive general information and to create an ideal environmental summary or sequence of facies. Therefore a reservoir model should act as a standard for comparison purposes and a guide for future observations (Walker, 1984). Well logs are very useful in reservoir modelling as it gives vital information of the porosity, permeability and water saturation of the field. Gamma ray log motifs are indicators of the depositional environment of the reservoir whereas seismic data contribute to the geometric, description of reservoir structure and stratigraphy by relevant interpretation of data (Selley, 1978). The paper is aimed at establishing connectivity and determining the impact of reservoir properties to the depositional environments in selected sandstone reservoirs by modeling the reservoirs of the correlated sand bodies across the wells characterizing the reservoir geometry, evaluating the reservoir properties and interpreting the environment of deposition.

Geology of the Niger Delta Basin

The Niger Delta is situated in the Gulf of Guinea and extends throughout the Niger Delta Province as defined by Klett, *et al., (*1997). The Niger Delta Basin evolved from the separation of the African and South American continental plates. Several researchers such as Grant (1971), Burke (1971) and Wright (1976) have attributed the origin of the Niger Delta Basin to the RRR (ridge - ridge - ridge) system. The geology, sedimentology stratigraphy, structural geology, and petroleum geology of the Niger Delta is well established. See the works of Orife and Avbovbo (1982), Corredo *et al* (2005), Burke *et al* (1971, 1972), Heinio and Davis (2006), Cohen and McClay (1996), Whiteman (1982), Olade (1975), Murat (1972), Doust and Omatsola (1989, 1990; Ejadawe *et al* (1984), Iheaturu and Ideozu (2017), Ideozu *et al* (2018), Selley (1978), Reijers, 1996 and Kulke, 1995Stratigraphically, the Niger Delta sequence comprises Akata, Agbada and Benin Formations. .

Location of the Study Area

The study area is located within the Northern Delta depo belt region of the Niger Delta. It lies between Longitude $4^0$0'00"E to $8^0$0'00"E and latitude $02^0$0'00"N to $06^0$0'00''N (Figure 1)

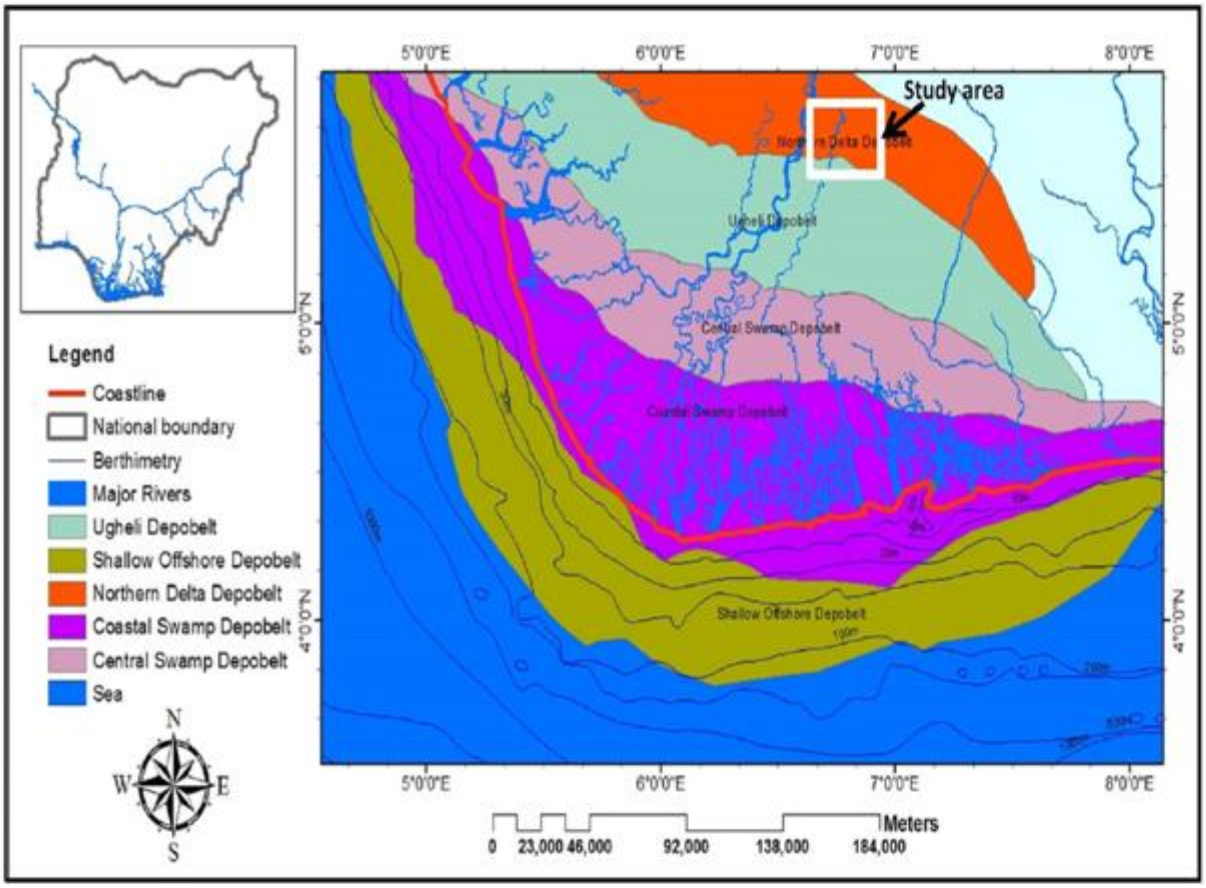

Figure 1: Location map of Welder Field

2. Materials and Method

2.1 Materials

3D Seismic Data and suites of wire line logs across four wells was used for this work. The suites of wire logs includes: gamma ray, neutron, density and sonic logs.

2.2 Methods

The data sets were interpreted with the aid of a standard geologic and geophysics software in order to understand and evaluate facies attributes/characteristics that would enable construction of potential reservoir models of the correlated sand bodies across the wells. The information was used for interpretation of the depositional environments Welder Field. The sand and shale sequences were analyzed from the Gamma Ray log signatures while the petrophysical properties of the reservoir sand bodies was computed using defined formulae for porosity, permeability, saturation of water, net - to - gross ratio and STOIIP. Apparently, the interpretation of environment of deposition was carried out using Gamma Ray log signatures across the wells. Seismic data analysis was carried out using the Petrel software; a synthetic seismogram of the seismic traces with respect to the rock responses at depth as a result of changes in geologic properties was produced. The synthetic seismogram helped in identification of the reflections seen on the seismic section. The picking of the reservoir tops was made possible by tying the synthetic seismogram to the seismic volume. In addition, the synthetic seismogram was used to carry out a well - to - seismic tie, structural interpretation of faults, while seismic horizon interpreted on the 3 - D seismic data for producing time and depth maps showing reservoir modeling Welder Field.

3. Results and Discussions

The results of this work is presented Figures 2 – 3 and Tables 1 - 3.

Reservoir Characterization

Reservoirs sand bodies (W100, W200, W300, W400, W500, W600, W700 and W800) were identified across the four (4) wells of Welder Field used in this work. The reservoirs of interest W700 and W800 they had good prognosis whereas the rest had not. W700 and W800 reservoirs are two very thick reservoir sands. W700 has an average thickness of 98m while W800 has an average thickness of 85m. Average porosity value of W700 is 0.23 while that of W800 is 0.21. The two reservoirs have an average net - to - gross of 0.9. The average water saturation of the W700 reservoir is 0.39, and that of W800 is 0.42. The average permeability value of W700 is 78 mD while that of W800 is 12 mD. The calculated oil volume from W700 reservoir is 84 million STB while that of W800 reservoir is 62 million STB. Both reservoirs have very good porosity and a fair to moderate permeability for reservoirs W800 and W700 respectively. (Table 2 and 3). See the results of the calculated petrophysical properties, volumes for the two reservoirs, in Table 1.

Depositional Environment

The stratigraphy shows sequences of alternating sand and shale lithologic units (Figure 2) where W700 and W800 reservoirs generally show a prograding to aggradational stacking pattern identified on the Gamma Ray log see Figure 3. Reservoir sand in W700 and W800 was divided into two parts, the lower parts representing a period of low energy deposition while the upper part represents a period of higher energy deposition. The Gamma - Ray log motif in Figure 3 shows a funnel shape (coarsening upward or cleaning upwards) at the upper part indicating deposits of mouth bars, deltaic front and shoreface environments. The log motif of the lower part of reservoir sands in W700 and W800 shows a blocky shaped profile suggesting fluvial/deltaic flood plain, fluvial channels, deltaic distributary or tidal channel environment. From the petrophysical evaluation, it was observed that the reservoir sand units in the W700 and W800, exhibited good to excellent reservoir qualities see Table 1.

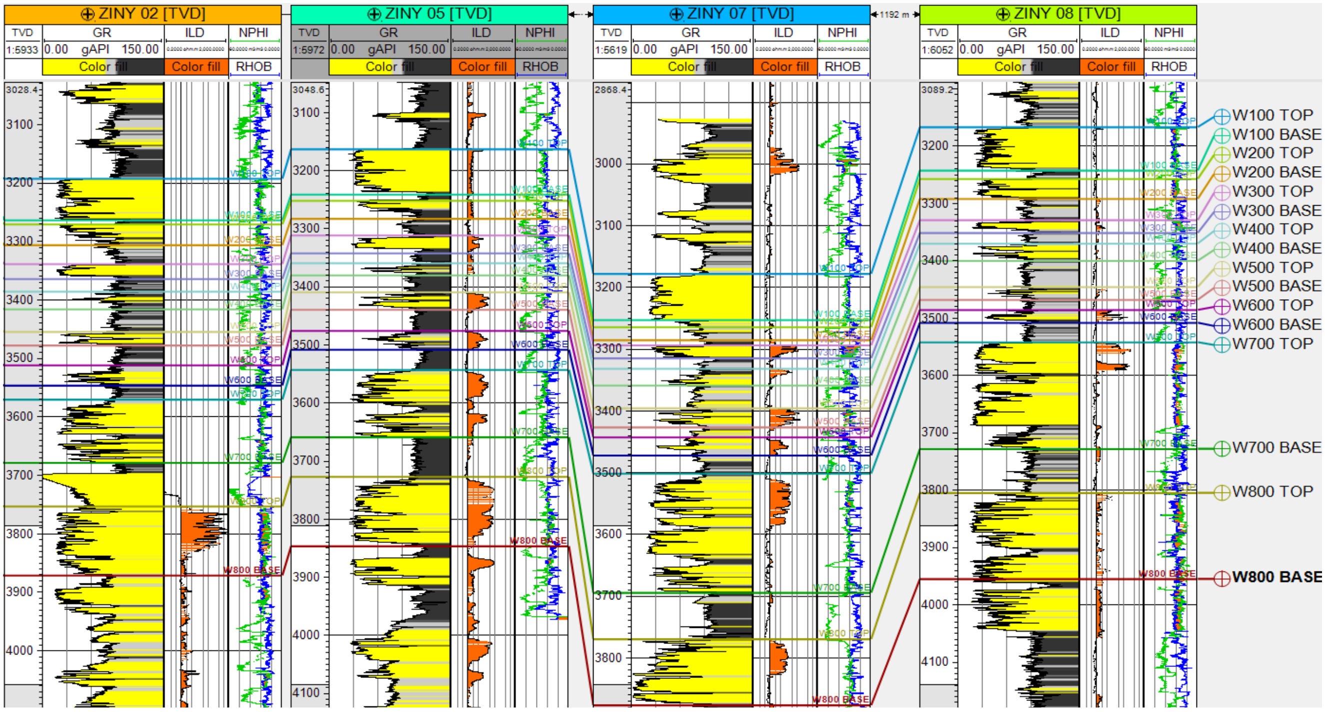

Figure 2: Well log correlation panel showing the stratigraphy and reservoirs identified across the Welder Field

Table 1: Reservoir petrophysical value

	Reservoir Petrophysical Values						Volume
Reservoir	Thickness [M]	Net - to - gross	Porosity	Water Saturation	Permeability [mD]	Formation Volume Factor	STOIIP [MMSTB]
W700	98	0.9	0.23	0.39	78	1.3	84
W800	85	0.9	0.21	0.42	12	1.3	62

Table 2: Qualitative description of porosity value (After Rider, 1986)

Porosity, (ϕ) IN %	Quality Description
0 - 5	Negligible
5 – 10	Poor
10 - 15	Fair
15 - 20	Good
>20	Very good

Table 3: Qualitative description of permeability value (After Rider, 1986)

Permeability, K IN mD	Quality Description
<10.5	Poor
11 – 15	Fair
15 - 50	Moderate
50 - 250	Good
250 – 1000	Very good
>1000	Excellent

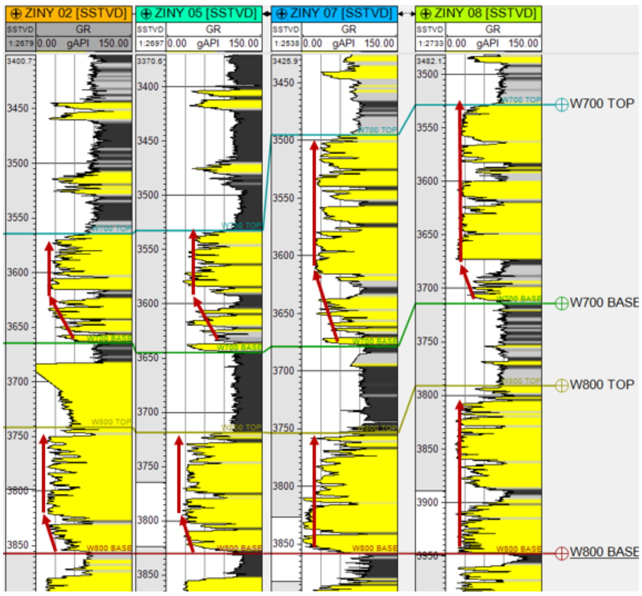

Figure 3: Gamma ray shape of W700 and W800 reservoir sands

4. Conclusion

The study revealed that W700 and W800 are potential reservoirs, since they exhibit good to excellent reservoir characteristics. The environments of deposition of the reservoirs are interpreted as mouth bar, deltaic front and shoreface respectively. The depositional environment is the major control on the reservoir properties.

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