Most of the fields in the onshore Niger Delta are undeveloped several years after discovery. Among the numerous challenges that have hindered optimal development of these fields include geological uncertainties such as complex reservoir geometry, spatial and temporal variation of reservoir fluid. Hence, this study is aimed at improving the geological understanding of the reservoir systems by integrating sedimentology and quantitative rock physics for optimal field development. The objectives of this study include: to reconstruct the depositional environment of the reservoir sands, investigate the presence of stratigraphic barriers to lateral fluid variation, construct predictive reservoir model for simulation, and finally define optimal field development strategy. Analogs, core, logs, seismic, and production data were integrated in the study. The methodology and workflow for the study have combined simultaneous amplitude variation with offset (AVO) inversion, seismic geomorphology, static modeling, and dynamic simulation. Segmentation of the AVO inversion attributes including: shear impedance, lambda-rho and mu-rho into discrete facies classes revealed macro-scale sedimentary features such as barrier mouth bar and braided channel systems with crosscutting relationship on horizon slices. Evidence from core interpretation supports a bay/lagoon marginal marine environment with characteristic layer cake and labyrinthine sand geometry. The conceptualization of the sedimentary environment and the sand geometry defined from the inversion attribute characterization, formed input for constructing a predictive reservoir model. The dynamic simulation of forty years production from the reservoir model gave a match of less than 10% difference between the simulated and historical production of oil and water respectively. Consequently, a three horizontal wells case with 4-1/2 inch tubing size and 1500 inch drain length, have been selected as the most realistic option for optimal field development and oil production at 1500 barrel per day rate using gas lift recovery mechanism. Finally, the integration of simultaneous AVO inversion, attribute segmentation, and sedimentology has reduced the geological uncertainty that had hindered optimal development in the field. This integrated methodology and workflow will serve as analog in solving complex geological problems and the associated development challenges in similar reservoir systems.

References Cited

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ABSTRACT

Most of the fields in the onshore Niger Delta are underdeveloped several years after discovery. Among the numerous challenges that have hindered optimal development of these fields are geological uncertainties such as complex reservoir geometry, spatially and temporally variable of reservoir fluid. Hence, this study is aimed at improving the geological understanding of the reservoir systems by integrating sedimentology and quantitative rock physics for optimal field development. The objectives of this study include; to reconstruct depositional environments of the reservoir sand, investigate the presence of stratigraphic barriers to lateral fluid movement, construct predictive reservoir model for simulation, and finally define optimal field development strategy. Analyses, core, logs, seismic, and production data were integrated in the study. The methodology and workflow for the study have combined simultaneous amplitude variation with offset (AVO) inversion, geology, seismic modeling, and dynamic simulation. Segmentation of the AVO inversion attributes including, depth to top reservoir, sand map, and mud map, from the seismic data allowed precise correlation with well data and structural features such as barrier mud and breccia channel systems. A study of core lithology related to hydrocarbon occurrence on horizon slice. Evidence from core interpretation supports a bay/lagoon marginally marine environment with characteristic barrier sandstone and lamination sandstone. The concept that understanding the sedimentary environment and sand geometry defined from the inversion attributes characterization formed major inputs for constructing a predictive reservoir model. The dynamic simulation of forty years production from the reservoir models gave a good match within 50% difference between the simulated and historical production of oil and water respectively. Consequently, a horizontal well case with 3 1/2 inch tubing size and 1000 inch drain length, have been selected as the most realistic option for optimal field development and oil production at $100 bbl/barrel as rate using gas lift recovery mechanism. This development strategy will increase of recovery factor from 7% to 35%. Finally, the integration of simultaneous AVO inversion, attribute segmentation, and sedimentology has reduced the geological uncertainties that had hindered optimal development in the field. This integrated methodology and workflow will serve as analog in solving complex geological problems and the associated development challenges in similar reservoir systems.

INTRODUCTION

Most Offshore Fields in the Niger Delta are associated with development challenges, drilling and business risk (Egboda, 2011). Hence, geological uncertainties including; facies heterogeneity, complex reservoir architecture, and sand connectivity, as well as lateral fluid distribution have been major challenges in characterizing fluvial and detrital reservoirs for field development (Ponsonnier, 2002). Typical fluvial-deltaic reservoirs exhibit complex geometry including; channel-levee, basin-local, and lobe-stratigraphy (Shi et al., 2017). Hence, the conventional reservoir characterization method for facies heterogeneity using the single layer case correlation could be unrealistic in fluvial and delta-dominated environments.

OBJECTIVES

1. To reconstruct depositional environments of the reservoirs;
2. To define sand geometry and correlation techniques in the study area;
3. To investigate the presence of stratigraphic barriers to lateral fluid movement and;
4. To build a predictive geological model for dynamic simulation and optimize field development planning.

INTEGRATED WORKFLOW AND METHODOLOGY

1. Sedimentological analysis & Emphasis on Depositional:
2. Rock Physics/Pre-stack AVO Inversion & Seismic Facies Segmentation
3. Static/Dynamic Reservoir Modeling & Field Development Scenarios

RESULTS & INTERPRETATION

CONCLUSIONS

1. The reservoir sand is deposited in a bay/lagoon environment on river mouth bar and braided channel deposit.
2. The reservoir geometry is a combination of simple lateral-sieve and basin-stratigraphic geometry.
3. The reservoir has combined structural and stratigraphic trapping to oil accumulation with the channel-forming stratigraphic barrier to flow.
4. The optimized reservoir model shows that the 2 additional horizontal wells on gas lift recovery mechanism will increase the recovery factor from 7% to 35%.

SELECTED REFERENCES