Hydrocarbon Potential of the Marginal Fields in Niger Delta – Oza Field, a case study*

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Abstract

The Niger Delta is situated in the Gulf of Guinea and has prograded southwestward from the Eocene to the present forming various depobelts. This delta complex was developed as a regressive offlap sequences, built across the Anambra Basin and the Cross River margins and extended to the Late Cretaceous continental margin. Sediments ranging in age from Paleocene to Recent are present with maximum sediment thickness of ~ 10 km in the depocenter. Gravity tectonics form the primary deformational process in this region both in onshore and offshore and is manifested through complex structures, including shale diapirs, roll-over anticlines, collapsed growth fault crests, and steeply dipping, closely spaced flank faults. The basin has a well-defined “Akata –Agbada Petroleum System” in the Tertiary package. Several discovered marginal fields exist in onland delta areas, which provide attractive opportunities for development due to the presence of multi-stacked good quality reservoirs associated with growth fault related structures. The first onshore commercial discovery in Niger Delta was made in 1956, since then, exploration activity has continued aggressively. Several fields were discovered with reserves exceeding 34 billion barrels of oil and 93 trillion cubic feet of gas. Oza field is one such field where oil and gas were discovered in 1959 and was under production until 1982. Three reservoir packages were produced and several others were awaiting assessment of their potentiality. Hardy, the technical partner, has reassessed the hydrocarbon potential of the field based on new 3D Seismic data and data of four wells. It has identified eleven prospective layers with good reservoir properties. The cumulative estimated STOIIP of the field is 114 MMBbl. The resource oil potential is 7MMBbl (contingent category), out of which 1 MMBbl has already been produced and is 27 MMBbl (prospective category). The field is in advance stage of development. The field indicates the quality of marginal field in Niger Delta.

Introduction

Oza Marginal Field is part of the Niger Delta, located onshore in the Abia State, Nigeria. Niger Delta has prograded southwestward from Eocene to the present forming various depobelts (Figure 1). This delta complex was developed as regressive offlap sequences, built across the Anambra basin and the Cross River margins and extended to the Late Cretaceous continental margin. Sediments ranging in age from Paleocene to Recent are present with max sediment thickness of ~ 10 km in the depocenter. The stratigraphy of the Niger Delta is divided into three diachronous units of Eocene to Recent age that form a major regressive cycle. The uppermost unit, the Benin Formation was deposited under continental/fluviatile and back swamp environment and is up to 2,500m thick. These are underlain by the Agbada Formation of paralic, brackish to marine, coastal and fluvio-marine deposits, organized into coarsening upwards ‘offlap’ cycles. The underlying Akata Formation is mainly pre-delta clays and is up to 6,500m. Shales of the Akata Formation constitute an excellent source rock and the widespread “Akata-Agbada Petroleum System” of Tertiary age is proven in the basin. Re-evaluation of the Oza field has been conducted by Hardy based on new 3D seismic data obtained from the Nigeria National data repository by the JV partner “Millennium Oil and Gas Company Limited (MOGCL)”. The study resulted in identification of additional eight prospective reservoir layers based on drilling information, petrophysical analysis and test data in addition to the three proved layers.

Geology of Oza Field

The area represents a part of the Niger Delta where the main three stratigraphic units viz. Benin (Plio-Pleistocene), Agbada (Mio-Pliocene) and Akata Shale (Eocene to Miocene) are encountered in the Oza wells. The area represents a growth fault regime with associated rollover structures providing the hydrocarbon traps (Figure 2). There are two growth fault sets running in NW-SE direction with their concavity to the southwest. The growth faults are also associated with antithetic faults. The discovered pays in Oza Field were encountered in the intervals below the base of Plio-Pleistocene fresh water Benin Formation sands. The Agbada Formation consists of alteration of these pay sands and shale deposited as paralic, delta bars and near shore fluvial deposits. Akata Shale represents the main source rocks in Niger Delta region and within the block.

Well Log Correlation of Oza Field

There are four wells drilled in the field where 11 pay sands (grouped under K, L and M) are identified. A detailed log correlation of all the wells in the Oza field suggests that all the pay sands are present in all the wells with varying thicknesses. A sample of two sands M and K are shown in the log (Figure 3). Hydrocarbon bearing sands at M 5.0 and other layers younger to L 7.0 are predominantly concentrated in and around Oza A and Oza D wells. In the rest of the wells, these sands are water wet. Structural interpretation and mapping at M 5.0 level indicate a terrace like feature around the Oza D well (Figure 4). General dip of the sands above L 7.0 level suggests a southerly trend. Similarly, the hydrocarbon bearing sands M 1.0 and M 2.2 are encountered in Oza B and Oza C wells but are water wet in other wells. Apart from the three partially produced hydrocarbon bearing sands (M 5.0, M 1.0 and M 2.1), the other eight prospective hydrocarbon bearing sands have clear OWCs and are distinct on the logs.

Geophysical Interpretation

The Oza Field concession was initially covered by scanty 2D data and all the wells were drilled based on 2D data interpretation. Subsequently, a 3D survey was carried out in and around Oza Field by SPDC. Hardy obtained the 3D volume, covering an area of ~150 km^2, from the operator and the same has been used for this study. Calibration of log data with seismic was done by using the available check shot data and logs. Seismic match with log data was done by applying a bulk correction to seismic data. In general, well sections passing through the well Oza B (Figure 2). The main objective of the correlation and mapping of these reflectors is to understand the structural disposition of various sand units present in the Oza Field. The log data of the Oza Field suggests that the entire reservoir section can be divided into three units, viz., lower, middle and upper units. The lower unit consists of M 5.0 sand and below (Figure 4) the middle pack L 7.0 to M 2.1 sands, and the upper unit may be considered to comprise of sands from K 7.0 to L 3.0. Therefore, to understand the structural disposition of these units, three levels (M 5.0, L 7.0 and K 7.0) were selected for seismic mapping and correlated throughout the entire volume. In addition, one more level L 2.6 was mapped in the central part of the area.

Hydrocarbon Potential of Oza Field

Petrophysical Parameters

Various studies were carried out earlier on the petrophysical properties analysis for the pay sands in Oza field prior to the present re-evaluation. Porosity derived from the sidewall cores of Oza B well and synthetic curves generated from through the density model of the cores in the nearby offshore wells are presently used for the robust petrophysical analysis. Volumetric estimations are based on the petrophysical analysis inputs. Effective pay thicknesses of the reservoir sands, OWC are calculated using 60% water saturation cut off.

Hydrocarbon Resources

In general, all the sands have excellent petrophysical properties, which are also supported by their log response. Still, for volumetric estimation, the net to gross was considered as a flat 70% that may be slightly on the conservative side. Gross rock volume (GRV) is calculated for the proved hydrocarbon bearing sands and for other reservoirs seen in the wells for volumetric estimation using Z-map CARM. Structural and fault closure away from the wells where the confidence level is high for possible hydrocarbon accumulation above the OWC have been considered for volumetric estimation with their Geological Chance of Success. In our opinion, most of these areas should be included for volumetric estimation due to the likely development of good reservoir facies. The estimated STOIIP (114 MMstb) for the block is categorized as Contingent (23 MMstb) based on the proven/tested hydrocarbon reservoirs in some of the wells and rest as Prospective (91 MMstb). After applying recovery factor (30%), the contingent resources are in the range of 7 MMstb (3 tested and produced zones: M 5.0, M 1.0 and M 2.1) out of which 1 MMstb have already been produced. Prospective resources of 27 MMstb in 8 zones interpreted to be hydrocarbon bearing from electro logs need to be tested in the existing wells for further upgradation of resources to contingent category. The present study identified appraisal/development well locations for future development of Oza Field.

Conclusion

This case study provides an example of the sizes of the Marginal fields in Niger delta. The marginal fields form attractive investment opportunities based on proven petroleum system, high geological chances of success and multiple stacking of reservoir sands. In addition, these are Tertiary reservoirs high porosity and permeability values, which make it less risky and more productive. The main risk is the entrapment and technical challenge of exploitation of the thin reservoirs with limited pool size.

Acknowledgements

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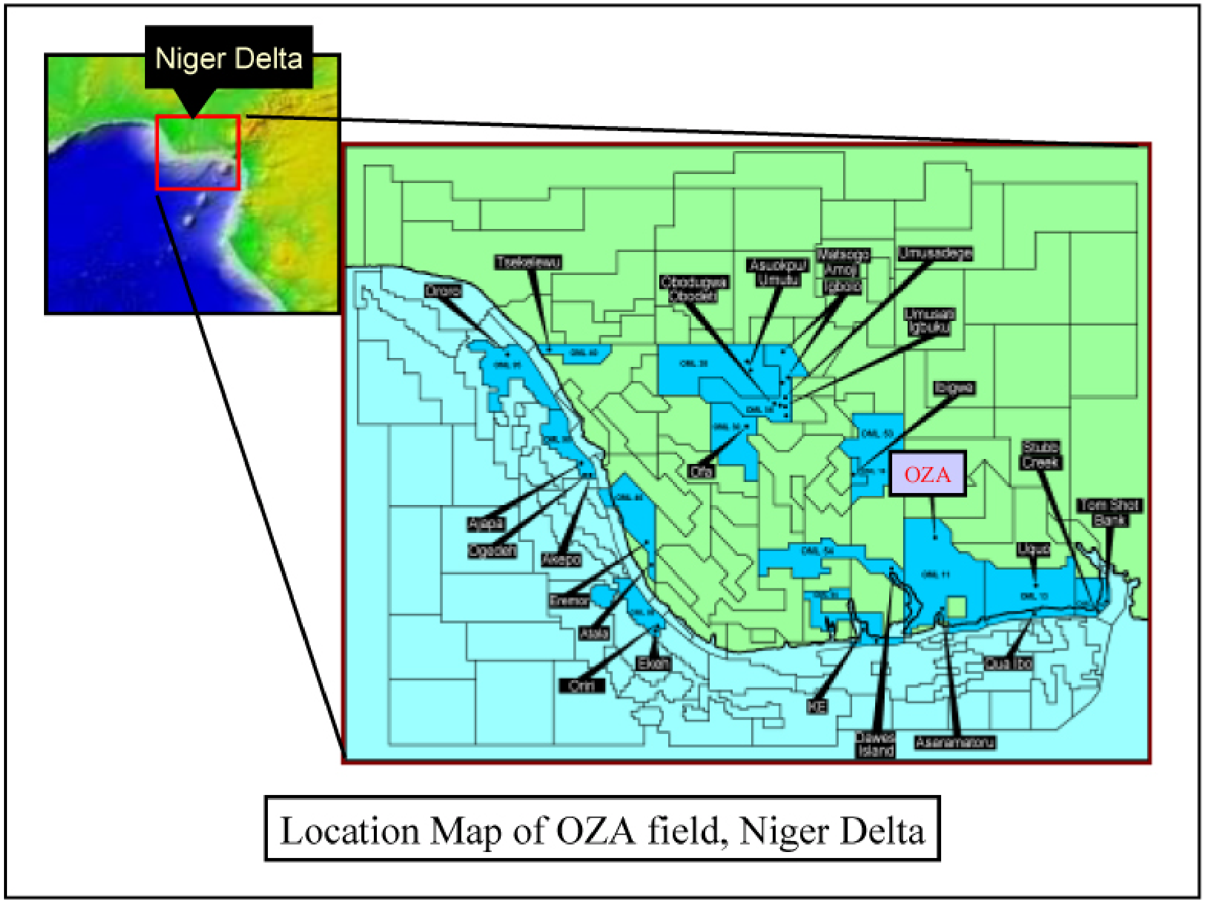

Figure 1. Location map of Oza Field, Niger Delta.

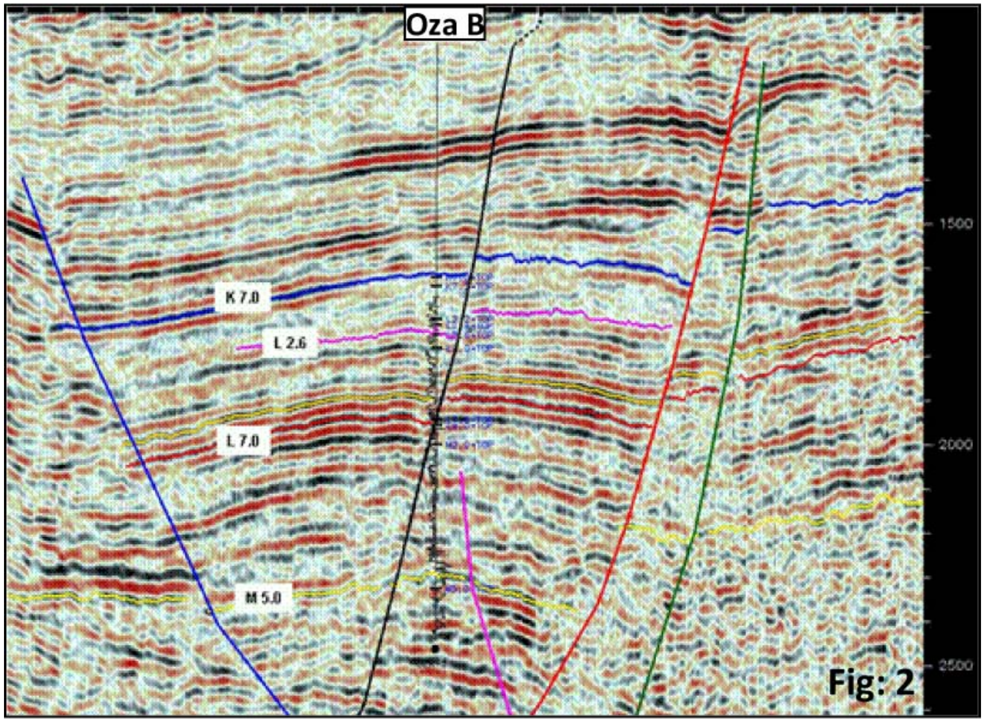

Figure 2. Seismic cross section illustrating subsurface structure.

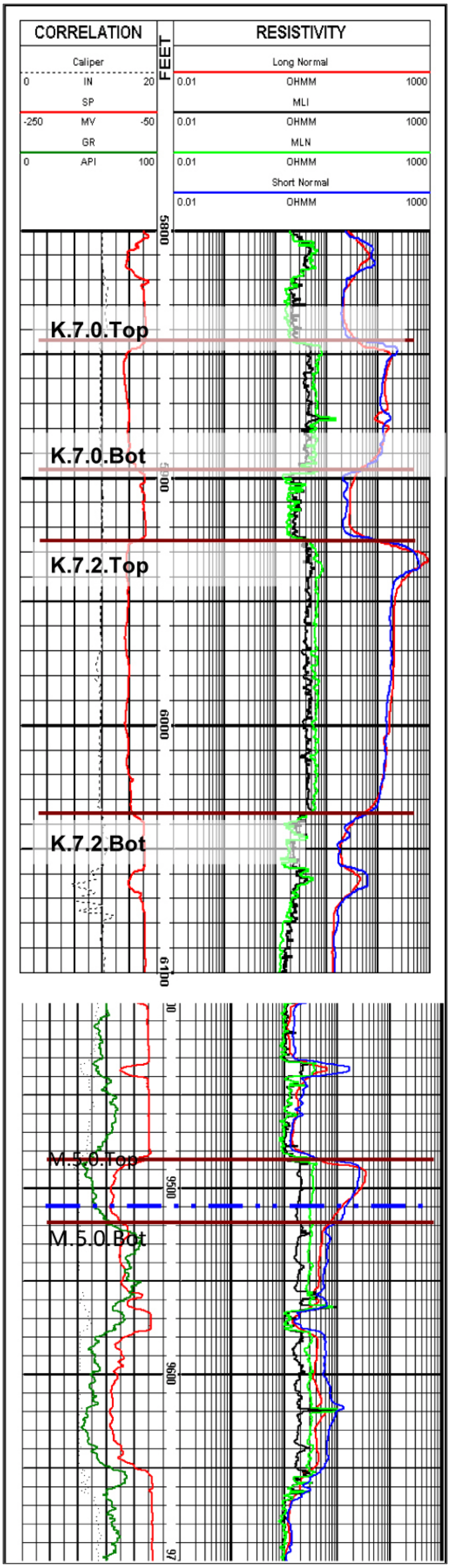

Figure 3. Oza Field type log.

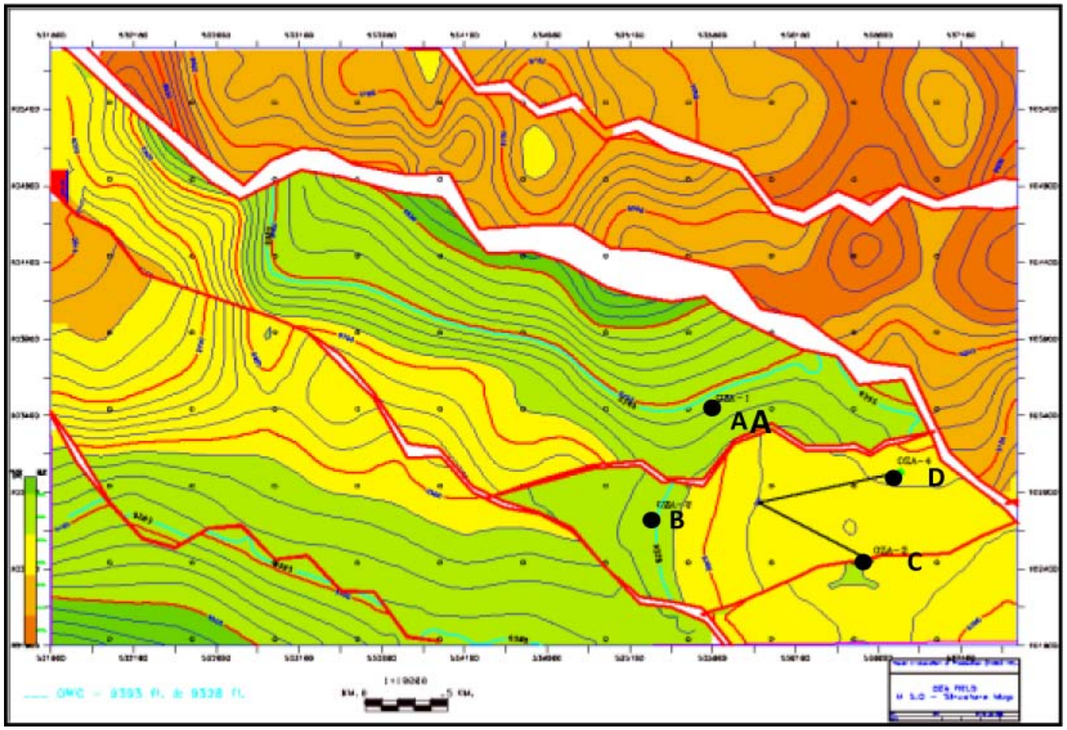

Figure 4. Oza Field structure map.