Value of Cost Effective and High Impact Data Acquisition Strategy- Learnings from Usari Graben Re-Development

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ABSTRACT

The Usari Field is an oil and gas field within the OML 70 NNPC/MPN JV acreage. The field was set up by a rollover anticline associated with a major growth fault. It has 5 major reservoir groups namely; Base Qua Iboe, Shallow, Intermediate, Deep and Graben Reservoirs. This paper focuses on the re-development of the Usari Graben Reservoirs. The Usari Graben is characterized by a series of fault dependent traps beneath a shallow gas anomaly which makes seismic imaging of the ~70% of the hydrocarbon area very challenging. This imaging challenge, in combination with sparse well penetrations, lead to significant subsurface risks and uncertainties within the Graben; uncertainties in gross rock volume, reservoir depth and fluid contact, and hydrocarbon presence risk in some reservoirs. Consequently, the Graben Reservoirs remain relatively under-developed compared to other reservoir groups within the Usari Field. The objectives of the Usari Graben re-development program were to provide optimally placed infill wells to drain the Reservoirs, test up-dip hydrocarbon potential in some reservoirs, prove potential oil columns, confirm current fluid contact estimates and acquire data to help mitigate risks and reduce uncertainties in the area. Given the stated subsurface risks and uncertainties, the team proposed and drilled the G2 pilot well to penetrate multiple stacked (8) Graben Reservoirs. The risks and uncertainties associated with the Usari Graben re-development were greatly reduced through this data gathering approach. Furthermore, the strategy led to significant cost savings by eliminating the need for more Graben pilot wells. Three of the de-risked reservoirs have been developed; the G2 pilot well was converted to a dual oil producer and completed in two reservoirs, and an additional infill well was drilled for the 3rd reservoir with a total uplift of 9.3KBD.

Keywords: Acquisition, Graben, Reservoir, Inversion, Development, Uncertainties

INTRODUCTION

The Usari Field, located in OML 70 (Figure1), is the second largest hydrocarbon field in the NNPC/MPN Joint Venture (JV) acreage, and has significant remaining reserve potential. The field was discovered by a Usari exploration well in 1964.

The Usari Graben reservoirs are one of five major reservoir groups that exist in the Usari Field. They can be found within the Bedded Benin Member of the Agbada Formation which are primarily fluvial and shallow marine (i.e., shoreface and deltaic) deposits in this area. The Graben reservoirs are defined by a four-way anticlinal closure with crestal faults. Hydrocarbon traps consists of a combination of anticlinal and fault dependent traps. In addition to extensive faulting, the Graben area is further masked by a shallow gas anomaly causing imaging issues including reflector sags, non-geologic undulations/kinks caused by the complexly varying velocities (Aikulola *et al.,* 2010). This affects the seismic

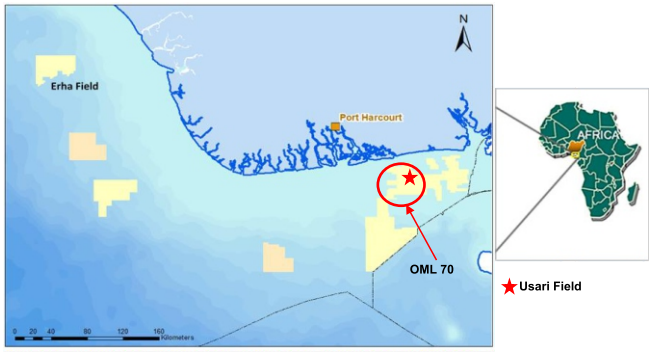

Figure 1: Regional map of Africa showing NNPC/MPN JV Acreage with Usari Field highlighted.

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image quality of about 70% of the Graben area (Figure 2).

This shallow gas anomaly combined with sparse well penetrations made development of the Usari Graben riskier when compared to the other reservoir groups within the Usari Field. Discoveries here are plagued by significant risks and uncertainties which include gross rock volume, reservoir depth and fluid contact uncertainties together with hydrocarbon presence risk in some reservoirs. Consequently, the hydrocarbon resource within Usari Graben (20% of total Usari Field resource) remains relatively under-developed.

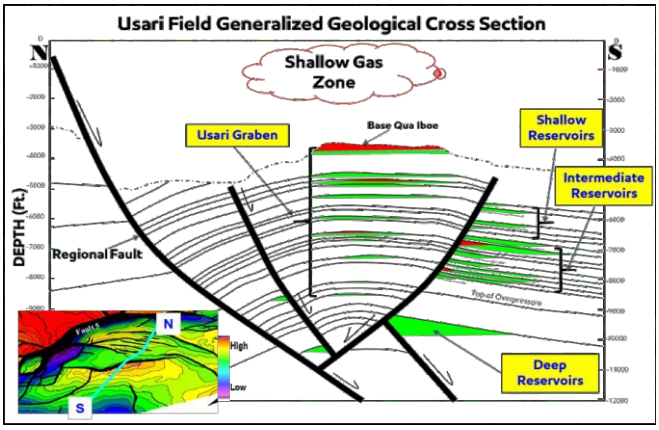

Figure 2: Generalized Usari Field Geological Cross-Section Showing Shallow Gas Anomaly above the Graben Area.

Usari Graben Development

The Graben reservoirs were discovered by the Usari G1 well in 1964. This was followed by 5 other appraisal wells which discovered and proved several compartments of hydrocarbon accumulations in sixteen (16) Graben reservoirs (Figure3). Most of these discoveries had some form of uncertainty which includes fluid type, fluid contact, structure etc. The discoveries led to the first phase of the Usari Graben development between 2009 and 2011, and at which time Seven (7) of the Graben reservoirs were developed with six (6) wells. The reservoirs selected for this initial development had larger STOIIPs and were less risky. Drive mechanisms observed were moderate to strong water drive and solution gas drive.

After the first phase of development, nine (9) of the Graben reservoirs remained undeveloped. A 2016 full wave field inversion (FWI) reprocessed 3D seismic data improved the imaging under the shallow gas anomaly thereby enabling updates to the subsurface characterization of this area. The improved subsurface understanding in the Usari Graben area kick-started a re-development campaign. The team was tasked with re-appraising the remaining opportunities in the Usari Graben and re-developing the area in a cost effective manner requiring a clear understanding of the development decisions ahead, and the existing uncertainties in the field. This has been discussed by previous authors (Burkholder *et al.,* 2012 Coopersmith *et al.,* 2003).

METHODOLOGY

The Graben Re-development

The Usari Graben still had a lot of potential left after the first phase development, both in the developed and undeveloped reservoirs. Only about 20% of the total Graben resource was recovered in Phase 1 development. A considerable amount of data was needed to support flawless execution of the next phase of drilling program. The capital intensiveness of the industry and emerging low oil price regime has necessitated scrutiny on every dollar spent on data gathering in the current business terrain (Singh *et al.,* 2017). The team was tasked with providing a cost effective approach to gather data needed to reduce the risks and uncertainty in the area and facilitate a re-development.

The Usari Graben area being complexly faulted and located under a shallow gas anomaly carries a major risk of reservoir structure and depth uncertainty. The 2016 reprocessed Full waveform Inversion (FWI) 3D Seismic data enabled imaging improvement under the shallow gas (Figure4) and reduced this uncertainty.

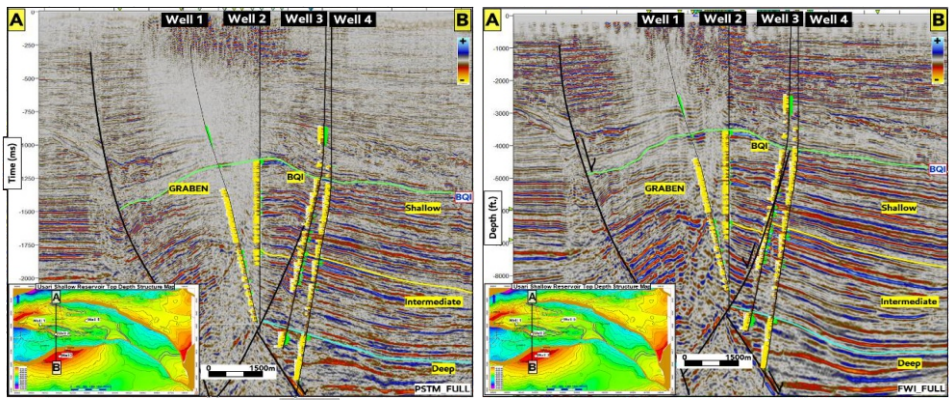

Figure 4: PSTM vs FWI highlighting seismic imaging uplifts (Olatunbosun *et al.,* 2019).

Even with an updated subsurface understanding of the area, wells were needed to provide additional control on the reservoir structure and to the depth uncertainty in the area. These wells had to be optimally placed to reduce the risk and uncertainties in other parameters like fluid type, reservoir pressures, and fluid contacts in multiple reservoirs.

Re-developing the Usari Graben at a minimal cost required a high impact data acquisition strategy to enable making informed sequential decisions leading to a development plan that optimizes cost and hydrocarbon recovery (Bratvold et al., 2009).

The team started by looking at the resource in the individual reservoirs in the Usari Graben. Three (3) of the undeveloped reservoirs (B5G, DG5 and F5G) and one (1) developed reservoir (B1G) were chosen to initiate re-development based on their resource size and relatively lower risk profile. These reservoirs would need pilot wells for optimal placement of producer well completions.

The Usari Graben Reservoirs are vertically stacked (Figure5) and this enabled the team to propose a single pilot well (Usari G2) to address most of the risks and uncertainties in the stacked reservoirs. In other to be cost efficient and improve well profitability, the Usari G2 pilot well would also serve as a deviated dual oil producer to drain the resource in 2 of the deeper Graben reservoirs (D5G and F5G). Two (2) optimally placed horizontal oil producers were planned to drain the other 2 reservoirs (B1G and B5G) and to gather additional information in the Graben area.

The wells were sequenced for execution such that the Usari G2 pilot was drilled first in order to give the team ample time to react to any surprises that might impact the other wells during execution.

RESULTS

The Usari Graben re-development program execution commenced in 2019, with the drilling of Usari G2 pilot well. Usari G2, achieved its objectives of reducing the risks and uncertainties in the Usari Graben area. Fluid type, fluid contacts, oil column and reservoir pressures were updated for 4 undeveloped and 4 developed Graben reservoirs (Table 1).

The producer wells were sequenced in a way that no additional pilot well was needed to develop the other reservoirs thereby saving costs on 2 additional pilot wells. The results from the Usari G2 pilot well changed the execution strategy for the other 2 planned horizontal oil producers.

The Usari G2 pilot well was finally converted to a dual oil producer and completed in the D5G and F5G reservoirs. Due to G2 pilot well proving additional oil column in the B5G reservoir a decision was made to increase the completion interval and rate of its dedicated horizontal oil producer. These 3 completions have increased Usari daily oil output by 9.3KBD.

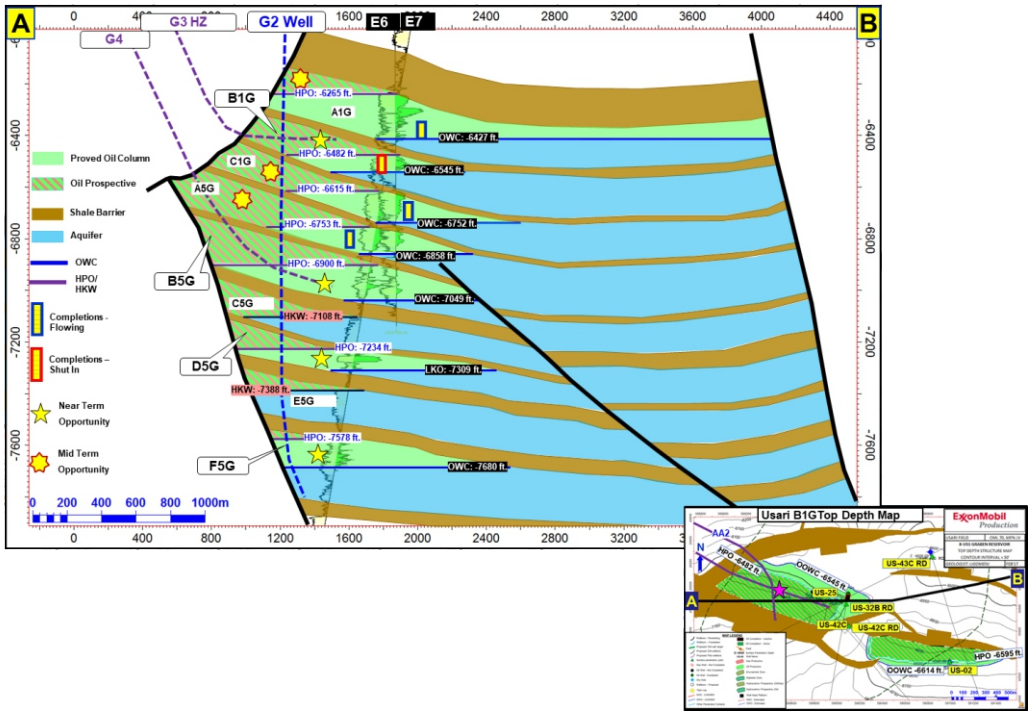

Figure 5: Cross section along dip of the B1G Reservoir showing the stacked Usari Graben Reservoirs and planned wells. (Modified from Omeni et al., 2018).

Table 1: Table Showing Drilling Results from the Usari G2 Well.

Reservoir	Proved / Remaining Oil Column (ft)	Comment
A1G_Upper	29	Existing well flowing and expected to capture RUR
A1G_Lower	66	Usari G2 logged undrained oil column. Pressure data confirms deferential depletion across flow units - additional near term drill-well opportunity under evaluaton
B1G	57	Logged gas 87ft deeper than prognosis Eliminated the cost of a dedicated pilot hole Identified potential flow units in this reservoir (GDT in flow unit 1) Re-evaluating development concept (optimized completion plan)
C1G	52	Existing well flowing and expected to capture RUR
A5G	87	Existing well S.I due to mechanical issue. Evaluate drill-well potential if existing well cannot be restored
B5G	150	Eliminated the cost of a dedicated pilot hole to optimize proposed horizontal oil producer
D5G	125	Completed as planned in Usari G2 dual oil producer
F5G	144	Completed as planned in Usari G2 dual oil producer

New Opportunity | Pilot Cost Eliminated | Completion Objective

CONCLUSIONS

Low oil price business environment necessitates prudent spends on data gathering needed to reduce subsurface risk and uncertainties, while maximizing investment returns. A cost effective and high impact data acquisition strategy using a pilot well was applied to reducing subsurface risk and uncertainties in Graben reservoirs at Usari Field. The results enabled a decision to go forward with the Graben re-development program with a potential to improve the Usari Graben recovery from 20% up to 25%. The data acquisition strategy enabled production drillings in three out of the eight Graben reservoirs with other reservoirs slated for near term drilling program.

REFERENCES CITED

Aikulola, U. O., S. O. Olotu, and I. Yamusa, 2010. Investigating fault shadows in the Niger Delta: The Leading Edge, 29, 16–22, http://doi.org/10.1190/1.3284048.

Bratvold, R.B., J.E. Bickel and H.P. Lohne, 2009. Value of information in the oil and gas industry: Past, present and future. SPE Reservoir Evaluat. Eng., 12: 630-638.

Burkholder, M.K., E.M. Coopersmith and J.H. Schulze, 2012. Appraisal excellence in unconventional reservoirs. Proceedings of the SPE Canadian Unconventional Resources Conference, Oct. 30- Nov. 1, Calgary, Alberta, Canada, pp: 1-13.

Coopersmith, E., M., P.C. Cunningham and C.A. Pena, 2003. A practical decision analysis approach to appraisal and development strategy evaluations. Proceedings of the SPE Hydrocarbon Economic Evaluation Symposium, Apr. 5-8, Dallas, Texas, USA, pp: 1-11.

Olatunbosun A., Orupabo S., Bansal R., 2019. Role of Advanced Seismic Processing in De-risking Investment Decisions in a Poorly Imaged, Structurally Complex Usari Graben. A publication of Nigerian Association of Petroleum Explorationist (NAPE).

Omeni G., Bassey N., and Banye O., 2018. An Integrated Drillwell Optimization Approach to Maximize Production and Reduce Costs in a Complex Graben Reservoir Structure in Usari Field, Nigeria JV. A publication of Nigerian Association of Petroleum Explorationist (NAPE).

Singh, V., Yemez, I., Izaguirre, E. and Racero, A., 2017. Optimal Subsurface Appraisal: A Key Link to the Success of Development Projects-Few Examples. American Journal of Applied Sciences, 14(2), pp.217-230.