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RERESERVOIR STATIC MODELLING AND RESERVOIR CHARACTERIZATION OF X-FIELD, NIGER DELTA BASIN, NIGERIA

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ABSTRACT
The static modeling methodology incorporates seismic structural information, geologic layering schemes, and petrophysical rock properties... Quality Check of the structural and stratigraphic modeling was done and subsequently facies and petrophysical data was brought into the model for further population. Petrophysical data was conditioned to facies during scaling up well logs process. Differences in petrophysical properties among lithofacies and within a lithofacies among different porosities illustrate the importance of integrated lithological-petrophysical modeling and of the need for closely defining these properties and their relationships. The model is a tool for predicting structural, lithofacies and petrophysical properties distribution, water saturations, and original oil in place (OOIP) that provides a quantitative basis for evaluating remaining-oil-in-place. The model proves instrumental in evaluating current practices and consideration of modified well-bore geometry and completion practices that will potentially enhance ultimate recovery. Both the knowledge gained and the techniques and workflow employed have implications for understanding and modeling similar reservoir systems worldwide.

INTRODUCTION
In petroleum applications, reservoir models are often constructed with a specific end goal in mind. Priority is then given to data relevant to that end goal. For example, if the determination of original oil in place is considered, then emphasis is given to data that provide information regarding the volume, structure, porosity and the saturation of the reservoir. Fine tuning permeability values or their anisotropy ratios at this point are of lesser consequence. In order to construct a static reservoir model that accurately depicts the reservoir, the model must be conditioned to all available relevant data. However, rarely is there enough data to fully constrain the reservoir model.

This study employs the use of static modeling approach in the characterization of a reservoir field. Integrating static data is a practical and challenging work. It is practical due to the variety of data sources from different data collecting techniques that are offered for reservoir characterization. It is a challenging work due to the differences in the scale of the data.

AIM OF THE STUDY
The aim of this study is to integrate well log data and seismic data to build a reservoir static model of an X-Field.

LOCATION OF STUDY AREA
X-Field is located in the onshore depobelt of the Niger Delta Basin, where thick Late Cenozoic Clastic sequence of Agbada Formation were deposited in a deltaic fluvio-marine environment

LITERATURE REVIEW

Reservoir characterization is the description of a reservoir using all available data such as petrophysical data, seismic data, core data, PVT (B_o, B_g, B_w) and production data (pressure). It involves the merging of reservoir geophysics, reservoir geology and reservoir engineering through an integrated flow model. The process requires a forward model that can be used to predict changes in seismic properties from reservoir processes and an inverse process to refine the reservoir model on the basis of observed data.

Amafule et al (1988) defined reservoir characterization as 'combined efforts aimed at discretizing the reservoir into subunits, such as layers and grid blocks and assigning values to all pertinent physical properties to these blocks'. Harris et al (1977) emphasized the importance of synergy in reservoir management and discussed the interplay of geological and engineering factors in reservoir characterization. Sneider and King (1978) have discussed the integration of core data and log data in formation evaluation. Keelan (1982) discussed the variety of measurement protocols, characterized certain rock properties such as porosity, permeability, grain density, and capillary pressure, and showed how these properties varied with the geological factors such as the environment of deposition. Amafule et al (1993) noted that for enhanced reservoir characterization, macroscopic core data must be integrated with megascopic log to account for the uncertainties that exist at both levels of measurement which must be recognized and incorporated in sensitivity studies

Paul (2003) explained the role of cut-offs in integrated reservoir studies. He revealed that the principal benefits of a properly conditioned set of petrophysical cut-offs are a more exact characterization of the reservoir with a better synergy between the static and dynamic reservoir models, so that an energy company can more fully realize the asset value.

This information is now preprocessed within a static model in a format ready for implementation into these tools. This ability has greatly reduced the construction time of many reservoir engineering tools and allowed engineers more time to focus on data analysis rather than on data manipulation, A. P. Wilson et al (1994).

METHODOLOGY

THE RESERVOIR MODELINGWORKFLOW

Reservoir modeling work flow proceeds in stages. The stages consist of structural modeling such as horizons and faults, facies modeling and petrophysical modeling. There is extensive conditioning to hard data and seismic data and these results to a high resolution geo-cellular model. This study aims to present the current practice for building a static reservoir model. This workflow will proceed with three major frameworks:

Determining the top, bottom and style of each layer and the determination of the location of fault blocks. Seismic data is used for this purpose, and Well tops are used to locally constrain the surfaces.

- Build a 3D stratigraphic grid that is aligned with the surfaces and the faults. These grids are usually corner point geometry and are refined where necessary such as around the faults.

The above steps are typically conducted in the actual reservoir depositional coordinates system.

- The third step will be to map this reservoir coordinates system to a depositional coordinate system which is Cartesian. All data, well paths and seismic will be mapped ontothis Cartesian box.
- On the Cartesian box, the facies geometry will be firstly simulated. Some of the mostcommon techniques for populating the facies information are: geostatistical indicatorsimulation (Deutsch and Journel, 1992; Goovaerts, 1997), Boolean techniques(Haldorsen and Damsleth, 1990) and more recently geostatistical simulation usingmultiple-pointgeostatistics (Strebelle, 2002). The workflow given is to enable the integration of static data from geological and geophysical sources. However, this workflow ignores any dynamic data. The integration of dynamic data, termed "history matching", requires an iterative, trial and error process involving multiple runs of

GEOLOGICAL DESCRIPTION OF A SAND

Sand A also suggests a shallow marine system. This unit is associated with possible coarse grains that are well sorted. The reservoir is within depths of 10231.12feet (3118.445 meters) to 10264.17feet (3128.519meters) of the XCPG2 well with a net thickness of 30.5feet (9.2964meters), and 10511.37feet (3203.866meters) to 10545.57feet (3214.29meters) of the XCPG3 well with a net thickness of 22.5feet(6.858meters). The shale separating this reservoir from the Y reservoir thickens.

GEOLOGICAL DESCRIPTION OF Y SAND

The combination of gamma ray and resistivity logs revealed that the upper section of the B sand is deposited in a fluvial environment, seated on the large deltaic section. This section contains a series of coarsening and thickening upwards sequence. The sand is within depths of 10594.33 feet (3229.152meters) and 10625.16 feet (3238.549meters) in the XCPG2 well with a net thickness of 29 feet (8.8392meters), and at depths 10862.92feet (3311.018meters) to 10890.11 feet (3319.306meters) in the XCPG3 well with a net thickness of 22 feet (6.7056meters). This sand has excellent reservoir qualities. The average porosity is 0.25 in XCPG2 well and 0.20 in XCPG3 well. The permeability values vary from 1000mD to 1900mD.

PROCEDURES AND METHODS

In order to present an inter-well correlation of the heterogeneous reservoir of the X-Field, Petrel software has been used. Due to computational and software application constraints, the model was divided stratigraphically into three (A1, A2, and B). In the approach, three types of modeling have been carried out according to the different results of study parameters of the X-Field reservoir. These modeling types are:

- Structural Modeling
- Property Modeling
    1) Facies Modeling
    2) Petrophysical Modeling

STRUCTURAL MODELING

Structural modeling is the first step in building a 3D model. Structural modeling consists of fault modeling, pillar gridding, and vertical layering. All three options are tied together into one single three dimensional grid. The structural model represents a skeleton of the study area from which all other models are built.

FAULT MODELING

This involves the definition of faults in the geological model that form the basis for the generation of the 3D grid. Figure 1. The faults were obtained from the seismic interpretation study of the X-Field and loaded into Petrel software using the appropriate file of type format.

PILLAR GRIDDING

Gridding involves creating of gridded surface from seismic interpretation, structural maps and faults. The gridded surfaces in this study have been created on the tops of A1 sand, A2 sand and B sand for petrophysical models (figure 2).

LAYERING

This involves building of stratigraphic horizons, zones, and layers into the 3D grid using the make horizon process. Horizons were defined using seismic surfaces as input data. Zonation is the process of creating the different zones of the reservoir from the surfaces. Layering involves creating inter-zone layering (table 1,). Layering within the models was done with the following hierarchy:

1. Division between horizons (18 zones).

2. Subdivision of the zones into 99 layers based on minimum vertical thickness of the key lithofacies in the wells.

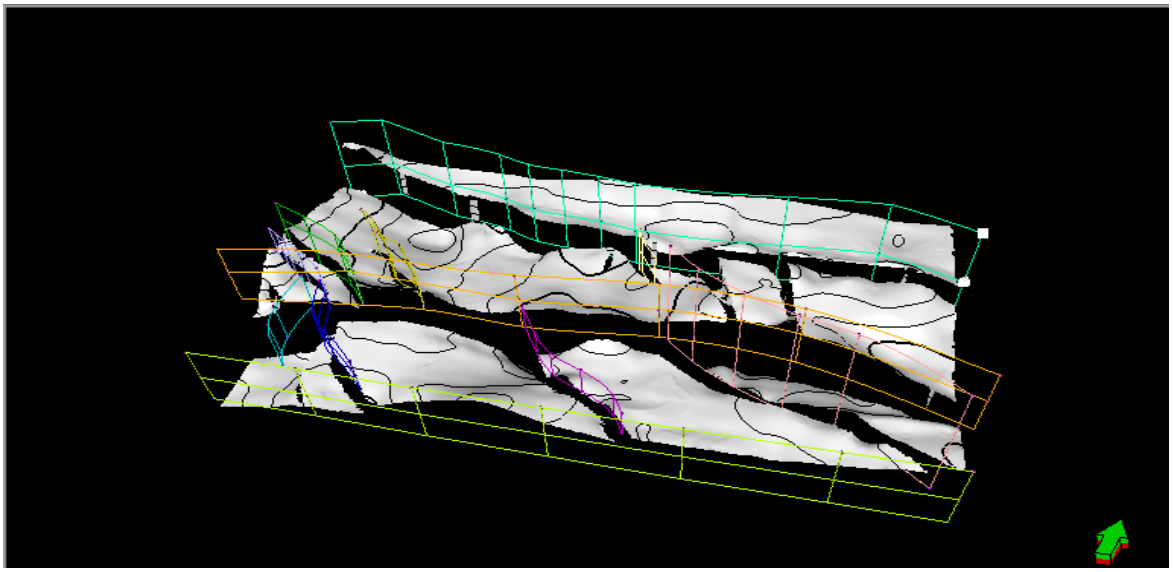

Figure 1: Illustration of fault model of the X-Field

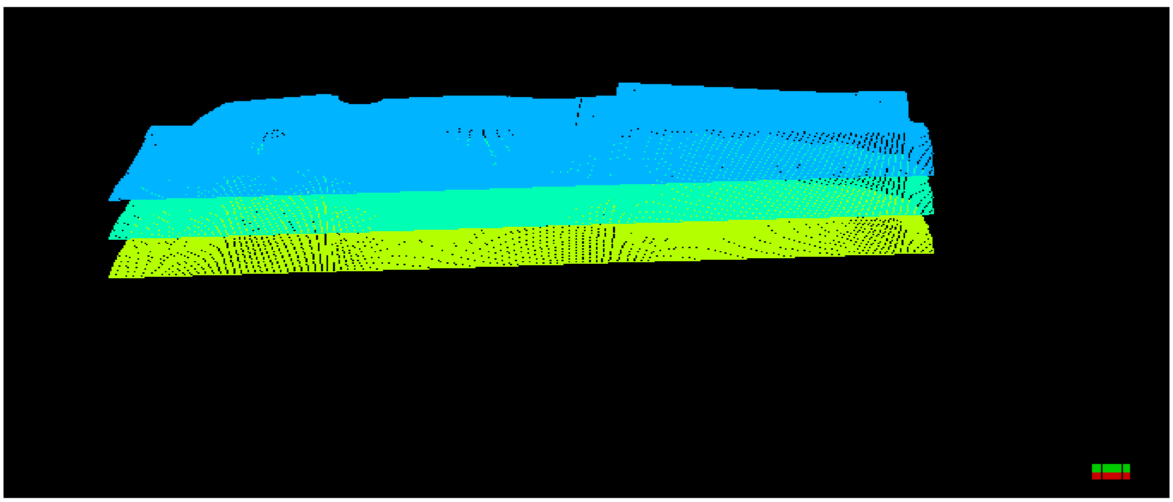

Figure 2: South view of the Top, Mid and Base of 3D Pillar Grid
Upscaling of Well Logs

PROPERTY MODELING

Property modeling is the process of filling the cells of the grid with petrophysical properties. The layer geometry given to the grid during the layering process follows the geological layering of the model area. These processes are therefore dependent on the geometry of the existing grid. When interpolating between data points, Petrel software propagates property values along the grid layers. Property modeling used for modeling in Petrel is divided into two separate processes:

1. Facies Modeling: Interpolation of discrete data such as facies
2. Petrophysical Modeling: Interpolation of continuous data such as permeability.

The purpose of property modeling is to distribute properties between the wells such that it realistically preserves the reservoir heterogeneity and matches the well data

Table 1: Different Sands of Well XCPG3 Reservoirs and their Equivalent Zones and Layers used in Reservoir Modeling

Sands	GrossThickness	Number of Zones	Number of Layers
A1	36.15	3	14
A2	34.20	3	18
B	27.19	3	12
Total	**97.54**	**9**	**44**

FACIES MODELING

Facies modeling is a means of distributing discrete facies throughout the model grid. The process involves many different facies modeling approach such as Object Modeling – mostly used for facies modeling to populate discrete facies models with different bodies of various geometry, facies code and fraction. In this study, two fundamental facies types were defined in the X-Field on the basis of reservoir property relationships and were used to populate the geocellular model of the X-Field reservoir.

1. Shale: The impermeable part of the reservoir.
2. Sand: The sand is the permeable part of the reservoir and is considered to have a good reservoir quality due to the relatively high energy of deposition and consequent coarse grained size.

The sands encountered in the reservoirs are fairly correlatable indicating a relatively longer period of depositional cycle. Sands deposited in different depositional environments are characterized by different sand body trend, shape, size, and heterogeneity. This tends to show that the physical characteristics of clastic reservoir rocks reflect the response of a complex interplay of processes operating in depositional environments. Hence, the reconstruction of depositional environments in clastic successions provides optimum framework for describing and predicting reservoir quality distribution. Also, knowledge of depositional environment of reservoirs through accurate description/interpretation of wire line logs and core data allows for a better understanding of reservoir characteristics and hence its quality for optimal utilization of the embedded resources.

PETROPHYSICAL MODELING

The most used method for petrophysical modeling is Sequential Gaussian Simulation. This study has focused on water saturation, net-to-gross, porosity, and permeability models. Sequential Gaussian Simulation honours well data, input parameter distributions, variograms, and trends. The variograms and distribution are used to create local variations, even away from input data.

PETROPHYSICAL PROPERTIES

Fundamental to development of the 3D model for the X-Field is the development of a suite of equations that predict petrophysical properties from widely available data. Data for routine net-to-gross (NTG), porosity, permeability, and water saturation were compiled.

Petrophysical analysis of X-Field reservoir rocks indicates that accurate reservoir-properties prediction requires input of lithofacies, and use of properties that represent reservoir (i.e., *in situ*) conditions.

GEOCELLULAR MODEL

A two-step geostatistical approach was used to populate 3D geocellular model. The first step of the process was to populate the model with the facies type. For this step, the Gaussian indicator simulation technique was used to simulate the facies. The second step in the process involved populating the model with the porosity and permeability values within each facies. For this step, the Gaussian Sequential Simulation (GSS) technique was used to simulate the porosity and permeability.

The use of this geostatistical approach required the calculation of vertical and area variograms of the X-Field reservoir. Since the well log data were collected on a half-foot basis (MD), the variability of facies, porosity, and permeability in the vertical direction was considered sufficient for the direct calculation of vertical variograms. For a real variograms, the database of facies, porosity, and permeability values for a given stratum is, at most, the number of wells which penetrate that stratum (for directional variograms, the database is considerably less than the number of well). For the X-Field reservoir, this database was considered to be inadequate to describe the spatial variability of the complex X-Field formation and, consequently, was considered insufficient for the development of areal variograms. Due to the highly stratified nature of the X-Field reservoir, the log derived water saturations were considered to be an amalgamation of thin bed effects. In order to populate the model with initial water saturations the facies based J-Functions were used.

Five geostatistical realizations of the fine grid model were generated for further evaluation. Figure 3 and 4 show the facies and petrophysical properties VV H H -distribution in one of the realizations respectively.

VOLUMETRICS

This involved the creation of hydrocarbon saturation property in the static model using a set of expressions that link the height above the fluid contacts and the porosity. The objective is to provide an estimate the reservoir hydrocarbon volume in place of the X-Field. Formulas used in volume estimation volumetric model as obtained for the X-Field reservoirs

Table 2: Formulae Algorithms Used for Petrophysical Evaluation of X-Field

$Shale_{Indicator} = \dfrac{GR_{log} - GR_{min}}{GR_{max} - GR_{min}}$	$Eqn\ 1.0$
$Vsh = 0.083 * 2^{(3.7 * Shale_{indicator})} - 1.0$ (Larionov Equation)	$Eqn\ 2.0$
$\emptyset_D = \dfrac{\rho_{ma} - \rho_b}{\rho_{ma} - \rho_{fl}}$	$Eqn\ 3.0$

$Por_{eff} = (1 - Vsh) * PoroT$ (Bob Harrison, London Russian Style)	Eqn 4.0
$Sw = \frac{0.082}{\emptyset\_Den}$ (Udegbunam, et al. 1988)	Eqn 5.0
$F = \frac{0.62}{\emptyset_D{}^{2.15}}$	Eqn 6.0
$Swirr = \sqrt{\frac{F}{2000}}$	Eqn 7.0
$K = 307 + 26552\emptyset^2 - 3450(\emptyset s_{wirr})^2$ (Owolabi et al, 1994)	Eqn 8.0

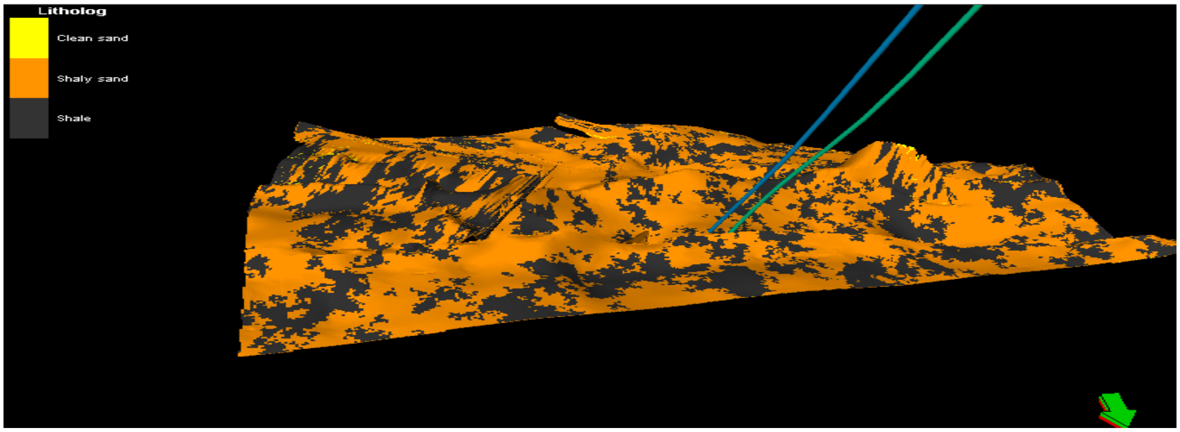

Figure 3: Facies Distribution for X-Field Reservoir

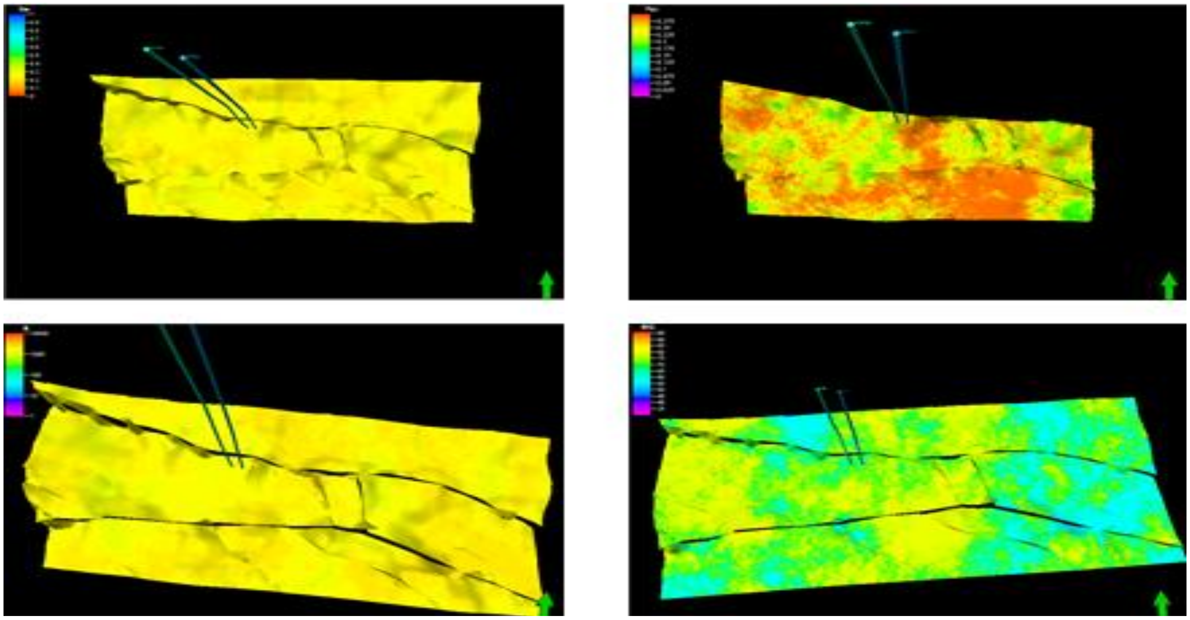

Figure 4: Petrophysical Properties Distribution for X-Field Reservoir

RESULTS AND INTERPRETATION

GEOLOGICAL CHARACTERIZATION

Three-dimensional geologic models were constructed for A1, A2, and B sands of the X-Field, onshore Niger Delta Basin. These models can be used for dynamic simulation of the reservoir. The models incorporate seismic data, geophysical logs as well as lithologic data of the X-Field. Specific geologic models produced include structural model, facies model, and petrophysical model. Multiple realizations of all the models were generated to represent the geometry of reservoir zones.

Some of the steps followed for constructing the three-dimensional geologic models are as follows:

1) Loaded bounding surface horizons to provide structural constraints;
2) Loaded continuous and discrete geophysical log:
3) Developed model architecture and geologic regions to define the grids;
4) Applied sequential indicator simulations to develop a representative and geologically reasonable lithofacies model; and
5) Applied Sequential Gaussian Simulation to develop petrophysical model.

LOG CHARACTERISTICS OF X-FIELD RESERVOIR

All available well logs (gamma, resistivity, neutron, and density) for the X-Field in the area of study were examined. The trend of data of X-Field reservoir sands were inferred as coarsening upward sequence based on the log shape in its sandstone bodies. X-Field sand beds are of funnel shape with gradational/transitional basal contact and sharp upper contact. Also, since grain size variations are used in sedimentology as an indicator of depositional environment, X-field reservoir sands which are coarse-grained are inferred to be associated with high energy environment.

Well log petrophysical evaluation, leading to the determination of reservoir properties and volumetric was performed. Petrophysical interpretation was based on standard interpretation parameters such as porosity, net-to-gross, and water saturation. Accuracy of calculated reservoir volume depends on reliability of used parameters. Shale volume was calculated on the basis of gamma ray logs. Estimation of petrophysical parameters of rock matrix sandstone does not constitute a problem, good enough values in this case are default ones.

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Total porosity was calculated from density log, water saturation was computed using Udegbunam formulaas shown in table 2 above. Permeability values were derived on the basis of porosity relationship, table 2.

CORRELATION AND STRATIGRAPHY

The reservoir horizons were qualitatively identified using the surfaces from seismic as benchmark. Beds with high gamma ray, low resistivity, low density, and high neutron readings indicated shale and were thus eliminated. The reservoir zones were also quantitatively identified by shale volume, porosity, and fluid content determinations through the use of some empirical equations already mentioned. The correlation of wells XCPG2 and XCPG3 is presented in figure 5

HYDROCARBONS-IN-PLACE VOLUME

The original hydrocarbon-in-place volume of the X-Field reservoir as shown in **table 4** was evaluated on the basis of the generated volumetric model using the following parameters:

Bo (formation vol. factor) = **1.476[RB/STB]**

Rs (solution gas/oil ratio) = **950[MSCF/STB]**

The volume estimation of the X-Field reservoir showed that E1 contains a STOIIP of 53MMSTB with GIIP of 20835BSCF; E2 contains STOIIP of 37MMSTB with a GIIP of 43319BSCF, while B contains STOIIP of 18MMSTB and a GIIP value of 40279BSCF.This cumulated to a STOIIP estimated to be 110MMSTB, and the GIIP is estimated to be 104433BSCF.

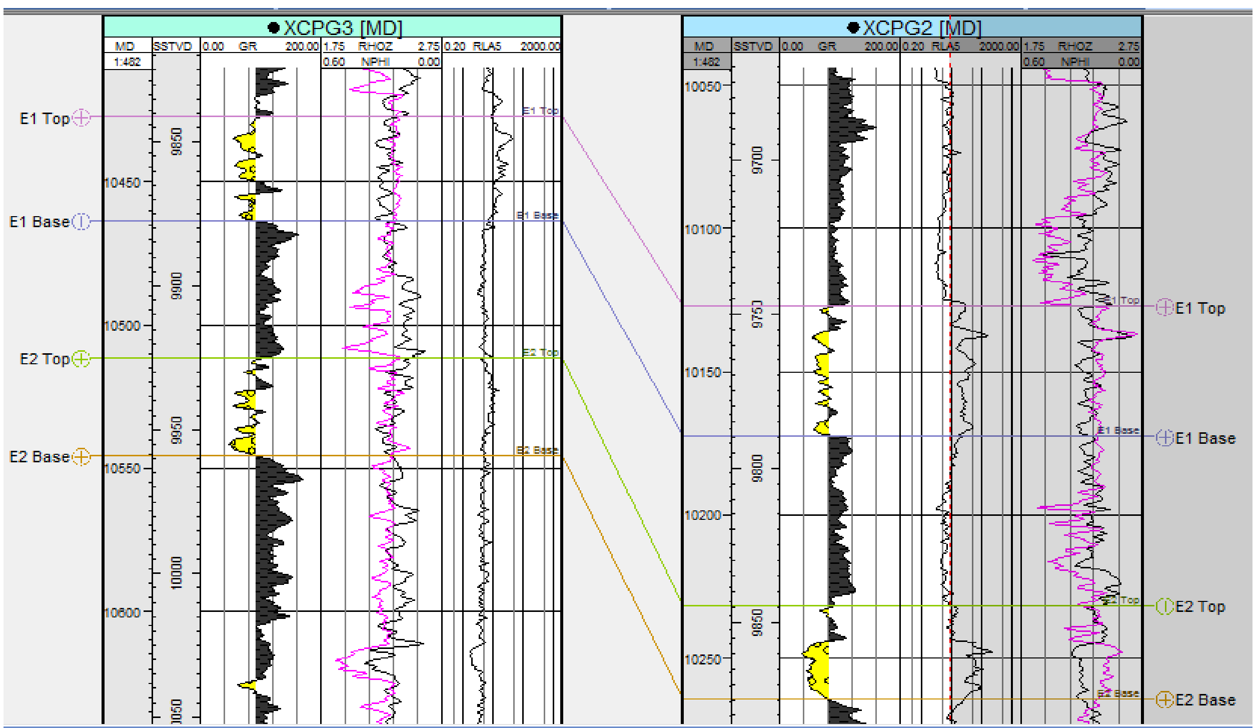

Figure 5: Correlation Panel of the interpreted A1 & A2 Hydrocarbon Sands

Table 3: XCPG3 Petrophysical Result Summary

Sand	Top (ft.)	Base (ft.)	H (ft.)	Net Sand	NTG	(ave)	K(ave)	Sw(ave)
A1	10427.04	10463.19	36.15	26	0.72	0.22	1260.44	0.32
A2	10511.37	10545.57	34.20	22.5	0.66	0.17	950.27	0.41
B1	10862.92	10890.11	27.19	22	0.81	0.20	1195.87	0.37

Table 4 : Hydrocarbon Volumes of A1, A2, and B1 Reservoirs

Fault Model A1		
Zones	STOIIP (MMSTB)	GIIP (BSCF)
1	18.23	
2	4.13	
3	30.63	
TOTAL	**53**	**20835**
Fault Model A2		
Zones	STOIIP (MMSTB)	GIIP(BSCF)
1	5.61	
2	3.60	
3	27.79	
TOTAL	**37**	**43319**
Fault Model B1		
Zones	STOIIP (MMSTB)	GIIP(BSCF)
1	3.03	
2	0.73	
3	14.24	
TOTAL	**18**	**40279**

CONCLUSION

Structural Modeling l model consists of a skeleton of the study area, including fault modeling, pillar gridding, and vertical layering and the facies model is a means of distributing described facies throughout the model grid in the area of interest. Petrophysical Modeling consists of the real distribution of the permeability, porosity, and saturation as a function of variograms parameters, like major range and minor range. Volumetric Modeling gives the volume of hydrocarbon initially in place in the reservoir. The intelligent petrel software was used to build these models, which is at present the most usable software for most petroleum companies.

The 3-D geologic model of the X-Field presented in this study demonstrates application of a detailed reservoir characterization and modeling workflow for a field. The static modeling methodology incorporates seismic structural information, geologic layering schemes, and petrophysical rock properties. Fault polygons were used in building the structural model. Pillar gridding method was used in the fault modeling. The cell geometries have been kept orthogonal to avoid any anticipated simulation problems. Quality Check of the structural and stratigraphic modeling was done and subsequently facies and petrophysical data was brought into the model for further population.

Petrophysical data was conditioned to facies during scaling up well logs process. Facies logs were brought into the model using “Most of method” whereas “Arithmetic method” was used for porosity and permeability logs. Population of facies and petrophysical properties was done for the three surfaces. Lithofacies modeling using wireline-log signatures, coupled with geologically constraining variables provided accurate lithofacies models at well to field scales. Differences in petrophysical properties among lithofacies and within a lithofacies among different porosities illustrate the importance of integrated lithological-petrophysical modeling and of the need for closely defining these properties and their relationships. Lithofacies models, coupled with lithofacies-dependent petrophysical properties, allowed the construction of a 3-D model for the X-Field that has been effective at the well scale.

The model is a tool for predicting structural, lithofacies and petrophysical properties distribution, water saturations, and original oil in place (OOIP) that provides a quantitative basis for evaluating remaining-oil-in-place. The model proves instrumental in evaluating current practices and consideration of modified well-bore geometry and completion practices that will potentially enhance ultimate recovery. Both the knowledge gained and the techniques and workflow employed have implications for understanding and modeling similar reservoir systems worldwide.

REFERENCES

1. Adaeze, I. U.,Samuel, O.O., and 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
2. Ainsworth, R.B., Stephenson, P.M., Johnson, D.A.,Seggie, R.J.,**2000,** Predicting Connected Hydrocarbon Volume Uncertainty Ranges: From Static Fault Model to Dynamic Simulator.Society of Petroleum Engineers, 64429
3. Cunha, L.B., **2003**, Integrating Static and Dynamic Data for Oil and Gas Reservoir Modeling,Petroleum Society’s Canadian International Petroleum Conference,2003-219
4. Deutsch, C.V., **2002,** Geostatistical Reservoir Modeling. Oxford University Press, New York, 376p.
5. Deutsch, C.V., and Journel, A.G., **1992,** Geostatistical Software Library and User’s Guide; Oxford UniversityPress, London
6. Djuro N., **2002,**Numerical Reservoir Characterization Using Dimensionless Scale Numbers With Application in Upscaling, Ph.D. Dissertation, Louisiana State University and Agricultural and Mechanical College
7. Evamy, B.D., Haremboure, J., Kamerling, P., Knaap, W.A., Molloy, F.A., and Rowlands, P.H., **1978**, Hydrocarbon habitat of Tertiary Niger Delta: American Association of Petroleum Geologists Bulletin, v. 62, p. 277-298.
8. Juliana, F.B., Rodrigo, D.D., Alexandre, C.V., Emilson, P.L.,Sérgio, S.S.,**2011,** ConstrainingUncertainty in Static

Reservoir Modeling: A Case Study from Namorado Field, Brazil, American Association of Petroleum Geologists
9. Kaplan, A., Lusser, C.U., Norton, I.O., **1994**, Tectonic map of the world, panel 10: Tulsa, American Association of Petroleum Geologists, scale 1:10,000,000.
10. Keelan, D.K., **1982**, Core Analysis for Aid in Reservoir Description. J. Pet. Tech. p. 2483-2491
11. Maghsood, A., Chip, C., Fangjian, X., Tom, N., Yong, Z., Zhen, Y.L., Rolf, B., James, W.,**2001,** Development of an Integrated Reservoir Model for a Naturally Fractured Volcanic Reservoir inChinaSociety of Petroleum Engineers, 74336
12. Reijers, T.J.A., Petters, S.W., and Nwajide, C.S., **1997**, The Niger Delta Basin, *in*Selley, R.C., ed., African Basins--Sedimentary Basin of the World 3: Amsterdam, Elsevier Science, pp. 151-172.
13. Ribeiro, M.T., Hassan, S.R., Gomes, J.S.,Bahamaish, J.N.,**2004,** The Synergy between Static Reservoir Modeling and Flow Simulations for the Optimization of a Field Development Plan of a Carbonate Reservoir, Onshore UAESociety of Petroleum Engineers, 88786
14. Sneider, R.M., and King, H.R., **1978**, Integrated Rock-Log Calibration in the Elm worth Field – Alberta, Canada, AAPG Memorandum.
15. Spilsbury-Schakel, J.A., **2006,** Quality Control of Static Reservoir Models, Society of Petroleum Engineers, 101875
16. Stacher, P., **1995**, Present understanding of the Niger Delta hydrocarbon habitat, *in*, Oti, M.N., and Postma, G., eds., Geology of Deltas: Rotterdam, A.A. Balkema, p. 257-267.
17. Steve, R., Doo-Hyun, L., Paul, F., Gang, H., **2012,**Static and Dynamic Data Integration for Improved Characterization of a Fractured Gas Reservoir, American Rock Mechanics Association 12-668
18. Strebelle, S., **2002,** "Conditioned Simulation of Complex Geological Structures Using Multiple Point Geostatistics," Mathematical Geology, 34, 1-25
19. Sylvester, I.F., Cook, R.S., Pritchard, T., McKeever, J., **2005**, Integrated Reservoir Modeling Enhances the Understanding of Reservoir Performance of the Dolphin Gas Field, Trinidad and Tobago, Society of Petroleum Engineers, 94343