OBAFEMI AWOLOWO UNIVERSITY

RESERVOIR MODELLING AND UNCERTAINTY EVALUATION OF "X" FIELD, NIGER DELTA, NIGERIA.

BY

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B.Sc. (Hons.) GEOLOGY

SCP/11/12/H/3145

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE DEGREE IN APPLIED GEOLOGY (SEDIMENTARY AND PETROLEUM GEOLOGY) OF THE DEPARTMENT OF GEOLOGY, FACULTY OF SCIENCE, OBAFEMI AWOLOWO UNIVERSITY, ILE-IFE, NIGERIA.

2015

CERTIFICATION

We certify that this research work was carried out by Mr. Etim, Anietie Raphael with registration number (SCP11/12/H/3145) in the Department of Geology, ObafemiAwolowo University, Ile-Ife under my supervision. The thesis has been read and approved as meeting part of the requirements for the award of Master of Science (M.Sc.) degree in Applied Geology (Sedimentary and Petroleum Geology).

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DEDICATION

This thesis is dedicated to my most prized possession, God and to all those who help others to achieve the best they can in life.

ACKNOWLEDGEMENT

Glory is to God for bringing to fruition this particular dream which you are holding in your hands despite the challenges in recent times. I appreciate my inner mind for the zeal to forge ahead upon all set back.

The accomplishment of this thesis depended on the immense contributions made by certain individuals and organizations which I feel obliged to accord them special recognition. Thus, I offer my unalloyed appreciation to Shell Petroleum Development Company of Nigeria, Port Harcourt for allowing me access to their facilities and staff in the cause of this research.

I am particularly indebted to my supervisor, Prof. J. I. Nwachukwu whose indispensable pieces of advice, helpful suggestions and painstaking review of the manuscript, had undoubtedly brought this thesis to lime light.

I am immeasurably grateful to Engr. Camillus E. Umoh, Mr. Moses Temuru, Mrs. EkaetteItuen, Mr. Emmanuel Ezim, Mr Stanley Harcourt of Shell Petroleum Development Company, Port Harcourt for their respective roles during this work. Also, Mr. Raymond Akpan and Mr. Jide of Department of Petroleum Resources (DPR) Lagos are acknowledged for their contributions.

I acknowledge with unfettered gratitude the encouragement and moral support I received from my B.Sc. supervisor, Prof. E. B. Akpan and Dr. N. U. Essien both of Geology Department; Dr. AkpanIdiok of Soil Science Department and Mr. Patrick Ndem of Registry, all of the University of Calabar.

The following very important people deserve inestimable gratitude for their comments and suggestions. They are; Dr. L. S. Fadiya, Dr. Adekola, Dr. Falebita, Dr. Ola, Mr. Ajibade, Mr. Edino and my Head of Department, Dr. A. A. Adepelumi.

I acknowledge with heart felt gratitude the contributions of my uncle, Dr. (Obong) L. M. Udoh JP, Mr. EtekambaUmoren, Hon ChrysanthusUdoh, Engr. AniebietEbu, Mr. NsikanIsidore, Pastor Stephen Udoh, Mr. Austen Umoh, Mr. ImeEbu, MrAniebietUsoro, Mr. UkpongeteJombo, Mr. Austen Umoh, Mr. ItoroNdem, Mr. Iboro Ernest, Mr. EmekAkpan, Mr. Rowland Nzeribe, Prince Idongesit Wilcox, Miss IdongesitAbatai and Miss Philomena Udoakang, may the good Lord reward you accordingly.

Most especially, I acknowledge the encouragement of my mother, Mrs. Martina R. Etim. My siblings James, Augustine, Emmanuel, Uduak, Grace, Agnes, Cornelia and my brother and sisters in-law are appreciated for their respective contributions towards this project. They are of great inspiration to me. My late sister, Mrs. NdifrekeEffiong Dan is acknowledged in a special way, she believed and supported this dream though she could not live to see its completion. May her soul continue to have repose in the bosom of our Lord, Amen.

For my colleagues SegunOgunleye, SalahudeenKazeem, Samuel Adeyemi, Ikenna and Sunday Omoteye, it has been a good moment. May the Lord bless you in all your future endeavors.

Above all, to God be the glory for all the things he has done for me.

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ABSTRACT

Reservoir Modelling and uncertainty evaluation was carried out using a suite of wireline logs of six wells and seismic sections from “X” Field, Niger Delta. This was with a view to develop a model that could be used to evaluate and quantify the uncertainties in reserve estimation.

The base map of the study area, 3D migrated seismic section, composite well logs, checkshot data from six wells (6) wells were used for the study. A combination of Petrel Software, Design Expert and Monte Carlo simulation package were used for the study. Also, three intervals were picked and mapped across the section for the volumetric analysis. These were labeled intervals 32, 36 and 40 for easy recognition. Stratigraphic correlation were carried out across the wells and subsequently seismic to well ties was established. New set of synthetic logs such as the Vshale log, water saturation logs, effective porosity log, total porosity log, facies log and NTG log were generated for all the wells. Possible fluid contacts such as Oil Water Contact (OWC), Gas Oil Contact (GOC), Oil Down To (ODT) within the intervals interpreted were identified. Faults and seismic horizons were mapped across the entire seismic section to generate structure maps both in time and depth domain.

Seismic interpretation of the 400 inlines and 200 cross lines and check shot data for the wells revealed that the predominant structure present is a fault dependent closure. The GR- log suggests a fluvial depositional environment and the deposits are distributary channel sands or tidal bar sands which are widely believed to have good reservoir properties. The volumetric estimates obtained from the tested interval 32 shows that 270 mmbbl of STOIIP, 4 BSCF of

GIIP was found. The interval 36 shows 337 mmbbl of STOIIP, and 5 BSCF of GIIP while interval 40 shows 274 mmbbl of STOIIP and 1 BSCF of GIIP.Water saturation has a regression coefficient of -0.77 and a regression coefficient of -0.02 for formation volume factor. Porosity has a regression coefficient of 0.58, NTG has a regression coefficient of 0.22 and fluid contact has a regression coefficient of 0.11. The regression analysis results, using the Tornado chart revealed that Water Saturation (SW) and Formation Volume Factor (FVF) had negative influence on STOIIP while Porosity, NTG and Fluid contacts have a positive influence on reservoir modelling.

The study concluded that reservoir modelling and uncertainty evaluation plays important role in hydrocarbon exploration especially in the determination of STOIIP.

CHAPTER ONE

INTRODUCTION

1.1 General Introduction

The increase in the demand for hydrocarbon products since the 20th century prompted an intensified exploration for oil and gas accumulation in reservoir rocks. This led to a detailed study of the Niger Delta depocenters after a long period of non-productive search in the Cretaceous sediments of the Benue Trough.

Petroleum in the Niger Delta is produced from sandstones and unconsolidated sands predominantly in the Agbada Formation. The recognized reservoir rocks are Eocene to Pliocene in age, and are often stacked. They range in thickness from less than15 meters to 450 meters with 10% having greater than 45 meters thickness (Evamy*et al.,* 1978). Based on reservoir geometry and quality, the lateral variation in reservoir thickness is strongly controlled by growth faults; with the reservoir thickening towards the fault within the down thrown block (Weber and Daukoru,1975).

The goal of reservoir modelling and uncertainty quantification in the Oil and Gas Industry is particularly to optimize the value of a project, an asset or a reservoir portfolio. Therefore, a paradigm shift from a deterministic thinking to a more amenable approach that appreciates management of subsurface uncertainties that are involved in geological modelling due to the heterogeneity of the complex earth structure is widely embraced.

Accurate estimation of Stock Tank Oil Initially in Place (STOIIP) is therefore an important issue in the oil industry as huge investment is put in place for reservoir evaluation and field development programmes. Hence, it is necessary to capture the uncertainties involved during reservoir (modelling) study.

The objective of this work is to quantify uncertainties associated with reservoir modelling thereby enabling sound reservoir management decisions at the different stages of reservoir development.

1.2 Reservoir Modelling

Reservoir modelling provides a geologically reasonable numerical representation of the geology, for input into the flow simulator, in order to predict the behavior of the subsurface reservoir and fluid flow under various hydrocarbon recovery scenarios. Thus, a reservoir model represents the physical space of the reservoir by an array of discrete cells, delineated by a grid which may be regular or irregular. The array of cells is usually three dimensional, although 1-D and 2-D models are sometimes used. Values for attributes such as porosity, permeability and water saturation are associated with each cell. The value of each attribute is implicitly deemed to apply uniformly throughout the volume of the reservoir represented by a cell.

There are two types of reservoir models, namely: geological model and reservoir simulation model. The former provides static description of the reservoir and the later uses finite difference method to stimulate the flow of fluids within the reservoir, over its production lifetime.

A geological model is constructed at a relatively high (fine) resolution and a coarser grid for reservoir simulation model. Simulation models are usually obtained from geological model by a process of "upscaling" i.e. decreasing the resolution of the grid by multiplying by a factor ratio.

1.3 Uncertainty Analysis

Reservoir geologists are concerned about quantities such as original hydrocarbon in place, reserves and type of recovery process. All these are critical economic factors that play a key role in making important decisions for both the oil producers and the investors at different phases of reservoir characterization. However the certainty of these quantities is questionable(Zhang, 2003).

Uncertainty is defined as "lack of assurance about the truth of a statement or about the exact magnitude of an unknown measurement or number (Ballin et al., 1993). The degree of the uncertainty varies from one variable to another. The uncertainty of a parameter may result from difficulty in directly and accurately measuring the quantity. This is true of the physical reservoir parameter which, at best can only be sampled at various points and subjected to errors caused by the changes that occur during the transfer of rock and its fluid, to laboratory temperature and pressure conditions (Walstrom*et al.*, 1967).

Quantification of these uncertainties and evaluation of the risks associated would improve decision making. However, estimating these uncertainties is complicated because it requires an understanding of both the static reservoir structure and dynamic behaviour during production.

Large number of uncertainties can be identified in the integrated reservoir modelling process. These uncertainties could be classified into five groups depending on the causes of the uncertainty. These are:

- The geophysical data: - These affect the reservoir envelope and its fault system.

- The geological data: - These involveuncertainties in reservoir sedimentary and petrophysical model that influence the hydrocarbon pore volume and dynamics of fluid flow.
- Dynamic data: - These uncertainties have an enormous impact on the determination of reserves and production profile.
- Reservoir fluiddata: - These uncertainties have a substantial impact on the optimization of the processing capacities of oil and gas.