QUANTITATIVE AVA ATTRIBUTES ANALYSIS USING SIMULTANEOUS AND ELASTIC IMPEDANCE INVERSIONS:

A CASE STUDY OF 'SANDFISH' FIELD, IN THE NIGER DELTA.

BY

ADESANYA, OLUWAKEMI YEMISI

MATRIC NO: 099076017

MARCH, 2017

QUANTITATIVE AVA ATTRIBUTES ANALYSIS USING SIMULTANEOUS AND ELASTIC IMPEDANCE INVERSIONS:

A CASE STUDY OF 'SANDFISH' FIELD, IN THE NIGER DELTA.

BY

ADESANYA, OLUWAKEMI YEMISI

B.Sc. (LASU); M.Sc. (UNILAG)

A THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES OF THE UNIVERSITY OF LAGOS, AKOKA, LAGOS, NIGERIA FOR THE AWARD OF DOCTOR OF PHILOSOPHY (Ph.D.) DEGREE IN GEOPHYSICS

MARCH, 2017

SCHOOL OF POSTGRADUATE STUDIES
UNIVERSITY OF LAGOS

CERTIFICATION
This is to certify that the Thesis:

QUANTITATIVE AVA ATTRIBUTES ANALYSIS USING SIMULTANEOUS AND ELASTIC IMPEDANCE INVERSIONS:

A CASE STUDY OF 'SANDFISH' FIELD, IN THE NIGER DELTA.
Submitted to the
School of Postgraduate Studies
University of Lagos

For the award of the degree of
DOCTOR OF PHILOSOPHY (Ph.D.)
is a record of original research carried out

By:
ADESANYA, OLUWAKEMI YEMISI
in the Department of Geosciences

.....	**……**	**.....**
AUTHOR'S NAME	**SIGNATURE**	**DATE**
.....	**……**	**.....**
1st SUPERVISOR'S NAME	**SIGNATURE**	**DATE**
…….....……...	**.....**	**.....**
2nd SUPERVISOR'S NAME	**SIGNATURE**	**DATE**
…….....…..	**……**	**.....**
1st INTERNAL EXAMINER	**SIGNATURE**	**DATE**
…….....…..	**……**	**.....**
2nd INTERNAL EXAMINER	**SIGNATURE**	**DATE**
…….....…..	**……**	**.....**
EXTERNAL EXAMINER	**SIGNATURE**	**DATE**
…….....…..	**……**	**.....**
SPGS REPRESENTATIVE	**SIGNATURE**	**DATE**

DEDICATION

This study is dedicated to the merciful and unrivalled God that has made the study possible. The dedication also extends to my father, Late Engr. Felix Adesanya, who sleeps in the bosom of the Lord. May his gentle soul rest in peace! Amen.

ACKNOWLEDGEMENTS

Adorable mercy and glory to the Lord Almighty for guiding me through this research work. I am sincerely grateful for His grace during the course of this study and will continue to appreciate His benevolence over my life till eternity. I would like to appreciate my supervisor, Dr. L. Adeoti for kind acceptance regardless of my inadequacies, support and mentoring not only during my Ph.D study but also as inspiration to a career path I have chosen. I quite appreciate the contributions of my other supervisor, Dr. K.F. Oyedele who didn't only supervise me but was always ready to give advice for the progress of my research.

I am grateful for the encouragement and concern of Prof. E.A Ayolabi, Prof. S. B. Olobaniyi, Dr. S.I. Bankole, Dr. S. Oladele and Dr. K.S. Ishola during the course of the research work. I wish also to express my gratitude to all the academic and non- academic staff of the Department of Geosciences, University of Lagos for contributing to the joyful atmosphere for conducive research. I am grateful to the Chevron Nigeria Limited and Department of Petroleum Resources (DPR) for providing the data used for this study. I also appreciate members of the Earth science and reservoir services unit of Chevron Nigeria Limited; Mr Sunkanmi Iyiola, Dr. Robert Kieckhefer, Mr Christopher Ogundare, Mr Peter Afinotan, Mr Ayo Adekanle, Mr Godwin Aguwenke and Mr Paul Evbotokhai for their support and encouragement during my internship.

I was privileged to have some of the following postgraduate students around me during the course of this study: Mr Olawunmi Fasakin, Mr Wale Alo, and Mr Taofik Adeleke. I quite appreciate the support of my good friends Miss Jumoke Kolade and Mrs A.O. Adesoji, thanks for being there. I am grateful for the encouragement and concern of academic staff of Distance Learning Institute,

University of Lagos most especially ex-Director; Prof. Funke Lawal, Prof. and Mrs A.A Adekunle, Dr. E.A. Ebabhi and Dr. A.J. Oladipo. I appreciate the motherly advice of Mrs K.L. Adeoti whose advice has enhanced the responsibility status of my personality.

The merciful Lord has honoured me with wonderful parents, Late Engr. Felix Adesanya and Mrs. F.M. Adesanya, who are source of enormous support and joy to me. I am grateful for the moral and financial support of my siblings: Mr and Mrs B.A. Adesanya, Mr and Mrs O. Atofarati, Mr and Mrs F. Oke, Saheed Alli, Fransisca Odeleye, Mr and Mrs S.O. Adeogun, Mr and Mrs E. Adeogun, Taiye Adeogun, Kehinde Adeogun, Bolu Adeogun, Biodun Adeogun, Damilare Adeogun, Tosin Adeogun, Eniola Adeogun, Deborah Adeogun, Felicia Adeogun, Victoria Adeogun, Seyi Adeogun, Iyanu Ogundele and Daniel Omiyinka.

The Lord graciously honoured me with a good friend and husband full of encouragement, patience, understanding and conviction that I will come out excellently in my study; Dr. Oluwagbenga Adeogun, thank you for the support, I am grateful and to my son Erifeoluwa Adeogun; you are precious.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

The global energy demand is rising and production from mature fields is on the decline while oil and gas companies are expanding activities into increasing challenging areas. Currently, mis-interpretation of seismic data due to subtle features of complex reservoirs has resulted into bypass of hydrocarbon zones and drilling of many dry holes. The combination of Simultaneous and Elastic impedance inversion techniques had been applied to estimate amplitude variation with angle (AVA) attributes such as P-impedance (Z_P), S-impedance (Z_S), density (ρ), lambda-rho ($\lambda\rho$), mu-rho ($\mu\rho$), Poisson's-ratio (σ), near and far-far elastic volumes with a view to reducing risk, enhancing hydrocarbon discovery and optimizing development plans in 'Sandfish' Field located offshore, Niger Delta. Four 'Sandfish' (Sfn) wells (Sfn-01, Sfn-02, Sfn-04 and Sfn-05), check-shots and 3D seismic data of five angle stacks (6°-12°, 12°-18°, 18°-26°, 26°-32° and 32°-42°) were used in the study. Sensitivity analysis involving cross-plots of petrophysical and elastic properties from well data was first carried out to establish rock property relationships in the interval of interest. Biot-Gassmann fluid substitution analysis was also used to reveal variation of rock properties to pore-fill types. Low frequency (0-2 Hz) models were generated from interpolation of high-cut-filtered compressional wave velocity log (P-sonic), shear wave velocity log (S-sonic) and density log guided by interpreted four seismic horizons. The low frequency models were used to broaden the spectrum and estimate the elastic volumes. The five partial angle stacks varying from 6°-42° were simultaneously inverted using Jason's Rock-Trace® inversion software which iterated trial inversions until the model sufficiently matched the seismic data. The near (6°-12°) angle and far-far (32°-42°) angle stacks were inverted to compliment the results from the simultaneous inversion. The inverted Z_P, Z_S, and ρ volumes from simultaneous inversion were used to derive σ, volume of sand (Vsand), $\lambda\rho$ and $\mu\rho$ volumes. The Sensitivity analysis carried out established that Z_P and Z_S were good candidates for lithology and fluid discrimination in the field of study. The cross-plot of Inverted Z_P and well Z_P gave correlation coefficient of 86% indicative of high quality inverted volume which will reduce exploration risk. The study revealed that $\lambda\rho$ was a better lithology and fluid discriminator when compared with other derived elastic volumes used in the study. The inversion results further showed good match with well logs from Sfn-04 away from the well control reflecting that the technique could be adopted in areas with limited well data. The elastic volumes revealed good correlation at 1850 ms and 2050 ms though the prospects were more visible at the far-far elastic volume compared to Z_P from simultaneous inversion and near elastic volume. The low σ from the fluid prediction map showed presence of hydrocarbon while lithology map reflected high Vsand of good quality. The study concluded that rock-property models from simultaneous and elastic impedance inversions were effective predictive tools for lithology and fluid types.

Keywords: Elastic Impedance Inversion, Simultaneous Inversion, Low Frequency Models, Reservoir Development.