



SUADAN UNIVERSITY OF SCIENCE AND TECHNOLOGY

COLLEGE OF GRADUATE STUDIES

Evaluation of Formations of Rakuba Basin

تقييم التكوينات في حوض الراكوبة

**A THESIS SUBMITTED IN FULFILMENTS FOR THE DEGREE OF M.Sc.
IN PETROLEUM EXPLORATION ENGINEERING**

M.Sc. Candidate: Hafiza Babiker Mohammed Ahmed

Supervisor : Dr. Abbas Musa Yagoub

July, 2015

Dedication

I dedicate this work to my mother, family and friends back home for their support and all the encouragements, without which it would have been difficult for me to pull through. Thank you for your prayers and everything.

Acknowledgments

First and foremost I want to thank Dr **Abbas Musa** who's supervised this study, I also extend my gratitude to **Abdullah Abdelgabar** and **Motaz Eltahir** for all the expert counsel and guidance they gave me to see the fruition of this study. Thank you for encouraging me to go on through the challenging moments of my research.

Special thanks to ministry of energy mining – Oil Exploration & Production Authority (OEPA) for their outstanding co-operation in sourcing and sharing their data with me.

Above all I give thanks to the Almighty God for His grace that saw me through it all during my study. I am forever indebted to Him.

Abstract

Muglad Basin of Sudan is highly complicated by faulting. Interpreted seismic data show large numbers of tensional faults which have affected the overall basin and have formed several sub-basins. One of the sub-basins distributed around Muglad Basin is Rakuba sub-basin.

This study aims to conduct formation evaluation on Rakuba sub-basin, and focuses on Bentiu and Abu Gabra formations through well logging data interpretation gathered from three wells Najah1, Falah1, and Rabah1. The main goal is divided into two stages; the first stage is to do petro-physical evaluation, and the other stage is log-facies analysis.

Petrophysical evaluation has been performed where shale volume has been calculated; furthermore porosity, water saturation, permeability, and cut off have been estimated. Moreover, results properties correlated, to facilitate second stage log-facies made based on K-mean cluster analysis.

According to methods applied to data and after analyzing, Bentiu formation classified as a good homogenous reservoir rock, Abu Gabra formation classified as heterogeneous formation and possible to be a source rock. However both of them are full saturated with water. The rock type identified and categorized into three facies.

ملخص الدراسة

يعتبر حوض الصخر الرسوبي معقد جدا بسبب الفوالق. تفسير البيانات الزلزالية اوضح ان هنالك عدد كبير من فوالق الشد اثرت علي كل هذا الحوض الرسوبي و نتج عن ذلك عدد من الاحواض الرسوبية الفرعية منهن حوض راكوبة الفرعي الرسوبي. احد هذه الاحواض الرسوبية الفرعية المتوزعه داخل حوض المجلد الرسوبي.

تهدف هذه الدراسة علي عمل تقييم للتكوينات الصخرية بحوض راكوبة الرسوبي الفرعي، حيث تستهدف الدراسة متكوني بانتيو وابوجابره من خلال تفسير بيانات تسجيلات الابار المتحصل عليها من ثلاثة ابار نجاح-1، فلاح-1، ورباح-1. ينقسم الهدف الاساسي الي مرحلتين: المرحلة الاولى عبارة عن عمل تقييم للخواص الفيزيائية للصخور، والمرحلة الثانية عبارة عن تحليل السحنات الصخرية.

تم تقييم الخواص الفيزيائية للصخور حيث تم حساب كمية الطفل، وايضا تم حساب كلا من المسامية والتشبع بالماء والنفذية. أيضا المضاهاة بين النتائج. بواسطة التحليل العقدي وعن طريق استخدام طريقة K-mean تم تحديد السحنات الصخرية.

بعد تطبيق الطرق وتحليل النتائج، خلاصنا الا ان متكون بانتيو عبارة عن صخور مكنية متجانسة، متكون ابوجابره عبارة عن صخور متجانسة ولها احتمالية علي ان تكون صخور مصدر. كما وجد ان المتكونين منشعبان تماما بالماء. كما تم تمييز الصخور وتصنيفها الي ثلاث سحنات اساسية

Table of Contents

Dedication	II
Acknowledgments	III
Abstract	IV
ملخص الدراسة	V
Table of Contents	VI
List of figures	VIII
List of tables	X

CHAPTER ONE: INTRODUCTION

1.1 Introduction	1
1.2 Problem statement:	1
1.3 Study objectives:	1
1.4 Overview of Study Area:	2
1.5 Previous studies:	3
1.6 Data Used	5
1.7 Methodology:	5

CHAPTER TWO: GEOLOGY OF THE AREA

2.1 Regional Geology	7
2.2 Tectonic evaluation of Muglad basin:	9
2.3 Stratigraphy of Rakuba sub basin:	9

CHAPTER THREE: WELL LOGGING TECHNIQUES

3.1 Introduction:	12
3.2 Well logs definition	12
3.3 Wireline Logging Tools and classification:	13
3.3.1 Spontaneous Potential (SP):	13
3.3.2 Gamma ray log (GR):	17
3.3.3 Formation density log:	22
3.3.4 Neutron logs:	23
3.4.4 Sonic Log	24
3.3.4 Resistivity Logging:	26
3.4 Facies from Well Logs “Electrofacies”	29

CHAPTER FOUR : PETROPHYSICS

4.1 Introduction:	31
4.2 petrophysical properties:	31
4.2.1 Porosity and Storage Capacity	31
4.2.2 Permeability	32
4.2.3 Saturation.....	34

CHAPTER FIVE: DATA INTERPRETATION, RESULTS AND DISCUSSION

5.1 Introduction:	35
5.2 Zonation and Lithology identification:	36
5.3 Shale volume:	38
5.3.1 Result of shale volume for Bentiu formation	40
5.3.2 Result of shale volume for Abu Gabra formation	43
5.4 Porosity:	45
5.5 water saturation:	45
5.4.1 Result of porosity and water saturation for Bentiu formation	47
5.4.2 Result of porosity and water saturation for Abu Gabra formation	54
3.7 Permeability:	58
5.4.1 Results of permeability for Bentiu formation	59
5.4.1 Results of permeability for Abu-Gabra formation.....	62
5.5 Well to well correlation:.....	64
5.6 Log-facies:.....	66
5.6.1 K-means algorithm steps:	66
5.6.2 Criteria for List of figuresdiscrimination.....	67
5.6.3 Electrofacies characteristics in Bentiu& Abu-Gabra Formations.....	68
5.6.4 Predicted Electrofacies in three wells:	69
5.7 Discussion	72

CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS

6.1 conclusions	74
6.2 Recommendations	75
REFERENCES.....	76

List of figures

Fig (1.1) Study Area (Block C).....	2
Fig (1.2) Work Stages Ordering Flow Chart.....	6
Fig (2.2) regional tectonic map of western and central african rifted basins.....	8
Fig (2.1) Geological sketch map of central Africa illustrates CASZ landing countries.....	8
Fig (2.3) schematic geological cross section of some muglad sub basins.	9
Fig (2.4) Typical Stratigraphy Columns Of Muglad Basin.....	11
Fig (3.1) Sketch of typical resistivity log.....	12
Fig (3.2) Chart for determining the value r_w or r_{mf} from r_{weq} or r_{mfeq}	15
Fig(3.3) Chart for adjusting fluid resistivity for temperature	16
Fig(3.4) Gamma ray log and depositional environment	19
Fig(3.5) Calculation of shale volume	20
Fig (3.6) Gamma Ray Emission Energy Spectra	20
Fig (3.7) Principle of acoustic tool.....	25
Fig(3.8) Current Path In Dual Lateral Log (Ddl).....	27
Fig(3.9) Micro Laterolog/Micro Spherically Focussed Logs	28
Fig(3.10) Principle of induction logging	28
Fig(4.1) Fluid Flow In Porous	32
Fig (5.1) wells location map.	35
Fig (5.2) typical frequency cross plot for neutron porosity vs. Density.....	37
Fig (5.3) Density-Neutron Cross Plot.....	39
Fig (5.4) (a) neutron-density cross-plot for bentiu formation in well najah1 compared to (b) neutron histogram, and (c) density histogram.	39
Fig (5.5) Shale Volume Result For Bentiu Formation In Najah-1	40
Fig (5.6) Histogram Of Shale Volume For Bentiu Formation In Najah-1.....	40
Fig (5.7) Shale volume result for bentiu formation in falah-1	41
Fig (5.8) Histogram of shale volume for bentiu formati on in falah-1.....	41
Fig (5.9) Shale volume result for bentiu formation in rabah-1	42
Fig (5.10) Histogram of shale volume for bentiu formation in rabah-1	42
Fig (5.11) Shale volume result in abu-gabra formation (falah-1)	43
Fig (5.12) Shale volume histogram in abu-gabra formation (falah-1)	43
Fig (5.13) Shale volume result in abu-gabra formation(rabah-1)	44
Fig (5.14) Shale volume histogram in rabah-1 (abu-gabra formation)	44
Fig (5.15) Porosity & Water Saturation In Bentiu Formation (Najah-1)	48

Fig (5.16) Total porosity in bentiu formation (najah-1)	48
Fig (5.17) Effective porosity in bentiu formation (najah-1)	49
Fig (5.18) Water saturation histogram in bentiu formation (najah-1)	49
Fig (5.19) Porosity & water saturation in bentiu formation (falah-1)	50
Fig (5.20) Effective porosity in bentiu formation (falah-1).....	50
Fig (5.21) Total porosity in bentiu formation (falah-1).....	51
Fig (5.23) Porosity & water saturation in bentiu formation (rabah-1)	51
Fig (5.24) Effective porosity in bentiu formation (rabah-1).....	52
Fig (5.25) Total porosity in bentiu formation (rabah-1).....	52
Fig (5.26) Water saturation histogram in bentiu formation (rabah-1)	53
Fig (5.27) Porosity And Water Saturation Result In Abu-Gabra Formation (Falah-1)	53
Fig (5.28) Total porosity histogram in falah-1(abu-gabra formation)	54
Fig (5.29) Effective porosity histogram in falah-1(abu-gabra formation).....	54
Fig (5.30) Saturation histogram in abu-gabra formation (falah-1).....	55
Fig (5.31) Porosity And Water Saturation Result In Abu Gabra Formation (Rabah-1)	55
Fig (5.32) Effective porosity histogram in abu gabra formation (rabah-1).....	56
Fig (5.33) Total porosity histogram in abu gabra formation (rabah-1).....	56
Fig (5.34) Saturation histogram in abu gabra formation (rabah-1).....	57
Fig (5.35) Permeability for bentiu formation (najah-1)	59
Fig (5.36) Permeability Histogram For Bentiu Formation (Najah-1).....	59
Fig (5.37) Permeability for bentiu formation (falah-1)	60
Fig (5.38) Permeability histogram for bentiu formation (falah-1).....	60
Fig (5.39) Permeability for bentiu formation (rabah-1).....	61
Fig (5.40) Permeability histogram for bentiu formation (rabah-1)	61
Fig (5.41)Permeability Result In Abu-Gabra Formation (Falah-1).....	62
Fig (5.42) Permeability histogram in abu-gabra formation (falah-1)	62
Fig (5.43) Permeability result in abu-gabra formation (rabah-1)	63
Fig (5.44) Permeability histogram in abu-gabra formation (falah-1)	63
Fig (5.45) illustration formation correlated between wells.....	65
Fig(5.46) Statistic mean and standard deviation of the inputs for each electrofacies.....	67
Fig (5.48) Vsh-rhob histograms and cross-plots show different electrofacies.	68
Fig (5.47) Cluster output for each Electrofacies	68
Fig (5.49) Predicted electrofacies and relative log data in falah-1.....	69
Fig (5.50) Predicted Electrofacies And Relative Log Data In Nahaj-1	70
Fig (5.51)Predicted Electrofacies And Relative Log Data In Rabah-1.....	71

List of tables

Table (2.1): stratigraphic units of the muglad rift basin, their lithology and depositional environment	10
table (3.1).expected gamma ray readings vs. formation	21
table(3.2). matrix density reading in different formations	23
table(3.3). neutron matrix reading in different formations	24
table (3.4) the transit time of different rock matrix	26
table (5.1) bentiu and abu gabra formations thickness through wells	36
table (5.2). statistical parameters of shale volume calculation- bentiu formation.....	42
table (5.3). statistical parameters of shale volume calculation- abu gabra formation	44
table (5.4) statistical parameters of porosity in bentiu formation(najah-1)	49
table(5.5)statistical parameters of porosity and saturation in bentiu formation (falah-1)	51
table (5.6). statistical parameters of porosity and saturation in bentiu formation (rabah-1)	53
table (5.7) statistical parameters of porosity and saturation in abugabra formation (falah-1).....	55
table (5.8) statistical parameters of porosity and saturation in abugabra formation (rabah-1)	57
table (5.9) statistical parameters of permeability in bentiu formation.....	61
table (5.10) statistical parameters of permeability in abu gabra formation	63
table (5.11). some logs parameter as discrimination	67
table (5.12). shale volume and density values in specific formations	68