

**INTEGRATION FORMATION - SUBSURFACE EVALUATION  
OF WADI EL-NATRUN AREA,  
NORTHERN WESTERN DESERT,  
EGYPT,  
USING WELL LOGGING DATA.**

**THESIS**  
**Submitted to Faculty of Science**  
**Ain Shams University**

**BY**  
**MOHAMED AHMED REDA MOHAMED**  
**( B. Sc. )**

**Supervisors**

**Assist. Prof. Dr.**  
**Ahmed S. Abu EL Ata**  
**Faculty of Science**  
**Ain Shams University**

**Assist. Prof. Dr.**  
**Samira H. Abdel Baki**  
**Petroleum Research Institute**  
**Cairo - Egypt**

**Dr.**  
**Maher A. EL-AZONI**  
**Petroleum Research Institute**  
**Cairo - Egypt**

**In Partial Fulfilment of the Requirements for**  
**the Degree of**  
**MASTER OF SCIENCE**  
**In Geophysics**

**1990**

**INTEGRATION FORMATION - SUBSURFACE EVALUATION  
OF WADI EL-NATRUN AREA,  
NORTHERN WESTERN DESERT,  
EGYPT,  
USING WELL LOGGING DATA.**

**THESIS**  
Submitted to Faculty of Science  
Ain Shams University

**BY**  
**MOHAMED AHMED REDA MOHAMED**  
( B. Sc. )

**Supervisors**

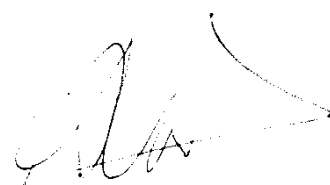
**Assist. Prof . Dr.**  
**Ahmed S. Abu EL Ata**  
Faculty of Science  
Ain Shams University

**Assist. Prof. Dr.**  
**Samira H. Abdel Baki**  
Petroleum Research Institute  
Cairo - Egypt

**Dr.**  
**Maher A. EL-AZONI**  
Petroleum Research Institute  
Cairo - Egypt

**In Partial Fulfilment of the Requirements for  
the Degree of  
MASTER OF SCIENCE  
In Geophysics**

**1990**





### ACKNOWLEDGEMENTS

The author wishes to express his great gratitude to Dr.Ahmed Said Abu El Ata, Assist. prof. of geophysics, Department of Geology, Faculty of science, Ain Shams University for his stimulating supervision of this work, the unlimited assistance in interpreting the results, revising the final manuscript, and for the valuable computational facilities kindly offered by him.

Special thanks are due to Dr.Samira Hassan Abdel Baki, Assist. prof of geophysics, Exploration Sector, Petroleum Research Institute for her valuable discussions, critical reading of the entire manuscript and for her generous advice offered by her at various stages of the work.

Deep thanks are also due to Dr.Maher Ali El Azoni, lecturer of geophysics, Exploration Sector, Petroleum Research Institute for his great help and continuous encouragement.

#### NOTE

The present thesis is submitted from Mohamed Ahmed Reda Mohamed to Ain Shams University in partial fulfilment of the requirements for the degree of Master of Science in Geophysics.

Beside the research work materialized in this thesis, the candidate has attended eleven graduate courses for one year in the following topics.

Well Logging  
Petrophysics  
Biostratigraphy  
Lithostratigraphy  
Sedimentation  
Sedimentary Petrology  
Geotectonics  
Structure Geology  
Statistics & Computer Science  
Field Geology  
English Language

He has successfully passed the final examinations of these courses in September 1987.

Prof.Dr. Mohamed Y. Meneisy

*M.Y. Meneisy*  
Head of the Geology  
Department.

## ABSTRACT

The present study deals with the evaluation of hydrocarbon potentialities of the Abu-Roash and Bahariya formations using six wells (BIRIGAT-1, NATRUN GHIBLI-1, T-56-1, ZEBEIDA-1X, WEST HALLIF-1 and FAYAD-1) scattered in Wadi El-Natron area, northern Western Desert. This study is accomplished using different types of open-hole well logs such as Resistivity, Neutron, Density, Sonic and Gamma-Ray for the determination of the included petrophysical parameters and the evaluation of the inherited source rocks.

However, the petrophysical parameters calculated are the rock components (sandstone, shale, Limestone and porosity) and the fluid saturations (water, movable and residual hydrocarbons). These parameters were presented zone-wise, in the form of litho-saturation cross plots to show their vertical variations within the wells, and also in the form of iso-parametric maps, to illustrate their lateral changes across the study area. The isopach maps of Abu-Roash and Bahariya Formations reveal a northwestward increase in thickness. The lithofacies conditions of Abu-Roash Formation show an increase of the sandstones and limestones northward reflecting oscillatory shallow to intermediate marine environments. Those of Bahariya Formation exhibit an increase of shales southwestward with the increase of the sandstones and limestones northward and eastward reflecting steadier shallower marine environment. The structural elements complicating the studied interval imply folding features as well as faulting elements (dip-slip).

Moreover, the source rock indicators were defined, as the organic content (vol%), the total organic carbon (wt%) and the discriminant function to differentiate between the source rocks and non-source rocks of the shales and shaly units of the Abu-Roash and Bahariya Formations in the investigated area. Their results were presented in organo-source logs and gradient maps to show the distribution of the implicated organic materials vertically and laterally.

Regarding the hydrocarbon potentialities of the study area, the evaluated sequence reflects inadequate source rocks with suitable reservoir and cap rocks. Transformation cycle of hydrocarbons seems to be sufficient for the considerable depth of burial and temperature needed for oil and gas maturation and generation, with the presence of primary and secondary migration paths needed for transporting the synthesized hydrocarbons to the final accumulation places.

Traps are existed with nearly the various structural, stratigraphic and miscellaneous types. The hydrocarbons of Abu-Roash Formation shows outward increase, while those of Bahariya Formation exhibit northward increase. But, the comparison between the trends of variation of the movable and residual hydrocarbons indicates that, most of the initiated hydrocarbons are from the residual type.

The mathematical sequential steps followed in the accomplishment of this work were done through eight computer programs listed at the end of this thesis.

# LIST OF SYMBOLS

<u>Symbol</u>	<u>Meaning</u>
$R_{mc}$	Resistivity of Mud Cake corrected at Formation Temp.
$R_t$	Resistivity of the uninvaded zone.
$R_{xo}$	Resistivity of the Flushed zone.
$R_w$	Resistivity of the Formation Water.
$R_o$	Resistivity of the Formation When 100% water-saturation.
$F$	Formation Resistivity Factor.
$m$	Cementation Factor.
$S_w$	Water Saturation.
$S_{xo}$	Water Saturation in the Flushed zone.
$S_h$	Hydrocarbon Saturation.
$S_{hr}$	Residual Hydrocarbon Saturation.
$S_{hm}$	Movable Hydrocarbon Saturation.
$\phi_N$	Porosity derived from the Neutron Log.
$\phi_D$	Porosity derived from the Density Log.
$\phi_S$	Porosity derived from the Sonic Log.
$\phi_T$	Total Corrected Porosity.
$\phi_E$	Effective Porosity.
$V_{sh}$	Volume of shale content.
$(V_{sh})_{GR}$	Volume of shale derived from Gamma-Ray Log.
$(V_{sh})_{\phi_N}$	Volume of shale derived from Neutron Porosity Log.
$(sh)_R$	Volume of shale derived from Resistivity Log.
$(V_{sh})_{sp}$	Volume of shale derived from Spontaneous Potential Log.
$\rho_b$	Bulk Density in grams per Cubic Centimeter.
$\rho_{bma}$	Bulk Density for the Matrix.
$\rho_f$	Fluid Density.
$\rho_{sh}$	Density Reading Opposite Thick Shale Bed.
$\Delta T$	Sonic Transit Time in Microsecond Per Foot.
$\Delta T_{ma}$	Sonic Transit Time for the Matrix.
$\Delta T_f$	Sonic Transit Time for the fluid.
$\Delta T_{sh}$	Sonic Transit Time Opposite Thick Shale Bed.
CAL	Caliper Log.



DIL	Dual Induction log.
GR	Gamma-Ray Log.
BHC	Bore-Hole Compensated Log.
CNL	Compensated Neutron Log.
FDC	Formation Density Compensted Log.
SNP	Side-Wall Neutron Porosity Log.
SP	Spontaneous Potential Log.
Hmc	Mud Cake Thickness.
ORG	Organic Contant.
TOC	Total organic carbon.

## LIST OF CONTENTS

	Page
CHAPTER I:	
GEOLOGIC SETTING .....	1
I.1. Introduction .....	1
I.2. Surface Geology .....	4
I.3. Subsurface stratigraphy ..	6
I.4. Geomorphology .....	12
I.5. Structural Pattern .....	14
I.6. Tectonism .....	18
I.7. Geologic History .....	19
CHAPTER II:	
WELL LOGGING ANALYSIS.....	23
II.1. Introduction .....	23
II.2. Available Well Logging Data .....	24
II.3. Way of Treatment .....	25
II.4. Analytical Formation Evaluation System .....	25
II.4.1. Measurements and Corrections of Fluid Resistivities .....	25
II.4.2. Measurements and Corrections of Rock Resistivities .....	29
II.4.3. Volume of Shale Determination .....	32
II.4.4. Porosity Determination .....	36
II.4.5. Matrix Identification .....	42
II.4.6. Determination of Fluid Saturations .....	46
II.5. Graphical Well Logging Analysis.....	49
II.5.1. Mono-Porosity Cross-Plots.....	50
CHAPTER III.	
SUBSURFACE EVALUATION.....	60
III.1. Introduction .....	60
III.2. Thickness Variations.....	61
III.3. Lithofacies Analysis .....	67
III.4. Depositional Environments.....	79

	Page
III.5. Structural Elements .....	80
<b>CHAPTER IV:</b>	
SOURCE ROCK EVALUATION.....	90
IV.1. Introduction .....	90
IV.2.1. Determination of Total Organic Content(Vol%)	91
IV.2.2. Determination of Total Organic Carbon (Wt %)	91
IV.2.3. Discrimination of source Rocks from Non-Source Rocks	92
IV.2.4. Definition of Hydrocarbon Habitat .....	94
IV.3. Application to the Study Area .....	94
IV.4. Graphical Presentation of Results.....	94
IV.4.1. Organo-Source analysis .....	95
IV.4.2. Iso-Parametric maps.....	105
<b>CHAPTER V:</b>	
HYDROCARBON POTENTIALITIES.....	112
V.1. Introduction .....	112
V.2. Vertical Distribution of Hydrocarbon Occurences	113
V.3. Oil Story .....	123
V.3.1. Stratigraphic Sequence .....	123
V.3.1.1. Source Rocks.....	125
V.3.1.2. Reservoir Rocks .....	126
V.3.1.3. Cap Rocks .....	131
V.3.2. Transformation Cycle.....	131
V.3.3. Entrapping Style .....	139
<b>CHAPTER VI:</b>	
SUMMARY AND CONCLUSTIONS .....	149
REFERENCES .....	154
APPENDIX I. ....	
APPENDIX II. ....	
ARABIC SUMMARY .....	

## LIST OF FIGURES

Fig. No.	Page
1. Location Map of the Study Area.....	2
2. Location Map Showing the Distribution of the studied Wells.....	3
3. Surface Geological Map of the Study Area.....	5
4. Generalized Stratigraphy of the Northern Western Desert .....	8
5. Geomorphological Map of the Study area.....	13
6. Mono-Porosity Cross-Plot of Abu Roash Formation FAYAD - 1 Well .....	54
7. Mono-Porosity Cross-Plot of Abu Roash Formation FAYAD 1- Well .....	55
8. Mono-Porosity Cross-Plot of Abu Roash Formation FAYAD - 1 well.....	56
9. Mono-Porosity Cross-Plot of Abu Roash Formation FAYAD - 1 Well .....	57
10. Lithology Identification from Formation Density Log and Sonic Log of Abu Roash Formation FAYAD- 1 Well .....	58
11. Isopach Map of Abu Roash FM. ....	63
12. Isopach Map of Bahariya FM. ....	64
13. Stratigraphic Correlation Chart Through the Studied Wells, FAYAD-1, ZEBEIDA-1x, and BIRIGAT-1.....	65
14. Stratigraphic Correlation Chart Through the Studied Wells, WEST-HALLIF-1, T. 56-1 and NATRUN GHIBLI-1.....	66
15. Stratigraphic Correlation Chart Through the studied Wells, FAYAD- 1 and WEST HALLIF- 1.....	68
16. Stratigraphic Correlation Chart Through the Studied Wells, T.56- 1, NATRUN GHIBLI- 1 and BIRIGAT - 1.....	69
17. Shale Distribution Map of Abu Roash FM .....	71
18. Matrix Distribution Map of Abu Roash FM.....	72
19. Sand Distribution Map of Abu Roash FM. ....	73
20. Limestone Distribution Map of Abu Roash FM.....	74

Fig. No.	Page
21. Shale Distribution Map of Bahariya FM. ....	75
22. Matrix Distribution Map of Bahariya FM . ....	76
23. Sand Distribution Map of Bahariya FM . ....	77
24. Limestone Distribution Map of Bahariya FM.....	78
25. Structure Relief Map on Top of the Abu Roash FM	82
26. Structure Relief Map on Top of the Bahariya FM	83
27. Geologic Cross section Through the Studied Wells, FAYAD-1, ZEBEIDA-1X and BIRIGAT-1.....	84
28. Geologic Cross Section Through the Studied wells, WEST HALLIF-1, T. 56-1 and NATRUN GHIBLI-1.....	86
29. Geologic Cross section Through the studied wells, FAYAD-1 and WEST HALLIF-1 .....	87
30. Geologic Cross Section Through the Studied wells, T.56-1, NATRUN GHIBLI-1, and BIRIGAT-1.....	88
31. Organo-Source Analysis T. 56-1 .....	96
32. Organo-Source Analysis WEST HALLIF No. 1 .....	98
33. Organo-Source Analysis NATRUN GHIBLI A-1 .....	99
34. Organo-Source Analysis BIRIGAT No. 1 .....	101
35. Organo-Saurce Analysis FAYAD 1 .....	102
36. Organo-Source Analysis ZEBEIDA- 1X .....	104
37. Organic Content (Vol%) of Abu Roash FM .....	106
38. Total Organic Carbon (WT%) of Abu Roash FM ....	107
39. Organic Content (Vol%) of Bahariya FM .....	108
40. Total Organic Carbon (WT%) of Bahariya FM .....	110
41. Lithology-Saturation Cross Plot of T. 56-1 Well	115
42. Lithology-Saturation Cross Plot of WEST HALLIF- 1 well .....	116
43. Lithology-Saturation Crossplot of NATRUN GHIBLI 1 Well .....	118
44. Lithology-Saturation Crossplot of BIRIGAT No. 1 Well .....	120
45. Lithology-Saturation Crossplot of FAYAD- 1 Well	122
46. Lithology-Saturation Crossplot of ZEBEIDA-1X well	124
47. Total Porosity Gradient Map of Abu Roash FM....	127

Fig. No.	Page
48. Effective Porosity Map of Abu Roash FM .....	128
49. Total Porosity Gradient Map of Bahariya FM ...	129
50. Total Porosity Map of Bahariya FM .....	130
51. Distribution Map of Water Saturation in Abu Roash FM .....	135
52. Distribution Map of Water Saturation in Bahariya FM .....	136
53. Water Saturation Map in Flushed Zone of Abu Roash F.M.....	137
54. Water Saturation Map in Flushed Zone of Bahariya F.M.....	138
55. Distribution Map of Hydrocarbon Saturation in Abu Roash FM .....	140
56. Distribution Map of Movable Hydrocarbon Saturation in Abu Roash FM .....	141
57. Distribution Map of Residual Hydrocarbon Saturation in Abu Roash FM .....	142
58. Distribution Map of Hydrocarbon Saturation in Bahariya FM .....	143
59. Distribution Map of Movable Hydrocarbon Saturation in Bahariya FM .....	144
60. Distribution Map of Residual Hydrocarbon Saturation in Bahariya FM .....	145

# CHAPTER I

## GEOLOGIC SETTING