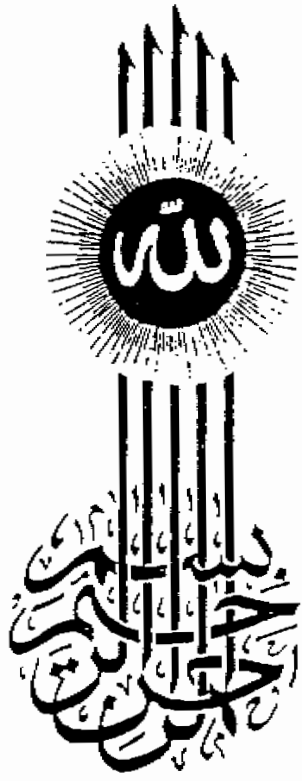


وقل رب زدني علماً

ASSESSMENT OF RESERVOIR CHARACTERISTICS IN RELATION TO THE ENVIRONMENTAL CONDITIONS OF THE MIOCENE CLASTICS, NORTH OF OCTOBER FIELD, GULF Of SUEZ, EGYPT

Ph.D THESIS
IN GEOPHYSICS

SUBMITTED TO
GEOPHYSICS DEPARTMENT
FACULTY OF SCIENCE,
AIN-SHAMS UNIVERSITY

BY
MAHMOUD ABDEL HALIM MOHAMED GHORAB
M.SC. GEOPHYSICS

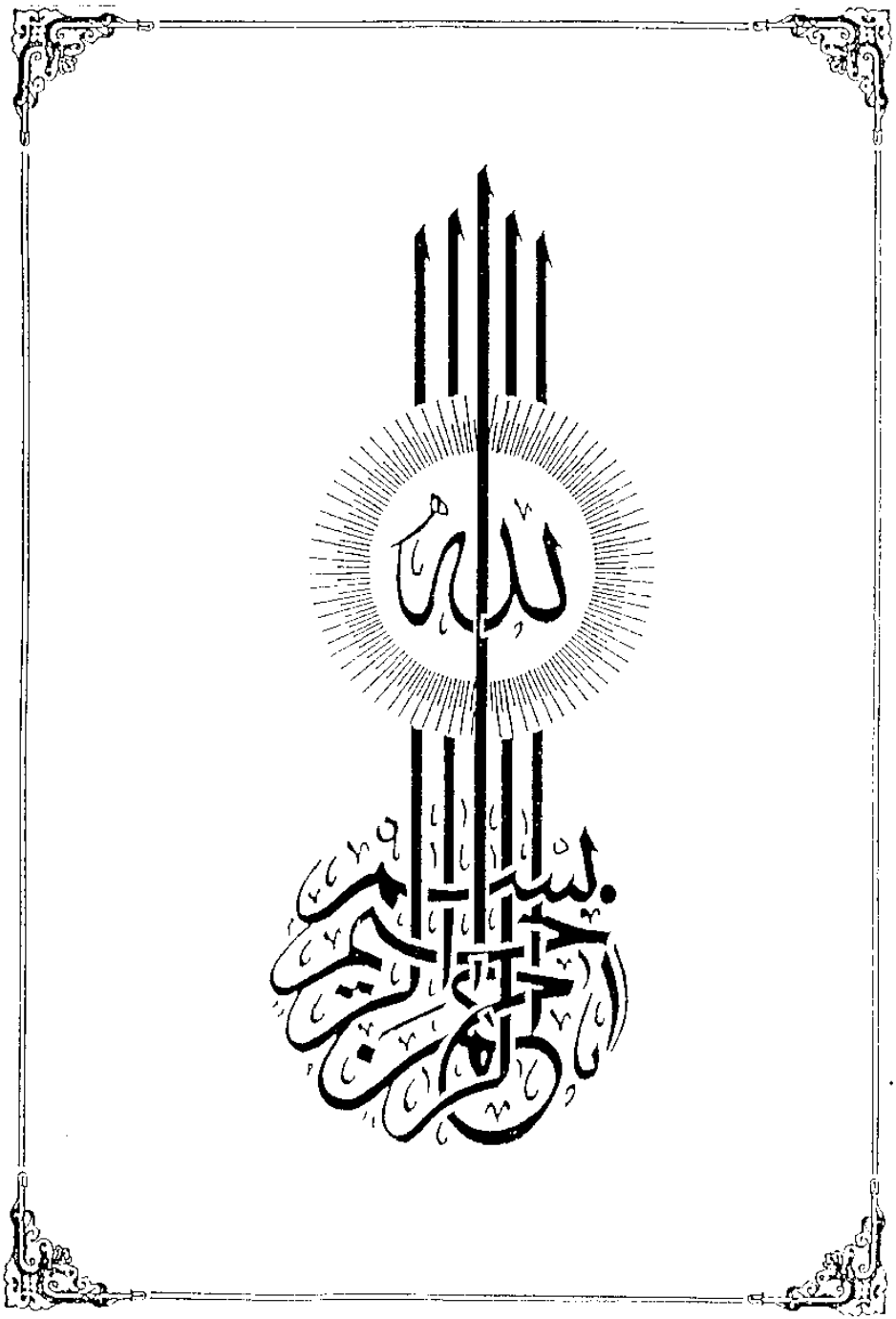
SUPERVISED BY

PROF. DR. : A. S. A. ABU EL-ATA
Prof. of Geophysics,
Geophysics Department,
Faculty of Science,
Ain Shams University

PROF. DR. : S. A. ABDEL-BAKY
Prof. of Geophysics and Head
of Exploration Department,
Egyptian Petroleum Research
Institute

DR. AHMED KAMAL BASAL
Ass.Prof. of Geophysics,
Geology Department,
Damietta University

CAIRO 1997



ACKNOWLEDGMENT

In the first place, praise be to **Allah** and gratitude is due to almighty **Allah** who guided me to bring forth this thesis to light.

Thanks **Allah**

The author wishes to express his gratitude to **Prof. Dr. Ahmed Said Abu El Ata**, Prof. of Geophysics, Department of Geophysics, Faculty of Science, Ain Shams University, for his stimulating supervision of this work, the unlimited assistance in interpreting the results, criticizing the final manuscript, and for the valuable computational facilities kindly offered by him.

Special thanks are due to **Prof. Dr. Samira Hassan Abdel Baki**, Prof. of Geophysics and Head of Exploration Sector, Petroleum Research Institute, for her great help and continuous encouragement.

Deep thank are due to **Dr. Ahmed Basal**, Assist. Prof. of Geophysics, Department of Geology, Faculty of Science, Damietta University, for valuable discussions, reading of the entire manuscript and for generous advice offered by him at various stages of the work

Deep thanks are also due to my colleagues for their great help and continuous encouragement.

Finally, from all my heart, I feels indebted to my family for their great help and permanent care

ABSTRACT

Mahmoud Abdel Halim Mohamed Ghorab. Assessment of Reservoir Characteristics in Relation to The Environmental Conditions of the Miocene Clastics, North of October Field, Gulf of Suez, Egypt.

The present study is devoted to assess the reservoir characteristics and their relation to the environmental conditions of the Miocene clastics. These include Belayim, Kareem, Rudeis and Nukhul Formations in the North of October Field central part of the Gulf of Suez. The log data used are derived from ten wells distributed from the north to south as follow : CLB-1, HB 80-1, North October 124-1, G.S 138-1, C3 A-1, North October 147-1, C4 NA-2, G.S 148-1, G.S 160-1 and EGB-1. The study area lies between latitudes 28° 40` and 29° 30` to the north and longitudes 32° 30` and 33° 20` to the east.

This study depends on different types of open hole well logs in the form of resistivity (shallow and deep), porosity tools (neutron, density and sonic) and gamma-ray to determined the petrophysical parameters and their effect on the reservoir characteristics. The lithologic components include the shale and matrix (limestone, sandstone and anhydrite), while the pore implications involve the porosity (total and effective) and permeability (absolute and relative), and the fluid contents include the connate waters (reducible and irreducible) and rock hydrocarbons. (movable and residual). The tar occurrences are identified and determined as residual hydrocarbons.

These petrophysical parameters are represented vertically in the form of litho-saturation crossplots to exhibit their collinear distribution through the wells and also in the form of iso-parameteric maps to illustrate their areal distribution of the evaluated formations across the area of study. The lithologic model of the area is established by utilizing the neutron-density

crossplots to detect the comparable facies conditions and depositional environments and their impact on the inherited reservoir characteristics.

Two comprehensive computer programs are in this work; the first is used for correcting the given log data and determining the needed petrophysical parameters, while the second is for determining the lithologic contents within the wells. These computer facilities are utilized for carrying out the listed wanted mathematical operations and for representing the acquired illustrations in this thesis.

LIST OF CONTENTS

Subject *Page*

LIST OF FIGURES. i

LIST OF TABLES. ix

CHAPTER I. GEOLOGIC SETTING.

I-1- INTRODUCTION. 1
I-2- STRATIGRAPHY. 2
I-3- PALEOGEOGRAPHY. 11
I-4- STRUCTURAL SETTING. 14
I-5- TECTONICS. 16
I-6- GEOLOGIC HISTORY. 19
I-7- AIM OF THE PRESENT WORK. 21

CHAPTER II. PETROPHYSICAL CORRECTIONS AND CALIBRATIONS.

II-1- INTRODUCTION. 23
II-2- AVAILABLE WELL LOGGING DATA. 24
II-3- MEASUREMENTS AND CORRECTIONS OF FLUID RESISTIVITIES. 25
II-4- DETERMINATION OF ROCK RESISTIVITIES. . 27
II-5- CORRECTION OF POROSITY TOOLS. 34
II-6- CALCULATION OF ROCK VARIABLES AND EXPONENTS. 38

CHAPTER III. LITHOLOGIC MODELING.

III-1- INTRODUCTION. 60
III-2- VOLUME OF SHALE DETERMINETION. . . . 60
III-3- MATRIX INDENTIFICATION. 63
III-4- SHALE DISTRIBUTION MAPS. 66
III-5- MATRIX DISTRIBUTION MAPS. 67
III-6- LITHOLOGY, FACIES AND ENVIRONMENTAL CONDITIONS. 67

Subject *Page*

CHAPTER IV. RESERVOIR CHARACTERISTICS.
IV-1- INTRODUCTION. 92
IV-2- POROSITY. 92
IV-3- PERMEABILITY. 95
IV-4- POROSITY DISTRIBUTION MAPS. 96
IV-5- PERMEABILITY DISTRIBUTION MAPS. . . . 97

CHAPTER V. SATURATION ASSESSMENT.
V-1- INTRODUCTION. 102
V-2- DETERMINATION OF FLUID SATURATIONS. 103
V-3- LITHO-SATURATION CROSSPOLT ANALYSIS. 107
V-4- FLUID SATURATION MAPS. 145

SUMMARY & CONCLUSIONS. 163
REFRENCES 167
APPENDIX I . . . . . .
APPENDIX II . . . . . .
ARABIC SUMMARY. . . . . .

LIST OF TABLES

Table No. *Page*

1 Available Well Logging Data. 24

2 The Values of the Rock Variable and Exponent. . . . 58

LIST OF FIGURES

Fig. No.		*Page*
1	Location map of the study area.	2
2	Lithological logs and corresponding stratigraphy of Late Oligocene-Miocene.	3
3	Pickett's plot of Kareem Formation, CLB-1 well. . .	40
4	Pickett's plot of Rudeis Formation, CLB-1 well. . .	40
5	Pickett's plot of Belayim Formation, HB 80-1 well. .	41
6	Pickett's plot of Kareem Formation, HB 80-1 well. .	41
7	Pickett's plot of Rudeis Formation, HB 80-1 well. .	42
8	Pickett's plot of Belayim Formation, North October 124-1 well.	43
9	Pickett's plot of Kareem Formation, North October 124-1 well.	43
10	Pickett's plot of Rudeis & Nukhul Formations, North October 124-1 well.	44
11	Pickett's plot of Belayim Formation, G.S 138-1 well.	45
12	Pickett's plot of Kareem Formation, G.S 138-1 well.	45
13	Pickett's plot of Rudeis Formation, G.S 138-1 well.	46
14	Pickett's plot of Rudeis Formation, C3 A-1 well. . .	47
15	Pickett's plot of Nukhul Formation, C3 A-1 well. . .	47
16	Pickett's plot of Belayim Formation, North October 147-1 well.	48
17	Pickett's plot of Kareem Formation, North October 147-1 well.	48
18	Pickett's plot of Rudeis Formation, North October 147-1 well.	49
19	Pickett's plot of Kareem Formation, C4 NA-2 well. .	50
20	Pickett's plot of Rudeis Formation, C4 NA-2 well. .	50
21	Pickett's plot of Nukhul Formation, C4 NA-2 well. .	51
22	Pickett's plot of Belayim Formation, G.S 148-1 well.	52
23	Pickett's plot of Kareem Formation, G.S 148-1 well.	52
24	Pickett's plot of Rudeis Formation, G.S 148-1 well. .	53

Fig. No.		*Page*
25	Pickett's plot of Belayim Formation, G.S 160-1 well.	54
26	Pickett's plot of Kareem Formation, G.S 160-1 well.	54
27	Pickett's plot of Rudeis Formation, G.S 160-1 well.	55
28	Pickett's plot of Nukhul Formation, G.S 160-1 well.	55
29	Pickett's plot of Belayim Formation, EGB-1 well.	56
30	Pickett's plot of Kareem Formation, EGB-1 well.	56
31	Pickett's plot of Rudeis Formation, EGB-1 well.	57
32	Pickett's plot of Nukhul Formation, EGB-1 well.	57
33	Shale distribution map of Belayim Formation, in the study area.	68
34	Shale distribution map of Kareem Formation, in the study area.	68
35	Shale distribution map of Rudeis Formation, in the study area.	69
36	Shale distribution map of Nukhul Formation, in the study area.	69
37	Matrix distribution map of Belayim Formation, in the study area.	70
38	Matrix distribution map of Kareem Formation, in the study area.	70
39	Matrix distribution map of Rudeis Formation, in the study area.	71
40	Matrix distribution map of Nukhul Formation, in the study area.	71
41	Neutron-density cross-plot of Belayim Formation, HB 80-1 well.	74
42	Neutron-density cross-plot of Belayim Formation, North October 124-1 well.	74
43	Neutron-density cross-plot of Belayim Formation, G.S 138-1 well.	75
44	Neutron-density cross-plot of Belayim Formation, North October 147-1 well.	75

Fig. No.		*Page*
45	Neutron-density cross-plot of Belayim Formation, G.S 148-1 well.	76
46	Neutron-density cross-plot of Belayim Formation, G.S 160-1 well.	76
47	Neutron-density cross-plot of Belayim Formation, EGB-1 well.	77
48	Neutron-density cross-plot of Kareem Formation, CLB-1 well.	77
49	Neutron-density cross-plot of Kareem Formation, HB 80-1 well.	78
50	Neutron-density cross-plot of Kareem Formation, North October 124-1 well.	78
51	Neutron-density cross-plot of Kareem Formation, G.S 138-1 well.	79
52	Neutron-density cross-plot of Kareem Formation, North October 147-1 well.	79
53	Neutron-density cross-plot of Kareem Formation, C4 NA-2 well.	80
54	Neutron-density cross-plot of Kareem Formation, G.S 148-1 well.	80
55	Neutron-density cross-plot of Kareem Formation, G.S 160-1 well.	81
56	Neutron-density cross-plot of Kareem Formation, EGB-1 well.	81
57	Neutron-density cross-plot of Rudeis Formation, CLB-1 well.	82
58	Neutron-density cross-plot of Rudeis Formation, HB 80-1 well.	82
59	Neutron-density cross-plot of Rudeis Formation, North October 124-1 well.	83
60	Neutron-density cross-plot of Rudeis Formation, G.S 138-1 well.	83

Fig. No.		*Page*
61	Neutron-density cross-plot of Rudeis Formation, C3 A-1 well.	84
62	Neutron-density cross-plot of Rudeis Formation, North October 147-1 well.	84
63	Neutron-density cross-plot of Rudeis Formation, C4 NA-2 well.	85
64	Neutron-density cross-plot of Rudeis Formation, G.S 148-1 well.	85
65	Neutron-density cross-plot of Rudeis Formation, G.S 160-1 well.	86
66	Neutron-density cross-plot of Rudeis Formation, EGB-1 well.	86
67	Neutron-density cross-plot of Nukhul Formation, C3 A-1 well.	88
68	Neutron-density cross-plot of Nukhul Formation, C4 NA-2 well.	88
69	Neutron-density cross-plot of Nukhul Formation, G.S 160-1 well.	89
70	Neutron-density cross-plot of Nukhul Formation, EGB-1 well.	89
71	Litho-facies map of Belayim Formation, in the study area.	90
72	Litho-facies map of Kareem Formation, in the study area.	90
73	Litho-facies map of Rudeis Formation, in the study area.	91
74	Litho-facies map of Nukhul Formation, in the study area.	91
75	Iso-porosity map of Belayim Formation, in the study area.	98
76	Iso-porosity map of Kareem Formation, in the study area.	98

Fig. No.		*Page*
77	Iso-porosity map of Rudeis Formation, in the study area.	99
78	Iso-porosity map of Nukhul Formation, in the study area.	99
79	Permeability distribution map of Belayim Formation, in the study area.	100
80	Permeability distribution map of Kareem Formation, in the study area.	100
81	Permeability distribution map of Rudeis Formation, in the study area.	101
82	Permeability distribution map of Nukhul Formation, in the study area.	101
83	Litho-saturation cross-plot of Kareem Formation, CLB-1 well.	108
84	Litho-saturation cross-plot of Rudeis Formation, CLB-1 well.	109
85	Litho-saturation cross-plot of Belayim Formation, HB 80-1 well.	110
86	Litho-saturation cross-plot of Kareem Formation, HB 80-1 well.	111
87	Litho-saturation cross-plot of Rudeis Formation, HB 80-1 well.	113
88	Litho-saturation cross-plot of Belayim Formation, North October 124-1 well.	114
89	Litho-saturation cross-plot of Kareem Formation, North October 124-1 well.	115
90	Litho-saturation cross-plot of Rudeis Formation, North October 124-1 well.	117
91	Litho-saturation cross-plot of Nukhul Formation, North October 124-1 well.	118
92	Litho-saturation cross-plot of Belayim Formation, G.S 138-1 well.	119

Fig. No.		*Page*
93	Litho-saturation cross-plot of Kareem Formation, G.S 138-1 well.	120
94	Litho-saturation cross-plot of Rudeis Formation, G.S 138-1 well.	122
95	Litho-saturation cross-plot of Rudeis Formation, C3 A-1 well.	123
96	Litho-saturation cross-plot of Nukhul Formation, C3 A-1 well.	124
97	Litho-saturation cross-plot of Belayim Formation, North October 147-1 well.	125
98	Litho-saturation cross-plot of Kareem Formation, North October 147-1 well.	127
99	Litho-saturation cross-plot of Rudeis Formation, North October 147-1 well.	128
100	Litho-saturation cross-plot of Kareem Formation, C4 NA-2 well.	129
101	Litho-saturation cross-plot of Rudeis Formation, C4 NA-2 well.	131
102	Litho-saturation cross-plot of Nukhul Formation, C4 NA-2 well.	132
103	Litho-saturation cross-plot of Belayim Formation, G.S 148-1 well.	133
104	Litho-saturation cross-plot of Kareem Formation, G.S 148-1 well.	134
105	Litho-saturation cross-plot of Rudeis Formation, G.S 148-1 well.	136
106	Litho-saturation cross-plot of Belayim Formation, G.S 160-1 well.	137
107	Litho-saturation cross-plot of Kareem Formation, G.S 160-1 well.	138
108	Litho-saturation cross-plot of Rudeis Formation, G.S 160-1 well.	139