



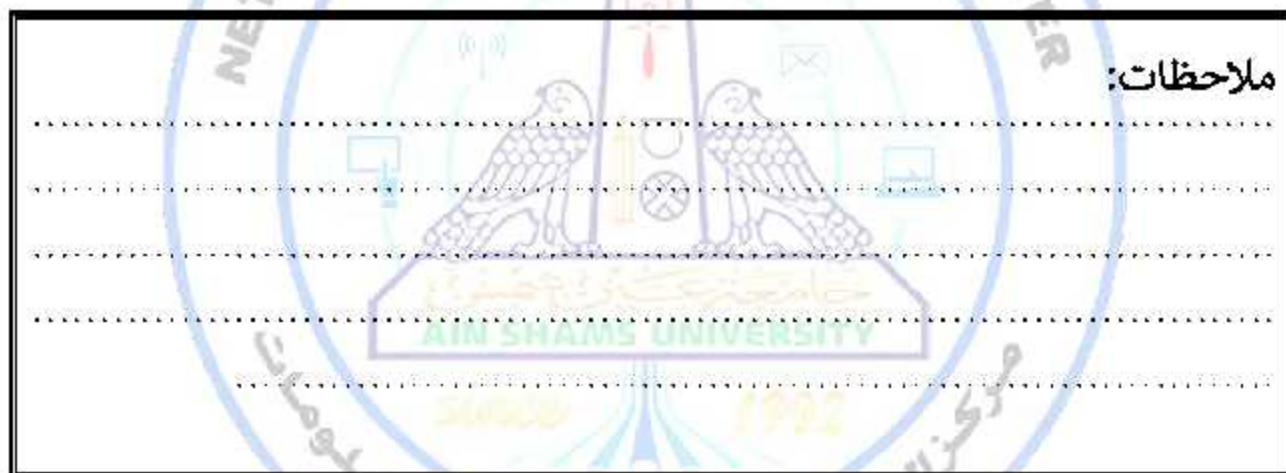
000000

تم رفع هذه الرسالة بواسطة / سنوي محمود عقل

بقسم التوثيق الإلكتروني بمركز الشبكات وتكنولوجيا المعلومات دون أدنى

مسئولية عن محتوى هذه الرسالة.

ملاحظات:



Ain Shams University
Faculty of Science
Geophysics Department



Study of the Physical Properties of the Miocene Limestone rocks, New El-Alamein City, North Coast, Egypt.

A Thesis Submitted in Partial Fulfillment of the Requirements for the Master
Degree of Science in Geophysics

BY

Ahmed Osama Kamal Mohammed

(B. Sc. In Geophysics, 2016)

Faculty of Science – Ain Shams University

To

Geophysics Department

Faculty of Science – Ain Shams University

Supervised by

Prof. Dr. Abdel Moktader A. ElSayed

Prof. of Petrophysics, Department of Geophysics, Faculty of Science, Ain
Shams University

Prof. Dr. Attia Mahmoud Attia

Professor and Dean of faculty of energy and environmental engineering
and supervisor of Petroleum Engineering and Gas Technology, BUE
University, Cairo, Egypt.

Dr. Ayman Shebl El Sayed

Associate professor of Geophysics, Geophysics Department, Faculty of
Science, Ain Shams University.

Cairo, 2022

Note

The present thesis is submitted to the Faculty of Science, Ain Shams University in partial fulfillment of the requirements of the Master's degree of Science in Geophysics.

Besides the research work materialized in this thesis, the candidate has attended ten post-graduate courses for one year in the following topics:

1. Geophysical field measurements
2. Numerical analysis and computer programming
3. Petrophysical Properties of Rocks
4. Advanced Well Logging
5. Formation Evaluation
6. Reservoir Evaluation
7. Subsurface Geology
8. Geophysical Prospecting
9. Sedimentary Basin Analysis
10. Fluid Dynamics

He successfully passed the final examinations in these courses. In fulfillment of the language requirement of the degree, he also passed the final examination of a course in the English language.

Head of Geophysics Department

Prof. Dr. Abdel-Khalek EL-Werr

Acknowledgment

First and foremost, I give **Allah** the glory that made this work complete.

I wish to thank **Prof. Dr. Abdel Moktader A. El Sayed** Professor of Petrophysics, Geophysics Department, Faculty of Science, Ain shams University for his valuable comments and for supporting me to produce the best in this thesis.

I wish to thank **Prof. Dr. Attia Mahmoud Attia** Professor and Dean of faculty of energy and environmental engineering and supervisor of Petroleum Engineering and Gas Technology, BUE University, Cairo, Egypt. for his valuable comments and for sharing his precious time to review and leading his comments in this thesis.

I want to thank **Dr. Ayman Shebl El Sayed** Associate Professor of Geophysics, Geophysics Department, Faculty of Science, Ain Shams University, for her helpful suggestions in the planning of this study.

I would like to express my sincere thanks to **Dr. Mohamed Kassab** Professor of Petrophysics, Department of Exploration, Egyptian Petroleum Research Institute for his valuable comments and for sharing his precious time to review and lead his comments in this thesis.

I want to thank **Dr. Nahla A. El Sayed** assistant professor in the geophysics department (Exploration division), EPRI, for reviewing and discussing various issues in lab measurements and supporting and encouraging me during this work.

Finally, I appreciate the helping of **Prof. Dr. Ashraf Rushdi Baghdady** Professor of sedimentary rocks, Geology Department, Faculty of Science, Ain shams University, for reviewing and discussing various issues Petrography chapter.

Dedication

I would like to dedicate my work to my parents, my sisters, and my dear brother, whose love, help, and support kept me going.

This thesis work is dedicated to my wife, Esraa, who has been a constant source of support and encouragement during the challenges of this work and life. I am truly thankful for having you in my life.

CONTENTS

Subject	Page number
1. Note	I
2. Acknowledgm	II
3. Dedication	III
4. List of Contents	IV
5. List of Figures	X
6. List of Tables	XIII
7. Nomenclature	XV
8. Abstract	XVI
9. Chapter One: INTRODUCTION	
1.1. Objective and Aims of the Study	3
1.2. Aims of this study	3
1.3. Methodology	5
1.4. Summary	5
2. Chapter Two: GEOLOGICAL SETTING	
2.1. Introduction	7
2.2. Geomorphology	7
2.2.1. Coastal Plain	8
2.2.2. Coastal Plain Depositional Features	10
2.2.2.1. Beach sediments	10
2.2.2.2. Beach edges	11
2.2.2.3. Coastal Depressions	11
2.2.2.4. Coastal Plain Erosional Features	11
2.2.2.4.1. Wave cutting platform	11
2.2.2.4.2. Elevated Plateau	11

CONTENTS

Subject	Page number
2.3. Stratigraphic Succession.....	12
2.3.1 Moghra Formation.....	13
2.3.2 Marmarica Formation.....	13
3. Chapter Three: PETROGRAPHY	
3.1. Methodology.....	17
3.2. Middle Miocene Limestone rocks.....	17
3.3. Microfacies Types of the Middle Miocene carbonates.....	19
3.4. Diagenetic features of the Middle Miocene carbonates.....	25
3.5. Summary.....	25
4. Chapter Four: STORAGE AND FLOW CAPACITY OF THE STUDIED SAMPLES	
4.1. Preparation of Samples for Petrophysical Measurements.....	28
4.1.1. Cutting of Samples.....	28
4.1.2. Cleaning of Samples.....	29
4.1.3. Drying after extraction.....	30
4.2. Rock Density.....	31
4.2.1. Bulk density.....	31
4.2.2. Grain density.....	33
4.3. Packing Index (PI).....	35
4.4. Porosity.....	37
4.4.1 Factors affecting porosity.....	38
4.4.2 Classification of porosity.....	40
4.4.3 Determination of porosity.....	41
4.5. Permeability.....	44
4.5.1. Laboratory measurements of permeability.....	44
4.5.2. Types of rock permeability.....	46

CONTENTS

Subject	Page number
4.6. The relation between Grain Density and Bulk Density.....	84
4.7. Relation between Bulk Density and Porosity.....	49
4.8. The relation between Grain Density and Porosity.....	49
4.9. The relation between Grain Density and Permeability.....	51
4.10. The relation between Bulk Density and Permeability.....	51
4.11. The relation between Permeability and Porosity.....	52
4.12. Hydraulic Flow Unit (HFU).....	54
4.13. WINLAND R35 METHOD.....	60
4.14. Pore aperture size (r36) calculation from permeability.....	64
4.15. Summary	66
5. Chapter Five: ELECTRICAL PROPERTIES OF STUDIED SAMPLES	
5.1. Electrical Resistivity.....	68
5.1.1. factors affect on Electrical resistivity.....	69
5.1.2. Electrical resistivity measurements.....	69
5.2. Formation Resistivity Factor (F).....	72
5.3. Electrical Tortuosity (τ).....	75
5.3.1 Relation between Formation Resistivity Factor (F) and Tortuosity (τ).....	78
5.4. The Relation between Formation Resistivity Factor (F) and Porosity (\emptyset).....	79
5.5. Cementation Exponent.....	80
5.6. Relation between Cementation Factor (m) and Tortuosity (τ)....	82
5.7. Electrical Flow Unit Concept (EFU).....	83
5.8. Summary.....	87
6. Chapter Six: ACOUSTIC PROPERTIES OF THE STUDY SAMPLES	

CONTENTS

Subject	Page number
6.1. Introduction.....	89
6.2. Compressional Wave Velocity (V_p).....	91
6.3. Shear Wave Velocity (V_s).....	94
6.4. Dynamic Elastic properties.....	96
6.4.1. Poisson's Ratio (σ).....	97
6.4.2. Young Modulus (E).....	98
6.4.3. Rigidity Modulus (μ).....	98
6.4.4. Bulk Modulus (K).....	99
6.4.5. N-Value (Standard Penetration Test (SPT)).....	99
6.4.6. Lamé's Constant (λ).....	100
6.5. Acoustic Properties and Storage, Flow Capacity and Rock Density Relationships.....	102
6.5.1. The relationship between acoustic wave velocities (v_p and v_s) and bulk density (ρ_b).....	102
6.5.2. Relationship between Acoustic Wave Velocities (V_p and V_s) and Porosity (\emptyset).....	103
6.5.3. The relationship between Compressional Wave Velocity (V_p) and Shear Wave Velocity (V_s)	104
6.5.4. The relationship between Young's modulus (E) and compressional (V_p) and shear wave (V_s) velocities.....	105
6.5.5. The relationship between rigidity modulus (μ) and compressional (V_p) and shear wave (V_s) velocities.....	106
6.5.6. The relationship between bulk modulus (K) and compressional (V_p) and shear wave (V_s) velocities.....	107
6.5.7. The relationship between Poisson's ratio (σ) and (V_p/V_s) ratio.....	108
6.5.8. The relationship between Porosity (\emptyset) and (V_p/V_s) ratio..	109

CONTENTS

Subject	Page number
6.5.9. The relationship between V_p and V_s	110
6.5.10. The relationship between bulk modulus (K) and shear modulus (μ).....	111
6.5.11. The relationship between Porosity (\emptyset) and shear modulus (μ) & Lamé constant (λ) ratio.....	112
6.5.12. The relationship between Porosity (\emptyset) and bulk density (ρ_b) time Lamé constant (λ).....	113
6.5.13. The relationship between Porosity (\emptyset) and bulk density (ρ_b) time shear modulus (μ).....	114
6.6. Summary.....	115
7. Chapter Seven: Material Competence And Material Bearing Capacity	
7.1. Material Competence Scales.....	117
7.1.1. The Material Index (ν).....	117
7.1.2. Concentration index (CI).....	120
7.1.3. Stress Ratio (SI).....	121
7.2. Foundation Material Bearing Capacity.....	126
7.2.1. Ultimate Bearing Capacity.....	126
7.2.2. Allowable Bearing Capacity.....	127
7.3. Summary	130
8. Chapter Eight: ROCK PHYSICS MODELING	
8.1. Porosity Modeling	132
8.2. Compressional Wave Velocity Modeling.....	133
8.3. Shear Wave Velocity Modeling.....	134
8.4. Permeability Modeling.....	135
8.5. Resistivity Modeling	136
8.6. Summary.....	137

CONTENTS

Subject	Page number
9. References	143
10. Appendix	151
11. Arabic Summary	157

LIST OF FIGURES

Figure	Page number
Fig. 1.1: The Location map of the study area.....	2
Fig. 1.2: The Location map of the boreholes in the study area.....	4
Fig. 2.1: location map showing four major aeolian depressions (Bondesan et al., 2013).....	9
Fig. 2.2: Mesas and cuestas on the El Taqa Plateau, bordering the southern side. The escarpments are approximately 30 m high (Bondesan et al., 2013).	9
Fig. 2.3: structural map of the Mediterranean Sea (Said, 1990).	10
Fig. 2.4: Fig. (2-4): Generalized stratigraphic column of the North-Western Desert.....	15
Fig. 3.1: Photomicrographs showing Bio Micrite Microfacies.	19
Fig. 3.2: Photomicrographs showing Pel Bio Micrite Microfacies.	20
Fig. 3.3: Photomicrographs showing Pel Bio Microsparate Microfacies.	21
Fig. 3.4: Photomicrographs showing Bio Pel Microsparate Microfacies.	22
Fig. 3.5: Photomicrographs showing Bio Pel Microsparate Microfacies.	23
Fig. 3.6: Photomicrographs showing Gypsem Microfacies.	24
Fig. 4.1: shows the cutting process.....	28
Fig. 4.2: shows the Soxhlet extraction apparatus.	30
Fig. 4.3: Histogram curve for bulk density of all samples.	33
Fig. 4.4: Histogram curve for grain density of all samples.	35
Fig. 4.5: Histogram curve for Packing Index values for all samples.	37
Fig. 4.6: Graphical representation of grain sorting.....	38
Fig. 4.7: Effect of cement on rock porosity.....	38
Fig. 4.8: Contrasting compaction processes.	39
Fig. 4.9: Effect of packing method.....	39
Fig. 4.10: Classification of pore types in carbonate rocks. Pore space is shown in black (modified from Choquette and Pray, 1970).....	41
Fig. 4.11: determination of rock porosity by helium porosimeter.....	42
Fig. 4.12: Histogram curve for Porosity values for all samples.	44
Fig. 4.13: Air permeameter Schon, J.H. (2011) discussed the various types of permeability.....	45
Fig. 4.14: Histogram curve for Permeability values for all samples.....	48

LIST OF FIGURES

Figure	Page number
Fig. 4.15: The relation between the bulk density and the grain density.....	49
Fig. 4.16: The relation between porosity and bulk density.	50
Fig. 4.17: The relation between grain density and porosity.	50
Fig. 4.18: The relation between grain density and permeability.	51
Fig. 4.19: The relation between bulk density and permeability.	52
Fig. 4.20: The relationship between porosity and permeability in carbonate rocks, (Schon J., 2011).	53
Fig. 4.21: The relationship between Porosity and permeability.	54
Fig. 4.22: the histogram frequency curve of the FZI of all the samples.	57
Fig. 4.23: the log-log plot of RQI vs. ϕ_z with HFU.	57
Fig. 4.24: Porosity–permeability relationship with HFU.	57
Fig. 4.25: shows the relation between the predicted permeability and the actual permeability.	58
Fig. 4.26: Porosity permeability relationship of all the study samples with R35 (Winland) lines.	62
Fig. 4.27: relation between R35 and FZI.	62
Fig. 4.28: shows the relationships between permeability and R35 and FZI.	63
Fig. 4.29: the relationship between R35 and R36.	64
Fig. 5.1: Histogram curve for all studied samples at 6000 ppm.	70
Fig. 5.2: Histogram curve for all studied samples at 60000 ppm.	71
Fig. 5.3: Histogram curve for all studied samples at 6000 ppm.	74
Fig. 5.4: Histogram curve for all studied samples at 60000 ppm.	74
Fig. 5.5: Histogram Curve for Electrical Tortuosity Values.	77
Fig. 5.6: relation between formation resistivity factor and Tortuosity.	78
Fig. 5.7: The relation between the formation resistivity factor of two different concentrations and porosity of the studied samples.	79
Fig. 5.8: Histogram curve for all studied samples at 6000 ppm.	80
Fig. 5.9: Histogram curve for all studied samples at 60000 ppm.	81
Fig. 5.10: relation between cementation factor and Tortuosity.	82
Fig. 5.11: The comparison between RQI and ERI.	84
Fig. 5.12: The relation between formation resistivity factor and porosity with CZI.	85
Fig. 6.1: OYO.Sonic Viewer 170 (model .5228).	91
Fig. 6.2: Histogram curve for Vp values of all samples.	93
Fig. 6.3: Range of compressional (higher values) and shear wave (lower values) velocities for commonly occurring rocks (Schön, 2011).	94
Fig. 6.4: Histogram curve for Vs values of all samples.	96

LIST OF FIGURES

Figure	Page number
Fig. 6.5: Elastic moduli with stress directions.....	97
Fig. 6.6: The relationship between bulk density (x-axis) and V_p & V_s (y-axis).....	102
Fig. 6.7: The relationship between Porosity (x-axis) and V_p & V_s (y-axis).....	103
Fig. 6.8: The relationship between V_p (x-axis) and V_s (y-axis).	104
Fig. 6.9: The relationship between (V_p and V_s) (x-axis) and (E) (y-axis).	105
Fig. 6.10: The relationship between (V_p and V_s) (x-axis) and (μ) (y-axis).	106
Fig. 6.11: The relationship between (V_p and V_s) (x-axis) and (K) (y-axis).....	107
Fig. 6.12: The relation between σ (y-axis) and V_p/V_s (x-axis) ratios.....	108
Fig. 6.13: The relation between Porosity (\emptyset) and (V_p/V_s) ratio.....	109
Fig. 6.14: The relation between V_p/V_s (y-axis) and V_p (x-axis) ratios.....	110
Fig. 6.15: The relation between bulk modulus (K) and shear modulus (μ).....	111
Fig. 6.16: The relation between Porosity (\emptyset) and shear modulus (μ) & the Lamé constant (λ) ratio.	112
Fig. 6.17: The relation between Porosity (\emptyset) and bulk density (ρ_b) time Lamé constant (λ).	113
Fig. 6.18: The relation between Porosity (\emptyset) and bulk density (ρ_b) time shear modulus (μ).	114
 Fig. 7.1: The relation between the Material index and Poisson's ratio.....	 119
Fig. 7.2: The relation between the Material index and $(v_s/v_p)^2$	119
Fig. 7.3: (A) The relation between the concentration index and the Poisson's ratio.....	122
Fig. 7.3: (B) The relation between the concentration index and $(V_s/V_p)^2$	122
Fig. 7.4: The relation between stress ratio and concentration index.....	123
 Fig. 8.1: The relationship between actual porosity and predicted porosity.	 133
Fig. 8.2: The relationship between calculated V_p and predicted V_p	134
Fig. 8.3: The relationship between calculated V_s and predicted V_s	135

LIST OF TABLES

Table	Page number
Tab. 4.1: shows the values of bulk density of all the samples.....	32
Tab. 4.2: shows the values of grain density of all the samples.....	34
Tab. 4.3: shows the values of the Packing Index of all the samples.....	36
Tab. 4.4: shows the values of the Porosity of all the samples.	43
Tab. 4.5: shows the values of the Permeability of all the samples.	47
Tab. 4.6: HFU Equations.....	58
Tab. 4.7: shows the values of the RQI, FZI, and ϕ_z and all the samples..	59
Tab. 4.8: shows the values of R35 for all the studied samples.....	61
Tab. 4.9: values of R36.....	65
Tab. 5.1: values of electrical resistivity at different concentrations.	71
Tab. 5.2: the values of the Formation Resistivity Factor (F).....	73
Tab. 5.3: The values of Electrical Tortuosity (τ).....	76
Tab. 5.4: Cementation Exponent (m).	81
Tab. 5.5: EFUs power equations.....	84
Tab. 5.6: The values of ERI and CZI.....	86
Tab. 6.1: Values of compressional wave velocity of all studied samples.	92
Tab. 6.2: Values of shear wave velocity of all studied samples.....	95
Tab. 6.3: N-Values for different soil types, after Bowles, 1984.....	100
Tab. 6.4: The calculated parameters for all study samples.....	101
Tab. 7.1: Material index correspondent to different materials, (after Birch, 1966; Gassman, 1973; Tatham, 1982 and Sheriff and Geldart, 1986).....	118
Tab. 7.2: Soil description concerning Material index (after Birch, 1966; Gassman, 1973; Tatham, 1982 and Sheriff and Geldart, 1986).....	118