

**PALAEOMAGNETIC AND MAGNETIC FABRIC STUDIES ON  
WADI DIB RING COMPLEX, NORTHERN EASTERN DESERT,  
EGYPT**

**A Thesis Submitted to  
Geophysics Department,  
Faculty of Science, Cairo University  
In Partial Fulfillment of the Requirements of M. Sc. Degree in  
Geophysics  
(Potential Field Methods)**

*By*

**MOHAMED HASSAN MOHAMED YOUSEF,  
GEOPHYSICIST,  
NUCLEAR MATERIALS AUTHORITY,  
CAIRO, EGYPT**

**Supervisors**

**Dr. El-Sayed Mohamed Abdelrahman  
Emeritus Professor of Geophysics, Faculty of Science,  
Cairo University, Geiza, Egypt.**

**Dr. Ahmed Abubakr Ammar  
Emeritus Professor of Applied Geophysics,  
Nuclear Materials Authority, Cairo, Egypt.**

**2010**

# APPROVAL SHEET

*Title of the M.Sc. Thesis:*

*Palaeomagnetic and Magnetic Fabric Studies on Wadi Dib Ring Complex,  
Northern Eastern Desert, Egypt*

*Submitted to*

*Faculty of Science, Cairo University*

*Name of the candidate:*

*Mohamed Hassan Mohamed Yousef*

*Supervision committee:*

*Prof. Dr. El-Sayed Mohamed Abdelrahman*

*Emeritus Professor of Geophysics,*

*Faculty of Science, Cairo University, Geiza, Egypt.*

*Prof. Dr. Ahmed Abubakr Ammar*

*Emeritus Professor of Applied Geophysics,*

*Nuclear Materials Authority, Cairo, Egypt.*

*Approved*

*Prof. Dr. Mostafa H. Kamel,  
Head of Geophysics Department,  
Faculty of science,  
Cairo University.*

## **PREFACE**

**Besides the research work presented in this thesis, the candidate attended 12 courses over one year period in the following topics.**

- (1) Gravity methods**
- (2) Magnetic methods**
- (3) Electromagnetic methods**
- (4) Geothermal and radiometric methods**
- (5) Electric methods**
- (6) Well logging methods**
- (7) Paleomagnetism**
- (8) Instrumentation**
- (9) Geotectonics**
- (10) Computer applications in Geophysics**
- (11) Integrated exploration methods**
- (12) Selected topics**

**He successfully passed the final examination in these courses in 2004.**

*Approved*

*Prof. Dr. Mostafa H. Kamel*  
*Head of Geophysics Department,*  
*Faculty of science,*  
*Cairo University*

## ACKNOWLEDGEMENTS

In the first place, my all gratitude and praise is to *Allah* who guided and helped me to start and perform this thesis.

My heartfelt gratitude to *Prof. Dr. Mostafa H. Kamel*, Prof. of Geophysics and Head of Geophysics Department, Faculty of Science, Cairo University, for his continuous encouragement during the completion of this work.

I am also grateful to *Prof. Dr. Abouhoda M. Elserafy*, President of the *NMA*, for his kind support and encouragement and providing the facilities offered to carry out this research work.

I would like to express my deep gratitude and acknowledgments to *Prof. Dr. El-Sayed M. Abdelrahman*, Professor of Geophysics, Geophysics Department, Faculty of Science, Cairo University, *Prof. Dr. Ahmed A. Ammar*, Professor of Applied Geophysics, Exploration Division, Nuclear Materials Authority Cairo, Egypt for their kind supervision and reviewing of this thesis.

My best gratitude to *Dr. Ragaa A. Mahmoud*, Assistant Professor of Applied Geophysics, Exploration Division, Nuclear Materials Authority, Cairo, Egypt, for her internal supervision, kind co-operation and revision.

Grateful thanks are due to *Dr. Hassan A. Shahin* and *Dr. Masaoud S. Masaoud* for their continuous guiding in the field.

Grateful thanks are also due to *Reda A. Yousef* and *Mostafa A. Mohamed*, Geophysicists, Exploration Division, Nuclear Materials Authority, for their help in the field.

I wish also to express my gratitude to *Ahmed M. Seifeldin* and *Haitham M. Abdelghany* for their assistances in preparation of samples.

Finally, grateful and deep thanks are due to my family, especially my mother and my wife for their continuous encouragement to carry out this work.

# CONTENTS

	<b>Page No.</b>
PREFACE	i
ACKNOWLEDGEMENTS	ii
CONTENTS	iii
LIST OF FIGURES	vi
LIST OF TABLES	xii
ABSTRACT	1
GENERAL INTRODUCTION	3
CHAPTER ONE:	
GEOLOGICAL OUTLINE AND PREVIOUS WORK	5
1.1. GENERAL	5
1.2. ALKALINE RING COMPLEXES OF EGYPT	7
1.2.1. Common	7
1.2.2. Classification and Age	8
1.2.3. Petrogenesis	11
1.2.4 Tectonic setting	12
1.3. WADI DIB RING COMPLEX	12
1.3.1. Location	12
1.3.2. Topography and Climate	12
1.3.3. Lithology and Structure	14
1.3.4. Rock Units and Petrography	15
1.3.5. Structural Development and Sequence of Formations	17
1.3.6. Age of Wadi Dib Ring Complex	18
CHAPTER TWO:	
MAGNETIC PROPERTIES OF ROCKS	19
2.1 GENERAL	19
2.2. PALAEOMAGNETISM	19
2.2.1 Natural Remanent Magnetism (NRM)	19

	<b>Page No.</b>
2.2.2 Types of Remanent Magnetization	20
2.2.3. Demagnetization and Stability of Remanence	22
2.2.4. Directions of Magnetization and their Analyses	24
2.2.5. Instruments	26
2.3. MAGNETIC FABRIC	30
2.3.1. Magnetic Susceptibility	30
2.3.2. Anisotropy of Magnetic Susceptibility (AMS)	30
2.2.3 Parameters of AMS	32
2.3.4. Magnetic Fabric in Igneous Rocks	34
2.3.5. Instruments	36
CHAPTER THREE:	
PALAEOMAGNETISM	38
1. WADI DIB RING COMPLEX	38
1.1. FIELD OBSERVATIONS AND SAMPLING	38
1.2. RESULTS AND ANALYSES	40
1.2.1. Alkaline Syenites	40
1.2.1.1. Initial natural remanent magnetization (NRM)	40
1.2.1.2. Isothermal remanent magnetization (IRM)	40
1.2.1.3. Demagnetization	42
1.2.1.4. Secondary and characteristic remanent magnetization	45
1.2.2. Quartz Syenites	50
1.2.2.1. Initial natural remanent magnetization (NRM)	50
1.2.2.2. Isothermal remanent magnetization (IRM)	50
1.2.2.3. Demagnetization	52
1.2.2.4. Secondary and characteristic remanent magnetization	54
1.2.3. Trachytes	58
1.2.3.1. Initial natural remanent magnetization (NRM)	58
1.2.3.2. Isothermal remanent magnetization (IRM)	59
1.2.3.3. Demagnetization	61
1.2.3.4. Secondary and characteristic remanent magnetization	62
1.2.4. Pink Granites	68

	<b>Page No.</b>
1.2.4.1. Initial natural remanent magnetization (NRM)	68
1.2.4.2. Isothermal remanent magnetization (IRM)	69
1.2.4.3. Demagnetization	69
1.2.4.4. Secondary and characteristic remanent magnetization	71
1.3. DISCUSSION AND INTERPRETATION	73
2. GRANODIORITES	79
2.1. FIELD OBSERVATIONS AND SAMPLING	79
2.2. RESULTS AND ANALYSES	80
2.2.1. Initial Natural Remanent Magnetization (NRM)	80
2.2.2. Isothermal Remanent Magnetization (IRM)	81
2.2.3. Demagnetization	82
2.2.4. Characteristic Remanent Magnetization (ChRM)	83
2.3. DISCUSSION AND INTERPRETATION	88
CHAPTER FOUR:	
MAGNETIC FABRIC	90
1. WADI DIB RING COMPLEX	90
1.1. MEASUREMENTS, RESULTS AND ANALYSES	90
1.1.1. Alkaline Syenites	90
1.1.2 Quartz Syenites	94
1.1.3. Trachytes	97
1.2. DISCUSSION AND INTERPRETATION	101
2. GRANODIORITES	104
2.1. MEASUREMENTS, RESULTS AND ANALYSES	104
2.2. DISCUSSION AND INTERPRETATION	108
SUMMARY AND CONCLUSIONS	109
REFERENCES	117
ARABIC SUMMARY	

## LIST OF FIGURES

Fig. No.		Page No.
(1)	Location map of Wadi Dib ring complex, Northern Eastern Desert, Egypt.	7
(2)	Types of ring complexes in the Eastern Desert of Egypt (Elramly et al., 1982)	9
(3)	Alkaline ring complexes and their ages in the Eastern Desert of Egypt (Elramly et al., 1971).	10
(4)	Distribution of Tectonic zones in the Eastern Desert of Egypt (Garson and Krs, 1976)	13
(5)	Alkaline Ring complex of Wadi Dib, Northern Eastern Desert, Egypt (Sabet et al., 1977).	14
(6)	JR-5A Spinner Magnetometer, Geofyzika Brno, Czech Republic, 1998.	28
(7)	A.F. Shielded Demagnetizer (MSA2), Molspin Ltd., UK 1998.	28
(8)	Thermal Demagnetizer (MMTD80), Magnetic Measurement Ltd, UK, 1998.	29
(9)	Pulse Magnetizer (MMPM9), Magnetic Measurement Ltd, UK, 1998.	29
(10)	The Minisip Susceptibility Meter, Molspin Ltd., UK, 1998.	37
(11)	Geological map showing the distribution of sampling sites from different rock types of Wadi Dib ring complex, Northern Eastern Desert, Egypt.	39
(12)	Equal-area stereographic projections of the initial NRM directions for ten sites from the alkaline syenites (AS) of Wadi Dib ring complex, Northern Eastern Desert, Egypt.	41
(13)	IRM acquisition behavior for a representative sample of the alkaline syenite (AS), Wadi Dib ring complex, Northern Eastern Desert, Egypt.	42
(14)	Progressive A.F. demagnetization diagrams for a pilot sample from site (AS.5) of the alkaline syenite (AS), Wadi Dib ring complex, Northern Eastern Desert, Egypt.	43
(15)	Progressive thermal demagnetization diagrams for a pilot sample from site (AS.3) of the alkaline (AS), Wadi Dib ring complex, Northern Eastern Desert, Egypt.	44
(16)	Equal-area stereographic projections of the secondary remanent magnetization (Component-B) directions for ten sites from the alkaline syenite (AS), Wadi Dib ring complex, Northern Eastern Desert, Egypt.	47

<b>Fig. No.</b>		<b>Page No.</b>
(17)	Equal-area stereographic projections of the ChRM (Component- <i>CI</i> ) directions for ten sites from the alkaline syenite (AS), Wadi Dib ring complex, Northern Eastern Desert, Egypt.	48
(18)	Equal-area stereographic projections of the site-mean for: a) Secondary remanent magnetization (component- <i>B</i> ) directions and b) ChRM directions (component- <i>CI</i> ) of the alkaline syenite (AS), Wadi Dib ring complex, Northern Eastern Desert, Egypt.	49
(19)	Lambert equal-area projection of the palaeomagnetic pole positions of the alkaline syenite (AS), Wadi Dib ring complex, Northern Eastern Desert, Egypt.	50
(20)	Equal-area stereographic projections of the initial NRM directions for twelve sites from the quartz syenite (QS) of Wadi Dib ring complex, Northern Eastern Desert, Egypt.	51
(21)	IRM acquisition behavior for a representative sample of the quartz syenite (QS), Wadi Dib ring complex, Northern Eastern Desert, Egypt.	52
(22)	Progressive A.F. demagnetization diagrams for a pilot sample from site (QS.1) of the quartz syenite (QS), Wadi Dib ring complex, Northern Eastern Desert, Egypt.	53
(23)	Progressive thermal demagnetization diagrams for a pilot sample from site (QS.1) of the quartz syenite (QS), Wadi Dib ring complex, Northern Eastern Desert, Egypt.	54
(24)	Equal-area stereographic projections of the ChRM (Component- <i>CI</i> ) directions for twelve sites from the Quartz syenite (QS), Wadi Dib ring complex, Northern Eastern Desert, Egypt.	56
(25)	Equal-area stereographic projections of the site-mean for the ChRM directions (component- <i>CI</i> ) of the Quartz syenite (QS), Wadi Dib ring complex, Northern Eastern Desert, Egypt.	57
(26)	Lambert equal-area projection of the palaeomagnetic pole position of the quartz syenite (QS), Wadi Dib ring complex, Northern Eastern Desert, Egypt.	57
(27)	Equal-area stereographic projections of the initial NRM directions for eleven sites from the trachytes (TR) of Wadi Dib ring complex, Northern Eastern Desert, Egypt.	58

<b>Fig. No.</b>		<b>Page No.</b>
(28)	IRM acquisition behavior for two representative samples from sites (TR.1) and (TR.2) respectively of the trachytes (TR), Wadi Dib ring complex, Northern Eastern Desert, Egypt.	60
(29)	IRM acquisition behavior for a representative sample from site (TR.11) of the trachytes (TR), Wadi Dib ring complex, Northern Eastern Desert, Egypt.	60
(30)	Progressive A.F. demagnetization diagrams for a pilot sample from site (TR.1) of the trachytes (TR), Wadi Dib ring complex, Northern Eastern Desert, Egypt.	63
(31)	Progressive A.F. demagnetization diagrams for pilot sample from site (TR.11) of the trachytes (TR), Wadi Dib ring complex, Northern Eastern Desert, Egypt.	63
(32)	Progressive thermal demagnetization diagrams for pilot sample from site (TR.2) of the trachytes (TR), Wadi Dib ring complex, Northern Eastern Desert, Egypt.	64
(33)	Progressive thermal demagnetization diagrams for pilot sample from site (TR.11) of the trachytes (TR), Wadi Dib ring complex, Northern Eastern Desert, Egypt.	64
(34)	Equal area stereographic projections of the ChRM directions for eleven sites from the trachytes (TR), Wadi Dib ring complex, Northern Eastern Desert, Egypt.	66
(35)	Equal area stereographic projections of the site-mean ChRM directions (component- <i>CI</i> & <i>CII</i> ) for the trachytes (TR), Wadi Dib ring complex, Northern Eastern Desert, Egypt.	67
(36)	Lambert equal-area projection of the palaeomagnetic pole position of the trachytes (TR), Wadi Dib ring complex, Northern Eastern Desert, Egypt.	67
(37)	Equal-area stereographic projections of the initial NRM directions for sites from the pink granites (GR), Wadi Dib ring complex, Northern Eastern Desert, Egypt.	68
(38)	IRM acquisition behavior for representative sample from pink granites (GR), Wadi Dib ring complex, Northern Eastern Desert, Egypt.	69
(39)	Progressive A.F. demagnetization diagrams for pilot sample from site (GR.1) of the pink granites (GR), Wadi Dib ring complex, Northern Eastern Desert, Egypt.	70

<b>Fig. No.</b>		<b>Page No.</b>
(40)	Progressive thermal demagnetization diagrams for pilot sample from site (GR.3) of the pink granites (GR), Wadi Dib ring complex, Northern Eastern Desert, Egypt.	71
(41)	Equal area stereographic projections of the ChRM directions for four sites from the pink granites (GR), W. Dib ring complex, Northern Eastern Desert, Egypt.	72
(42)	Equal area stereographic projections of the site-mean ChRM directions (component- <i>CIII</i> ) for the pink granites (GR), Wadi Dib ring complex, Northern Eastern Desert, Egypt.	72
(43)	Lambert equal-area projection of the palaeomagnetic pole position of the pink granites (GR), Wadi Dib ring complex, Northern Eastern Desert, Egypt.	73
(44)	Equal area stereographic projections of the site-mean secondary and ChRM directions for the different rock types of Wadi Dib ring complex, Northern Eastern Desert, Egypt.	74
(45)	Geological map showing the distribution of sampling sites for the granodiorites (GD) of Wadi Dib area, Northern Eastern Desert, Egypt.	79
(46)	Equal-area stereographic projections of the initial NRM directions for thirteen sites from the granodiorites (GD) of Wadi Dib area, Northern eastern Desert, Egypt.	80
(47)	IRM acquisition behavior and thermal demagnetization of IRM for representative samples of the granodiorites (GD) of Wadi Dib area, Northern Eastern Desert, Egypt.	82
(48)	Progressive A.F. demagnetization diagrams for a pilot sample from site (GD.8) of the granodiorites (GD), Wadi Dib area, Northern eastern Desert, Egypt.	84
(49)	Progressive A.F. demagnetization diagrams for a pilot sample from site (GD.11) of the granodiorites (GD), Wadi Dib area, Northern eastern Desert, Egypt.	84
(50)	Progressive thermal demagnetization diagrams for a pilot sample from site (GD.8) of the granodiorites (GD), Wadi Dib area, Northern eastern Desert, Egypt.	85

<b>Fig. No.</b>		<b>Page No.</b>
(51)	Progressive thermal demagnetization diagrams for pilot sample from site GD11 of the granodiorites (GD), Wadi Dib area, Northern eastern Desert, Egypt.	85
(52)	Equal-area stereographic projections of the ChRM directions for the thirteen sites from the granodiorites (GD) of Wadi Dib area, Northern eastern Desert, Egypt.	86
(53)	Equal-area stereographic projection of the site-mean ChRM directions for the granodiorites (GD) of Wadi Dib area, Northern eastern Desert, Egypt.	87
(54)	Lambert equal-area projection of the palaeomagnetic pole position of the granodiorites (GD) of Wadi Dib area, Northern eastern Desert, Egypt.	87
(55)	Relationships between: (a) Anisotropy degree ( $P_j$ ) and magnetic susceptibility ( $K$ ), (b) Foliation ( $P_3$ ) versus lineation ( $P_1$ ) and (c) anisotropy degree ( $P_j$ ) and ellipsoid shape ( $T$ ) of the alkaline syenites (AS), Wadi Dib ring complex, Northern Eastern Desert, Egypt.	92
(56)	Equal-area lower hemisphere stereographic projections of the principal susceptibility axes for sites from the alkaline syenites (AS) of Wadi Dib ring complex, Northern Eastern Desert, Egypt.	93
(57)	Equal-area lower hemisphere stereographic projections of site-mean of principal magnetic susceptibility axes for the alkaline syenites (AS) of Wadi Dib ring complex, Northern Eastern Desert, Egypt.	93
(58)	Relationships between (a) Anisotropy degree ( $P_j$ ) and magnetic susceptibility ( $K$ ), (b) Foliation ( $P_3$ ) versus lineation ( $P_1$ ) and (c) Anisotropy degree ( $P_j$ ) and ellipsoid shape ( $T$ ) of the quartz syenites (QS), Wadi Dib ring complex, Northern Eastern Desert, Egypt.	95
(59)	Equal-area lower hemisphere stereographic projections of site-mean of principal magnetic susceptibility axes for the quartz syenites (QS) of Wadi Dib ring complex, Northern Eastern Desert, Egypt.	96
(60)	Equal-area lower hemisphere stereographic projections of site-mean of principal magnetic susceptibility axes for the quartz syenites (QS) of Wadi Dib ring complex, Northern Eastern Desert, Egypt.	96

<b>Fig. No.</b>		<b>Page No.</b>
(61)	Relationships between (a) Anisotropy degree ( $P_j$ ) and magnetic susceptibility ( $K$ ), (b) Foliation ( $P_3$ ) versus lineation ( $P_1$ ) and (c) Anisotropy degree ( $P_j$ ) and ellipsoid shape ( $T$ ) of the trachytes (TR), Wadi Dib ring complex, Northern Eastern Desert, Egypt.	99
(62)	Equal-area lower hemisphere stereographic projections of site-mean of principal magnetic susceptibility axes for the trachytes (TR) of Wadi Dib ring complex, Northern Eastern Desert, Egypt.	100
(63)	Equal-area lower hemisphere stereographic projections of site-mean of principal magnetic susceptibility axes for the trachytes (TR) of Wadi Dib ring complex, Northern Eastern Desert, Egypt.	100
(64)	Relationships between: (a) Anisotropy degree ( $P_j$ ) and magnetic susceptibility ( $K$ ), (b) Foliation ( $P_3$ ) versus lineation ( $P_1$ ) and (c) Anisotropy degree ( $P_j$ ) and ellipsoid shape ( $T$ ) of the granodiorites (GD), Wadi Dib area, Northern Eastern Desert, Egypt.	106
(65)	Equal-area lower hemisphere stereographic projections of the principal susceptibility axes for sites from the granodiorites (GD) of Wadi Dib area, Northern Eastern Desert, Egypt.	107
(66)	Equal-area lower hemisphere stereographic projections of site-mean of principal magnetic susceptibility axes for the granodiorites (GD) of Wadi Dib area, Northern Eastern Desert, Egypt.	107

## LIST OF TABLES

Table No.		Page No.
(1)	Site-mean initial NRM data for ten sites from the alkaline syenite (AS), Wadi Dib ring complex, Northern Eastern Desert, Egypt.	41
(2)	Site-mean secondary remanent magnetization (Component- <i>B</i> ) directions and their corresponding VGPs for ten sites from the alkaline syenite (AS), Wadi Dib ring complex, Northern Eastern Desert, Egypt.	47
(3)	Site-mean ChRM (Component- <i>CI</i> ) directions and their corresponding VGPs for ten sites from the alkaline syenite (AS), Wadi Dib ring complex, Northern Eastern Desert, Egypt.	48
(4)	Secondary and ChRM directions with the corresponding palaeomagnetic poles for the alkaline syenite (AS), Wadi Dib ring complex, Northern Eastern Desert, Egypt.	49
(5)	Site-mean initial NRM data for twelve sites from the quartz syenite (QS), Wadi Dib ring complex, Northern Eastern Desert, Egypt.	51
(6)	Site-mean ChRM (Component- <i>CI</i> ) directions and their corresponding VGPs for twelve sites from the quartz syenite (QS), Wadi Dib ring complex, Northern Eastern Desert, Egypt.	56
(7)	ChRM directions with the corresponding palaeomagnetic poles for the quartz syenite (QS), Wadi Dib ring complex, Northern Eastern Desert, Egypt.	57
(8)	Site-mean initial NRM data for eleven sites from the trachytes (TR), Wadi Dib ring complex, Northern Eastern Desert, Egypt.	59
(9)	Site-mean ChRM directions and corresponding VGPs for eleven sites from the trachytes (TR), Wadi Dib ring complex, Northern Eastern Desert, Egypt.	66
(10)	ChRM directions with the corresponding palaeomagnetic poles for the trachytes (TR), Wadi Dib ring complex, Northern Eastern Desert, Egypt.	67
(11)	Site-mean initial NRM data for the pink granites (GR), Wadi Dib ring complex, Northern Eastern Desert, Egypt.	68
(12)	Site-mean ChRM data and virtual geomagnetic poles (VGP) for the pink granites (GR), Wadi Dib ring complex, Northern Eastern Desert, Egypt.	72

<b>Table No.</b>		<b>Page No.</b>
(13)	Rock mean directions and Palaeomagnetic poles of secondary and ChRM components for the four rock units of Wadi Dib ring complex, Northern Eastern Desert, Egypt.	75
(14)	Site-mean initial NRM data for the thirteen sites from the granodiorites (GD), Wadi Dib area, Northern Eastern Desert, Egypt.	81
(15)	Site-mean ChRM data and virtual geomagnetic poles (VGP) for the thirteen sites from the granodiorites (GD) of Wadi Dib ring area, Northern eastern Desert, Egypt.	86
(16)	Characteristic remanent magnetization (ChRM) direction and Palaeomagnetic pole for the granodiorites (GD), Wadi Dib area, Northern eastern Desert, Egypt.	87
(17)	Representative Precambrian-Lower Cambrian Palaeomagnetic poles from Africa	89
(18)	Site-mean magnetic susceptibility and AMS data for the alkaline syenites (AS) of Wadi Dib ring complex, Northern Eastern Desert, Egypt.	91
(19)	Site-mean magnetic susceptibility and AMS data for the quartz syenites (QS) of Wadi Dib ring complex, Northern Eastern Desert, Egypt.	95
(20)	Site-mean magnetic susceptibility and AMS data for the trachytes (TR) of Wadi Dib ring complex, Northern Eastern Desert, Egypt.	98
(21)	Site-mean magnetic susceptibility and AMS data for the granodiorites (GD) of Wadi Dib area, Northern Eastern Desert, Egypt.	105