

AIN SHAMS UNIVERSITY
FACULTY OF SCIENCE
GEOPHYSICS DEPARTMENT

**STRUCTURAL, LITHOLOGICAL AND METALLOGENIC CONTRIBUTION
TO THE WADI ATALLA - WADI ABU - ZIRAN AREA, CENTRAL
EASTERN DESERT, EGYPT, USING AEROSPECTROMETRIC
AND AEROMAGNETIC SURVEY DATA**

A THESIS SUBMITTED TO THE GEOPHYSICS DEPARTMENT,
FACULTY OF SCIENCE, AIN SHAMS UNIVERSITY FOR
THE DEGREE OF DOCTOR OF PHILOSOPHY
IN APPLIED GEOPHYSICS

BY
MAGDY ABDELLATIF AFIFI GOUDA
*Geophysicist, Nuclear Materials Authority,
Cairo, Egypt*



553

M. A

Supervised by
Prof. Dr. Nasser M. Abu-Ashour
Head of Geophysics Department,
Faculty of Science,
Ain Shams University

Prof. Dr. Ahmed A. Ammar
Prof. of Applied Geophysics,
Exploration Division
Nuclear Materials Authority,
Cairo, Egypt

Prof. Dr. Said I. Rabie
Prof. of Applied Geophysics,
Exploration Division
Nuclear Materials Authority,
Cairo, Egypt

1998





**THIS WORK IS DEDICATED
TO
THE MEMORY OF MY BELOVED BROTHER,
THE LATE DR. *MOHAMED ABDELLATIF GOUDA*,
PROF. OF MECHANICAL ENGINEERING,
FACULTY OF ENGINEERING, CAIRO UNIVERSITY
GIZA, EGYPT.**

LIST OF CONTENTS

Contents	Page
	No.
LIST OF CONTENTS	i
LIST OF TABLES	viii
LIST OF FIGURES	x
ACKNOWLEDGEMENTS	xix
ABSTRACT	xx
 CHAPTER I	
INTRODUCTION	
I.1- Location	1
I.2- Relief and Topography	1
I.3- Geomorphology	4
I.4- Objectives of The Study	4
I.5- Previous Work	7
A- Previous geological work	7
B- Previous geophysical work	13
 CHAPTER II	
GEOLOGICAL OUTLINE	
II.1- General	18
II.2- Lithostratigraphical Sequence	18
II.2.1- Precambrian Basement Rocks	21
A- First Basement (Geosynclinal) Sediments	21
A.a. Gneisses and migmatites	21
A.b. Metamudstones	21
B- First Basement (Main Geosynclinal) Volcanics	22
B.a. Shadli Metavolcanics	22
B.b. Serpentinites	22
C- Second Basement (Synorogenic) Plutonites	23

	Page No.
C.a. Granodiorites	23
C.b. Metagabbro-diorite complex	24
D- Second Basement (Emerging Geosynclinal) Volcanics	24
E- Second Basement (Postgeosynclinal) Sediments	24
F- Third Basement (Late Orogenic) Plutonites and Related Rocks ...	25
F.a. Post-Hammamat Felsites	25
F.b. Gabbros	26
F.c. Granites	26
G- Paleozoic Volcanicity (Postorogenic Volcanics)	27
II.2.2- Phanerozoic Cover (Foreland) Sediments.	28
A- Third Detrital (Early Cretaceous) Sediments (Nubian Sandstones and Shales)	28
B- Fourth Calcareous (Late Cretaceous-Middle Eocene) sediments ..	28
C- Fifth Detrital-Calcareous-Evaporite Sediments	28
II.3- Recent Egyptian Basement Classifications in Terms of Plate Tectonic Theory	29
II.4- Tectonic History	32

CHAPTER III

AEROSPECTROMETRIC SURVEY, METHODS AND TECHNIQUES OF INTERPRETATION

III.1- General	34
III.2- Aerial Gamma-Ray Spectrometric Survey	34
III.2.1- Theoretical Considerations	34
III.2.2- Distribution of Radioelements in Bedrocks	37
III.2.3- Data Acquisition	40
III.2.4- Sources of Error and Data Reduction	42
(A) Background correction	42
(B) Stripping correction	43
(C) Altitude correction	44
(D) The conversion of the corrected data to ground concentrations ..	44

	Page No.
III.2.5- Organization of Data For Natural Radioelement Mapping	46
III.2.6- Instrumentation	46
(A) Gamma-ray spectrometer	46
A.a- Detector package	46
A.b- Detector interface	48
A.c- Analog-to-digital converter	48
A.d- Analog recording	48
A.e- Temperature sensor	48
(B) Radar altimeter	50
(C) Barometric altimeter	50
(D) Voltage-to-frequency converter	50
(E) Path recovery camera	50
(F) Doppler navigation system	50
F.a- Doppler-radar	50
F.b- Sperry "C-12" magnetically-slaved gyrocompass system	50
F.c- Multi-channel synchro-to-digital converter system	50
F.d- Doppler guidance unit (DGU)	51
III.3- Aerospectrometric Methods and Techniques /	51
III.3.1- General	51
III.3.2- Factor Analysis	52
A- Common	52
B- Procedure	55
B.a- Computation of correlation matrix	55
B.b- Factor extraction	56
B.c- Rotation of the extracted factors	57
B.d- Interpretation of rotated factor matrix	58
C- Fundamental equations	58
D- Data processing	60
III.3.3- Remobilization of Uranium	61
III.3.4- Calculation of Uranium Favourability Index	63

	Page No.
III.3.5- Identification and Outlining Radiospectrometric Anomalies . . .	64
A- Common	64
B- Interpretation problems	65
B.a- Factor affecting the statistical processing	65
B.b- Meteorological or erosional effects	66
B.c- Errors in lithological mapping	66
C- Methods and techniques	67
C.a- Significance factor	67
C.a.1- Geochemical nature of radiometric data	67
C.a.2- Statistical method of anomaly detection	67
C.a.3- Data analysis	69
C.b- Examination of stacked profiles	70

CHAPTER IV

AEROMAGNETOMETRIC SURVEY, METHODS AND TECHNIQUES OF INTERPRETATION

IV.1- Airborne Magnetic Survey	72
IV.1.1- Theoretical Considerations	72
IV.1.2- Airborne Magnetometer	72
IV.1.3- Reduction of Aeromagnetic data	73
(A) Acquisition system errors	74
(B) Diurnal correction	74
(C) Normal correction	75
IV.1.4- Magnetic Data Processing	75
IV.2- Aeromagnetometric Methods and Techniques	76
IV.2.1- General	76
IV.2.2- Reduction To The North Magnetic Pole (RTP)	76
A- Theoretical considerations	76
B- Principles of calculation of the RTP coefficients	77
IV.2.3- Calculation of Power Spectrum For Interface Determination	80
A- Common	80

	Page No.
B- Mathematical statements	82
IV.2.4- Regional-Residual Separation (Filtering)	85
A- Common	85
B- Filtering combined with analytical downward continuation	85
IV.2.5- Normalized Total Vector (Gradient) of The Field Intensity	87
IV.2.6- Normalized Horizontal Vector (Gradient) of The Field intensity	89
IV.2.7- Phase Angle Calculations For The Aeromagnetic Data.	90
IV.2.8- Statistical Trend Analysis	92
A- General	92
B- Autocovariance function technique	94
C- The successive overlap technique.	96

CHAPTER V

INTERPRETATION OF AERIAL GAMMA-RAY RADIOSPECTROMETRIC SURVEY DATA

V.1- General	98
V.2- Qualitative Interpretation	99
V.2.1- Common	99
V.2.2- Relation of Aeroradiospectrometric Data To Lithology	101
V.2.3- Consequences and Inferences	113
V.3- Quantitative Interpretation	114
V.3.1- Common	114
V.3.2- Discussion of The Results of Application of Factor Analysis	115
V.3.3- Descriptive statistical Characteristics	132
V.3.4- The Degree of Remobilization of Uranium	142
V.3.5- Discussion of The Results of Calculation of Uranium Favourability Index	149
V.3.6- Identification And Outlining Radiospectrometric Provinces	151
A- General	151
B- Discussion of the interpreted eU and eTh anomalies	152

	Page No.
C- Impact of topography, surface faulting and interpreted aeromagnetic lineaments on the evaluation and spatial distribution of the identified radiospectrometric anomalies . . .	176
CHAPTER VI	
INTERPRETATION OF AERIAL MAGNETOMETRIC SURVEY DATA	
VI.1- General	181
VI.2- Qualitative Interpretation	183
VI 2.1- Common	183
VI.2.2- Discussion and Description of Aeromagnetic Maps	185
VI.2.3- Reduction-To- Pole (RTP) Aeromagnetic Map	189
A- Magnetic zone No.I	189
B- Magnetic zone No.II	190
C- Magnetic zone No.III	192
D- Magnetic zone No.IV	192
E- Magnetic zone No.V	193
VI.2.4-Filtered Regional and Residual Aeromagnetic-Component Maps	
A- Regional magnetic-component maps	194
B- Residual magnetic-component maps	195
VI.2.5- Normalized Total and Horizontal Magnetic Vector (Gradient) Maps	199
VI.2.6- Normalized Total and Horizontal Magnetic Phase Angle Maps	
VI.3- Quantitative Interpretation	200
VI.3.1- Common	204
VI.3.2- Interpreted RTP Aeromagnetic Map	204
VI.3.3- Discussion of The Results of Power Spectrum Analysis	204
VI.3.4- Discussion of The Results of Filtering of Aeromagnetic Anomalies	213

	Page No.
VI.3.5- Discussion of The Normalized Total and Horizontal Magnetic Vector (Gradient) Maps	217
VI.3.6- Discussion of The Total and Horizontal Magnetic Phase Angle Maps	218
VI.3.7- Magnetic Trend Analysis	218
VI.3.8- Basement Structural Mapping	219
A- General	219
B- Discussion	221
C- Structural trend analysis	228
 CHAPTER VII	
RESULTS OF STATISTICAL TREND ANALYSIS	
VII.1- Discussion of The Various Trend Directions	231
VII.1.1- Common	231
VII.1.2- General Argument	241
1- N-S (Meridional or East African) trend	241
2- NNW (Atalla) trend	242
3- NW (Gulf of Suez-Red Sea, Clysmic or Erythrean) trend	243
4- WNW (Najd) trend	245
5- E-W (Tethyan or Mediterranean) trend	245
6- ENE (Syrian arc or Qattara) trend	246
7- NE (Trans-African, Aualitic or Qena-Safaga) trend	248
8- NNE (Gulf of Aqaba or Dead Sea) trend	249
VII.1.3- General Outcome	249
 SUMMARY AND CONCLUSIONS	
A- Aeroradiospectrometric Interpretation	254
B- Aeromagnetic Interpretation	258
C- Statistical Trend Analysis	260
REFERENCES	262
ARABIC SUMMARY	

LIST OF TABLES

Table No.		Page No.
1	Chronological and lithostratigraphical sequence of the major rock groups exposed in W. Atalla-W.Abu-Ziran area, Central Eastern Desert, Egypt	19
2	Standard windows for natural radioelement mapping (IAEA, 1991)	35
3	Radioelement concentrations in different classes of crustal rock (after Killeen, 1979)	39
4	Matrix of correlation coefficients of the airborne radio-spectrometric survey data (T.C., eU, eTh, and K) and their ratios (eU/eTh, eU/K and eTh/K), W. Atalla-W. Abu-Ziran area, Central Eastern Desert, Egypt	116
5	Unrotated factor loadings matrix for the seven-variables (T.C., eU, eTh, K, eU/eTh, eU/K and eTh/K), W. Atalla-W. Abu-Ziran area, Central Eastern Desert, Egypt	119
6	Varimax rotated factor loadings matrix for the 7-variables, W. Atalla-W. Abu-Ziran area, Central Eastern Desert, Egypt ..	122
7	Standard factor scores (multiplied by 100) characterizing the various rock units, W. Atalla-W. Abu-Ziran area, Central Eastern Desert, Egypt	128
8	Computed T.C.-statistical characteristics of the different IRL units and the results of application of the Chi-square test (χ^2 -test), W. Atalla- W. Abu-Ziran area, Central Eastern Desert, Egypt	134
9	Computed K-statistical characteristics of the different IRL units and the results of application of the Chi-square test (χ^2 -test), W. Atalla- W. Abu-Ziran area, Central Eastern Desert, Egypt	136
10	Computed eU-statistical characteristics of the different IRL units and the results of application of the Chi-square test (χ^2 -test), W. Atalla- W. Abu-Ziran area, Central Eastern Desert, Egypt	138

Table No.		Page No.
11	Computed eTh-statistical characteristics of the different IRL units and the results of application of the Chi-square test (χ^2 -test), W. Atalla- W. Abu-Ziran area, Central Eastern Desert, Egypt	140
12	Maximum amplitudes (absolute and ratios) of the airborne radio- spectrometric (U and Th) anomalies as well as their geologic environment, W. Atalla-W. Abu-Ziran area, Central Eastern Desert, Egypt	173
13	Summary of the trend directions as interpreted from the various geologic, topographic, aerospectrometric and aeromagnetic data, W. Atalla-W. Abu-Ziran area, Central Eastern Desert, Egypt	251

LIST OF FIGURES

Fig. No.		Page No.
1	Map of Egypt showing the location of W. Atalla-W. Abu Ziran area, Central Eastern Desert, Egypt	2
2	Topographical map of W. Atalla-W. Abu-Ziran area, Central Eastern Desert, Egypt	3
3	Elevation contour map, W. Atalla-W. Abu-Ziran area, Central Eastern Desert, Egypt	5
4	Compiled geological map of W. Atalla-W. Abu-Ziran area, Central Eastern Desert, Egypt	20
5	Typical gamma-ray spectrum recorded at a survey altitude of 120 metres (after Grasty, 1987)	36
6	Variation in average K, U and Th contents with increasing Si content, from ultrabasic to acid igneous rocks (afetr Galbraith and Saunders, 1983, Ford and Garson, 1986)	38
7	Variation in average radioelement ratios with increasing Si content, from ultrabasic to acid igneous rocks (after Damley and Ford, 1989).	38
8	Index map showing the airborne gamma-ray spectrometric and magnetic surveys conducted by Aero Service, 1984, in relation to W. Atalla-W. Abu-Ziran area, Central Eastern Desert, Egypt	41
9	Block diagram showing the main components of the airborne 256-channel gamma-ray spectrometer system (after Bristow, 1979)	47
10	A schematic diagram showing the configuration of the downward-looking NaI (Tl) detectors and the upward-looking lead-shielded NaI (Tl) detectors of the 256-channel gamma- ray spectrometer system (after Grasty et al., 1988)	49
11	Change of rms with different odd numbers of rows of northern coefficients at a constant number of rows of southern coefficients (29) at various magnetic inclinations (after Fouad et al., 1987)	79