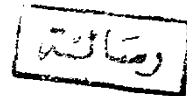


**GEOLOGICAL, STRUCTURAL AND GEOCHEMICAL
STUDIES ON THE PAN-AFRICAN BASEMENT
ROCKS, WADI ZEIDUN, CENTRAL EASTERN
DESERT, EGYPT**

A THESIS

*SUBMITTED TO
DEPARTMENT OF GEOLOGY
FACULTY OF SCIENCE
AIN SHAMS UNIVERSITY*



**BY
ALI FARRAG SAYED OSMAN
B.Sc., M.Sc. (GEOLOGY)**

FOR

**THE DEGREE OF DOCTOR
OF PHILOSOPHY IN
GEOLOGY**



1994

47.986

5 51.382
A.f

اسم الطالب : على فراج سيد عثمان

الدرجة العلمية : دكتوراه فى العلوم (الجيولوجيا)

القسم التابع له : الجيولوجيا

اسم الكلية : العلوم

الجامعة : عين شمس

سنة التخرج : 1981

سنة المنح : 1994



رسالة دكتوراة

اسم الطالب: على فراج سيد عثمان

عنوان الرسالة : 'دراسات جيولوجية و تركيبية و جيوكيميائية على صخور القاعدة , البان
لفريكان , بواى زيدون - وسط الصحراء الشرقية - مصر'

اسم الدرجة : دكتوراة فى العلوم " جيولوجيا "

لجنة الاشراف

- 1- الاستاذ الدكتور محمد عز الدين حلمى
- 2- الاستاذ الدكتور ر. و . جرينج
- 3- الاستاذ محمود فوزى الرملى
- 4- الاستاذ الدكتور عبد الغنى رجب

تاريخ البحث : ١١٤ / ١٩٨٧

لجنة الممتحنين

- 1- الاستاذ الدكتور محمد عبد الحميد الشرقاوى (جامعة القاهرة)
- 2- الاستاذ الدكتور عبد العزيز عبد القادر حسين (هيئة المساحة الجيولوجية)
- 3- الاستاذ الدكتور عبد الغنى ابراهيم رجب (استاذ بالكلية)
- 4- الاستاذ الدكتور محمود فوزى الرملى (استاذ غير متفرغ بالكلية)

لدراسات العليا

اجيزت الرسالة بتاريخ ١٨ / ١٢ / ١٩٩١

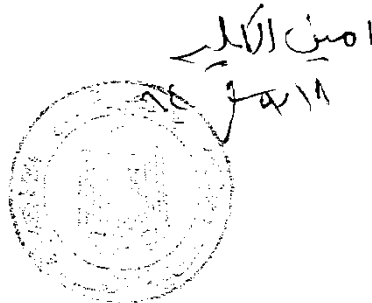
ختم الاجازة :

موافقة مجلس الجامعة

موافقة مجلس الكلية

19 ١١

١٩٩١ ٩١١٥



إمضاء
رئيس

شكر

اشكر السادة الاساتذة الذين قاموا بالاشراف و هم :

- 1) - الاستاذ الدكتور محمد عز الدين حلمي
- (- الاستاذ الدكتور ر. و . جرينج
- (- الاستاذ محمود فوزي الرملي
- (- الاستاذ الدكتور عبد القى رجب

ثم الاشخاص الذين تعاونوا معى فى البحث و هم :

- 1) - الدكتور باهر عبد الحميد القليوبى
- (- الدكتور رسمى اسماعيل الغرباوى

و كذلك الهيئات :

- (- معهد الجيولوجيا - جامعة هايدلبرج - المانيا الغربية
- (- الهيئة الالمانية للتبادل العلمى (DAAD)

CONTENTS

	<u>Page</u>
ACKNOWLEDGEMENTS	viii
ABSTRACT	x
CHAPTER 1: INTRODUCTION	1
1.1 General Statement.....	1
1.2 Location	2
1.3 Accessibility	2
1.4 Physiography and Climate	4
1.5 Previous Work - General	4
1.5.1 Previous Work on the Study Area and Environs ...	6
1.6 Objective and Scope of the Present Work	16
CHAPTER 2: GEOLOGIC SETTING	18
Introduction	18
2.1 Island - Arc Assemblage	19
2.1.1 The Metavolcanics	19
2.1.1.1 Basic metavolcanics	20
2.1.1.2 Intermediate metavolcanics	20
2.1.1.3 Acidic metavolcanics	23
2.1.2 The Volcaniclastic Rocks	23
2.1.2.1 Wadi Arak volcaniclastics	24
2.1.2.2 Volcanic breccia and Hyaloclastite	27
2.1.3 Banded Thinly Laminated Tuffs and Agglomerates ...	29
2.1.4 Arc - Granitoids	31
2.2 The Volcanogenic Metasedimentary Rocks	34
2.2.1 The Green Metaconglomerates	38
2.2.2 Pebbly Metamudstones	38
2.2.3 Metamudstones and Metasiltstones	40
2.2.4 The Grey Phyllites and Slates	40
2.2.5 Metagreywackes	42
2.2.6 Chlorite - Biotite - Epidote Schist	42
2.3 Molasse - Type Sediments (Hammamat Group)	42
2.3.1 Wadi Zeidun East and Wadi Meesar	
Molasse Basins	44
2.3.1.1 Wadi Zeidun basin	44
2.3.1.1 Wadi Meesar basin	47
2.3.2 Wadi Zeidun West Basin	50
2.3.3 Conglomerates	51
2.3.3.1 Basal conglomerate	51
2.3.3.2 Massive conglomerate	53

	Page
2.3.3.3 Graded and bedded conglomerate	55
2.3.4 Sandstones	55
2.3.5 Siltstones	57
2.4 Late - Collision Granites	60
2.4.1 El Shalul Pluton	60
2.4.2 El Hassanawia Pluton	64
2.4.2.1 Pink and porphyritic coarse grained granites	64
2.4.2.2 Buff, equigranular granites	67
2.4.3 Felsite and Microgranite Minor Intrusions	67
2.5 Dikes and Veins	67
CHAPTER 3 : PETROGRAPHY	70
3.1 Island - Arc Assemblage	70
3.1.1 The Metavolcanics	70
3.1.1.1 Metabasalt	70
3.1.1.2 Basaltic meta-andesite	73
3.1.1.3 Meta-andesite	77
3.1.2 The Volcaniclastic Rocks	77
3.1.2.1 Fine metatuffs	79
3.1.2.2 Lapilli metatuffs	79
3.1.2.3 Volcanic breccia	84
3.1.2.4 The banded iron oxide	84
3.1.2.5 Banded, laminated siliceous metatuffs	86
3.1.3 Arc - Granitoids	86
3.2 The Volcanogenic Metasedimentary Rocks	92
3.2.1 Metamudstone and Metasiltstone	92
3.2.2 Slate	92
3.2.3 Phyllite	93
3.2.3.1 Quartz phyllite	93
3.2.3.2 Calcareous phyllite	93
3.2.3.4 Chlorite phyllite	97
3.2.3.5 Biotite - chlorite phyllite	97
3.2.4 Metagreywacke	97
3.2.4.1 Bedded metagreywacke	99
3.2.4.2 Foliated metagreywacke	99
3.2.4.3 Biotite-chlorite-epidote schist	101
3.2.5 Metaconglomerate	101
3.3 Molasse - Type Sediments (Hammamat Group)	104
3.3.1 Conglomerate	106

	Page
3.3.1.1 Purple and green conglomerates	106
3.3.1.2 Pebbles forming the conglomerates	106
3.3.2 Sandstone	113
3.3.2.1 Lithic arenites (subgreywackes)	113
3.3.2.2 Arkose	115
3.3.2.3 Feldspathic lithic arenites	115
3.3.2.4 Ferruginous arenites	115
3.3.3 Siltstone	115
3.3.4 Modal Composition and Provenance	118
3.3.4.1 Molasse sandstone	118
3.3.4.2 Volcanogenic sandstone	119
3.4 Late - Collision Granites and Felsites	122
3.4.1 El Shalul Pluton	122
3.4.1.1 Foliated, cataclastic granite	122
3.4.1.2 Pink alkali feldspar granite	124
3.4.2 El Hassanawia Pluton	124
3.4.2.1 Pink coarse grained granite	124
3.4.2.2 Porphyritic alkali feldspar granite	125
3.4.2.3 Buff medium grained granite	127
3.4.3 Porphyritic Microgranite and Felsite	129
3.4.4 Modal Analysis of the Granites	129
3.5 Dikes	131
CHAPTER 4: METAMORPHISM	136
4.1 Illite "Crystallinity" and Metamorphism	136
Introduction	136
4.1.1 Results and Discussion	139
4.2 Mineral Assemblage and Metamorphism	145
CHAPTER 5: GEOCHEMISTRY	147
Introduction	147
5.1 Geochemistry of the Metavolcanic Rocks	148
Generalities	148
5.1.1 Chemical Classification of the Studied Metavolcanics and Comparison with Other Metavolcanic Suites	152
5.1.2 Petrochemical Characteristics	155
5.1.3 Magma Type and Tectonic Setting	157
5.2 Geochemistry of the Volcanogenic Metasediments	167

	Page
5.3 Geochemistry of the Granitoid Rocks	170
5.3.1 Geochemistry of Wadi Maasar Granitoids and the Pink Granites	172
5.3.1.1 Magma characteristics and variation diagrams	176
5.3.1.2 Classification of the granitic rocks and tectonic environments	181
5.4 Geochemistry of the Granitic Pebbles Forming the Conglomerates	188
5.4.1 Petrochemical Characteristics	190
5.4.2 Classification and Tectonic Environments of the Granitic Pebbles	191
CHAPTER 6: STRUCTURE	194
6.1 Previous Work and Tectonic Context	194
6.2 Present Structural Studies and Evolution	195
6.2.2 Bedding (S°)	197
6.2.3 Foliation	197
6.2.3 Lineation	200
6.2.3.1 Pencil structure	200
6.2.3.2 Pebble elongation lineation	200
6.2.3.3 Mineral lineation	205
6.2.3.4 Fold axes	205
6.2.4 Faults	205
6.2.5 Folds	214
6.2.6 Shearing and Microstructures.....	218
6.2.6.1 Sense of shear	218
6.3 Strain Analysis of the Volcanogenic Metasediments and Molasse Sediments	225
6.3.1 Flinn Diagrams and Stereonet Projection	229
6.3.1.1 Concept and measurements	229
6.3.1.2 Results and discussion	230
6.3.2 Strain Analysis Using Rf/Phi Technique	232
DISCUSSION AND CONCLUSIONS	239
REFERENCES	250
ARABIC SUMMARY	At end

ILLUSTRATIONS

Fig. No.		Page
1	Location of the studied area on a simplified geologic map of the Eastern Desert of Egypt. Data compiled from the Geological map of Egypt (1981) and Ragab et al.(1994)...	3
2	Simplified geological map of the Central Eastern Desert of Egypt. (after El Ramly, 1972)	7
3	Fig. 3: Geologic map of the study area as shown on the geological map of Wadi Al Barramiyah quadrangle, Egypt (Geological Survey of Egypt, 1992)	10
4	Geological and Structural Map of Wadi Zeidun and Two Geologic Cross Sections in pocket	
5-52	Photographs taken in the field illustrating various geologic features	21-68
53-104	Photomicrographs illustrating mineral assemblages, textures and structures of the Island-arc assemblage and the volcanogenic metasediments	72-120
105	Plots of the detrital modes of the molasse sandstone on the QFL diagram after Dickinson et al. (1983)	120
106-113	Photomicrographs illustrating mineral assemblages, textures and structures of the Late - collision granites and felsites	123-132
114	Plots of the modal composition of the granitoids in the study area, on the Q-A-P ternary diagram of Streckeisen (1976)	132
115	Photomicrograph of a camptonite dyke showing elongated, prismatic and rhombic cross sections of brown hornblende, altered feldspar, chlorite and opaques	135
116	The principal changes of illite during diagenesis and low-grade metamorphism, after De Segonzac (1970)	137
117	Metamorphic map of Wadi Zeidun area, based on illite and chlorite "crystallinity". The boundary limits are based on those of Kish (1980)	140
118-120	X-ray diffraction patterns showing the 10 Å illite (Il) and 14 Å chlorite peak (Ch) in the volcanogenic meta-sediments, laminated tuffs and molasse sediments	141-143

Fig. No.		Page
121	Diagram showing the relationships between illite crystallinity(IC) and chlorite crystallinity (ChC) for the different types of sediments	144
122-148	Variation diagrams illustrating the relationships between the different chemical components and the calculated parameters for the studied rocks	154-192
149	Structural map of the Pan - African basement in the central part of the Eastern Desert of Egypt, after Greiling et al. (1993)	196
150	Equal area, lower hemisphere projection, A - Bedding (SO) in the molasse sediments, NE basin. B - Foliation in the volcanogenic metasediments in El Shalul area	198
151-180	Photographs taken in the field illustrating various geologic structures for the different rock units beside a Rose diagram showing fault trends in the study area .	199-220
181-189	Photomicrographs illustrating the microstructures and shearing criteria in some studied rock units	222-228
190-191	Various diagrams showing the Flinn plots and stereonet for the different structural data points of the volcanogenic metasediments and molasse sediments . . .	231-233
192	Effect of deformation on a series of elliptical objects with initial orientation ϕ and ellipticity Ri. Diagram after Ramsay and Huber (1987)	235
193-194	Various Rf/Phi diagrams showing the strain analysis of the volcanogenic metasediments and molasse sediments .	236-237
195	Diagrammatic cross-section of an arc system showing major components and sediment basins, after Condie (1982)	240

Tables

<u>Table No.</u>	<u>Page</u>
1	Results of point count analyses (%) of the molasse sandstones and volcanogenic metagreywackes 121
2	Modal analyses of the studied granitoids 123
3	Major oxides and trace element contents of the studied metavolcanics 150
4	Major oxide contents of the Younger metavolcanics (Stern, 1981) and the metavolcanics north of Gabal Abu El-Tiyur (El Alfy, 1992) 151
5	CIPW normative minerals of the analysed metavolcanics . . 153
6	Major oxides and trace element contents of the studied volcanogenic metasediments 168
7	Major oxides (wt %) and trace element contents of the felsites and granitoid rocks 173
8	CIPW normative minerals of the studied granitoids 174
9	Major oxides (wt %) and trace element contents of the studied granitic pebbles 175
10	CIPW normative minerals of the studied granitic pebbles 175
11	Compilation of magmatic activity, sedimentation and the deformational phases in the study area 248

ACKNOWLEDGEMENTS

The present work has been carried out through a Scientific Channel Program between Ain Shams University and the University of Heidelberg, whereby part of it was carried out at the Institute of Geology and Palaeontology of this University during the period from February 1991 till March 1993.

The author is greatly indebted to Prof.Dr. W.M. Abdel Malek, Chairman of the Geology Department, Ain Shams University and his colleagues in the same department for the many facilities provided while carrying out this work.

The author wishes to express his sincere thanks to the eminent scientists who supervised this work namely; Professor. Dr. M. Ezzeldin Hilmy, Professor of Mineralogy, Faculty of Science, Ain Shams University, for recommending my name to the German authorities to obtain a grant of study in Heidelberg University according to the Scientific Channel Program, his continuous advice, valuable suggestions and critical reading of the manuscript; Professor. M.F. El Ramly, Emeritus Professor of Geology, Faculty of Science, Ain Shams University and former Chairman of the Egyptian Geological Survey for suggesting the present point of study, fruitful discussions, continuous help during the progress of work and his critical reading and revision of the manuscript; Prof. Dr. R.O. Greiling, Professor of Structural Geology, Heidelberg University for his unfailing help to the author while visiting the area of study; to formulate its tectonic evolution, supervision of this work and his thorough reading of the chapter dealing with the structural setup of the area, and last but not the least Professor. Dr. Abdel Ghani I. Ragab, Professor of Petrology, Faculty of Sceince, Ain Shams University for his supervision of this work, sincere help, guidance in the field and fruitful discussions during the progress of work, comments and reading the manuscript.

Cordial thanks are also due to Dr.B.A. El Kalioubi, Assistant Professor, Geology Department, Ain Shams University (Now Lecturer at the Geology Department, Faculty of Science, Qatar University) for guiding the author to the area of study before leaving for Qatar in 1989 and valuable suggestions during his short visits to Egypt.

The writer wishes to thank Dr.R.I. El Gharabawi, Lecturer, Department of Geology, Faculty of Science, Ain Shams University for his help and advice during the different stages of this work.

The author would like to express his appreciation and sincere thanks to the Staff Members, Secretaries and Assistants in the Geological and Palaeontological Institute, the University of Heidelberg for their kind help and the assistance they offered while being in Germany.

Thanks are also rendered to Mr. Dorfner, Institute of Mineralogy and Petrography, Munchen University, Germany who carried out the chemical analyses of some rock samples. Dr. Mervat El Haddad, Assistant Professor, Geology Department, Assiut University, helped the author with the analysis of the major oxides of a number of samples.

The author wishes to thank Dr. Z. El Alfy, Geological Survey of Egypt, for his kind help while carrying out the field studies at the start of this work.

ABSTRACT

The present work is a geological, structural and geochemical study on the Pan-African basement rocks in the area of Wadi Zeidun and its southern tributaries Wadi Maasar and Wadi Meesar, which cover approximately 600 km² in the Central Eastern Desert of Egypt.

Detailed field studies revealed that the area comprises four main petrotectonic assemblages: 1)- Island-arc assemblage; 2)- Volcanogenic metasediments; 3)- Molasse-type sediments, and 4)- Late-collision granitoids and felsites as well as minor dykes and veins.

The island arc-assemblage in the study area includes low-k, calc-alkaline/tholeiitic metavolcanics and a volcanoclastic sequence intruded by Wadi Maasar arc-granitoids.

The volcanogenic metasediments east and northeast of Gabal El Shalul are composed mainly of a foliated, cleaved and bedded sequence of green metaconglomerates interbedded with grey phyllites, slates, metamudstones, metasiltstones and graded bedded metagreywackes. The petrochemical characters of these rocks revealed that they are comparable with the oceanic island arc sandstones.

The molasse-type sediments in the study area form three isolated exposures (basins). They are composed mainly of a succession of interbedded purple conglomerates, sandstones and siltstones of alluvial fan-braided stream deposition. The modal composition of these sandstones plot in the two fields of dissected arc and recycled orogen.

The late-collision granites are represented by two main plutons; El Shalul and El Hassanawia. Both are essentially pink in colour, composed mainly of quartz, perthite, plagioclase and minor biotite in addition to hornblende in El Hassanawia granite. The geochemistry of these granites shows a calc-alkaline character of normal granite composition, being formed in an environment of compression.