

٢٢٥

**PETROLOGICAL AND MINERALOGICAL  
STUDIES ON THE MESOZOIC SANDSTONES  
IN WEST CENTRAL SINAI**

٧٠٤

**THESIS**

Submitted To  
The Faculty of Science  
Ain Shams University



By  
*د. ر. محمد*  
**Ragaa A. El Mohammady**  
B.Sc., M.Sc.

٢٢٥

For  
The Degree of Ph. D. in Geology

٥٥٥  
١٩٩٣

Contribution From  
The Earth Sciences Department  
National Research Center , Cairo

١٩٩٣

**1993**



بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ  
﴿ وَقُلْ رَبِّ زِدْنِي عِلْمًا ﴾



***To My Family***

**PETROLOGICAL AND MINERALOGICAL  
STUDIES ON THE MESOZOIC SANDSTONES  
IN WEST CENTRAL SINAI**

Thesis Advisors

*Prof. Dr. M. M. Abu - Zeid*

*Prof. Dr. K. M. Amer*

Approved

*M. M. Abu - Zeid*  
*K. M. Amer*

*Prof. Dr. W. M. Abdelmalik*  
Head of Geology Department

---

صفحة للمعلومات

اسم الطالب: ..... رجاء عبد الفتاح المحمدي  
الدرجة العلمية: ..... دكتوراه الفلسفة في العلوم (جيولوجيا)  
القسم التابع له: ..... (الجيولوجيا)  
اسم الكلية: ..... العلوم  
الجامعة: ..... عين شمس  
سنة التخرج: ..... ١٩٧٨  
سنة النشر: ..... ١٩٩٣

شروط علمية

يوضع شعار الجامعة على الفيلاد الخارجى على (الكاتب والمؤلف)



رسالة ماجستير / دكتوراه

اسم الطالب : .. ر.جاء .. عبد الفتاح .. المحمدي ..  
عنوان الرسالة : دراسات بترولوجية ومعدنية علي الصخور الرملية التابعة للحقب  
الميزوزوي بغرب وسط سيناء  
اسم المرجعية : ( ماجستير / دكتوراه )

لجنة الاختصاص

١- الاسم / أ.د. محمد محمود ابو زيد / استاذ الصخور الرسوبية  
٢- الاسم أ.د. خيرى محمد عامر / استاذ الصخور الرسوبية

تاريخ البحث : ١٤ / ٦ / ١٩٩٣

الدراسات العليا

اجيزت الرسالة بتاريخ / / ١٩٩٩

ختم الاجازة :

مواقفة مجلس الجامعة

/ / ١٩٩٩

مواقفة مجلس الكلية

/ / ١٩٩٩

شكر

- اشكر المصداقة الاساتذة الذين قاموا بالاشراف
- وهم : ( ١ : أ.د. : خيرى محمد عامر أستاذ الجيولوجيا بالمركز القومى للبحوث
- ( ٢ : أ.د. : محمد محمود أبو زيد أستاذ يقسم الجيولوجيا - جامعة عين شمس
- ( ٣ : .....
- ( ٤ : .....

- ثم الاشخاص الذين تعاونوا معى فى نفس البحث
- وهم : ( ١ : د. : مصطفى عبد العزيز أبو المجدى باحث بالمركز القومى للبحوث
- ( ٢ : /.../ باحث جليل عبد الرحيم جيولوجى بشركة جايكو للبتروول
- ( ٣ : .....

- وكذلك الهيئات : ( ١ : .....
- ( ٢ : .....
- ( ٣ : .....

Handwritten signature or mark.

## ACKNOWLEDGEMENTS

*The author gratefully acknowledges the various facilities offered by the National Research Center and the Department of Geology , Ain Shams University which enabled her to complete this research project . Particular gratitude is expressed to Prof . E. E. El - Hinnawi , former Head of the Earth Sciences Department ( N.R.C. ) and Prof. M. Rasmay , Head of the Earth Sciences Department ( N.R.C. ) for their constant support and sincere encouragement .*

*I am greatly indebted to Prof . Khairy M. Amer , Earth Sciences Department ( N. R. C. ) and Prof. Mohamed M. Abu - Zeid , Geology Department , Ain Shams University who suggested , planned , closely supervised and sincerely guided all steps of this research project. The successful completion of this work was , to a large extent , the result of their continuous support , unlimited valuable advice , fruitful discussions and critical reviewing of the manuscript .*

*The author wishes to express her deep gratitude to Dr. M. A. Abu El Maaty , Earth Sciences Department ( N.R.C. ) and her husband Geologist M. G. Abdel Reheem ( GUPCO ) for their great help during the field work. Finally , much appreciation is expressed to my mother , father , sisters , brother , and all colleagues who helped directly or indirectly during the various phases of the present work.*

## CONTENTS

|                                              | Page |
|----------------------------------------------|------|
| <b>ABSTRACT</b> .....                        | i    |
| <br><b>CHAPTER I</b>                         |      |
| <b>INTRODUCTION</b> .....                    | 1    |
| Aim of the study .....                       | 4    |
| <br><b>CHAPTER II</b>                        |      |
| <b>LITHOSTRATIGRAPHY</b> .....               | 7    |
| The Um Bogma section .....                   | 9    |
| The Wadi Mokattab section .....              | 13   |
| <br><b>CHAPTER III</b>                       |      |
| <b>PARTICLE - SIZE ANALYSIS</b> .....        | 25   |
| Nomenclature and vertical variations .....   | 25   |
| Particle - size characteristics .....        | 37   |
| Histograms .....                             | 37   |
| Cumulative curves .....                      | 47   |
| Statistical particle - size parameters ..... | 69   |
| Bivariant relationships .....                | 90   |
| Multivariant relationships .....             | 02   |
| <br><b>CHAPTER IV</b>                        |      |
| <b>PETROGRAPHY</b> .....                     | 109  |
| The Qiseib Formation .....                   | 109  |
| The Raqaba Formation .....                   | 118  |
| The Temmariya Formation .....                | 118  |
| The Malha Formation .....                    | 123  |
| Diagenesis .....                             | 127  |
| Dissolution .....                            | 127  |
| Cementation .....                            | 127  |
| Compaction .....                             | 135  |

## **CHAPTER V**

|                                         |     |
|-----------------------------------------|-----|
| <b>MINERALOGY</b> .....                 | 142 |
| Mineralogy of the light fractions ..... | 142 |
| Mineralogy of the heavy fractions ..... | 160 |
| Mineralogy of the clay fractions .....  | 201 |

## **CHAPTER VI**

|                                                         |         |
|---------------------------------------------------------|---------|
| <b>PETROGENESIS AND ENVIRONMENT OF DEPOSITION</b> ..... | 213     |
| Petrogenesis .....                                      | 213     |
| Environment of deposition .....                         | 225     |
| <br><b>SUMMARY AND CONCLUSIONS</b> .....                | <br>227 |
| <br><b>REFERENCES</b> .....                             | <br>236 |

## ABSTRACT

This research project aims at the recognition of the petrography, mineralogy, sedimentary history and diagenesis of the Mesozoic sediments in west central Sinai. The studied sections at Um Bogma (~ 269 m) and Wadi Mokattab (~ 198 m) consist of (from older to younger): the Qiseib (~ 49 m; at Um Bogma only), the Raqaba (80, 86 m), the Temmariya (50, 54 m) and the Malha (63, 87 m) Formations. The sequence is dominated by sandstones occasionally intercalated with siltstones and claystones especially in the Qiseib Formation. Sandstones are mainly fine - to medium - grained, occasionally pebbly especially at Wadi Mokattab, kaolinitic and, in places, graded - or cross - bedded.

Detailed quantitative petrographical and mineralogical studies comprised particle - size analyses of 215 samples, microscopic examination of more than 70 thin - sections and 26 dyed epoxy - impregnated specimens, identification of the composition and roundness characteristics of the light - and heavy - mineral grains separated from the very fine sand and fine sand fractions of 173 samples, X - ray diffractometry of the clay fractions of 24 samples and examination of 14 samples using the SEM.

The studied Mesozoic sediments are generally slightly calcareous. The majority of the Qiseib sediments are texturally classified as sands, clayey sands and silty sands having uni - and bimodal distributions, while those of the younger formations are mainly sands showing commonly unimodal distributions. The sediments are dominated by well - sorted saltation populations which are occasionally composed of two subpopulations. Poorly - sorted suspension populations are present in all samples while minor amounts of poorly - to well - sorted rolling populations are recorded in some samples. Statistical grain - size parameters show that the sediments are dominated by very fine sands in the Qiseib Formation and medium sands in younger formations. Sorting increases upwards in the sequence (from poor to moderate) and at Um Bogma relative to Wadi Mokattab. The distribution curves are commonly fine - skewed and extremely -, very and leptokurtic. Bi - and multivariant relationships between the statistical parameters were tested in an attempt to decipher the mechanism of transportation and environments of deposition.

The Qiseib sandstones are composed of quartz arenites and, less commonly, sublitharenites and quartz and arkosic wackes. Those of the younger formations are dominantly quartz arenites and, rarely, quartz wackes. Quartz grains with worm overgrowths are scarce. Feldspars and chert, igneous and metamorphic fragments are occasionally recorded especially in the Qiseib Formation. The matrix is composed commonly of clay and silt - sized quartz. Diagenesis in the sandstones includes dissolution of feldspar grains. Cementation with carbonates is relatively more common in the Um Bogma sediments. Silica cements tend to increase in muddy sediments. The effects of burial compaction on packing and porosity of sandstones were studied through the determination of CI (contact index), CF (consolidation factor) and CS (contact strength). Commonly, there are 0 - 3 contacts per grain. They are (in order of decreasing abundance): tangential, long, concavo - convex and sutured. Values of the total, intergranular, oversize and pre - cement porosities were calculated. Authigenesis of clay minerals in the sandstones is minor. The products of the various diagenetic processes, their paragenesis and the conditions prevailed were discussed.

The light fractions of the sandstones are dominated by quartz. The grains are commonly sub - to well - rounded especially in the younger formations and at Um Bogma. They are commonly monocrystalline displaying either slightly

undulose , uniform or strongly undulose extinction ( in order of decreasing abundance ). The heavy - mineral assemblage consists of opaques ( magnetite , ilmenite , hematite ) together with smaller concentrations of zircon and tourmaline and minor amounts of rutile , epidotes , staurolite , spinel and muscovite . Values of the ZTR index increase upwards in the sequences and are higher at Um Bogma . Epidotes are represented by the species ( in decreasing order of abundance ) : pistacite , clinozoisite and zoisite .

The clay fractions of the Mesozoic sediments consist almost entirely of moderately - crystallized kaolinite . Minor amounts of illite are recorded in the younger formations while traces of smectite - chlorite appear in the Temmariya Formation at Wadi Mokattab . These clay minerals are mainly detrital and are present as coatings on sand grains or filling the intergranular pores . Authigenic kaolinite occurs mainly as aggregates of tightly - packed pseudo-hexagonal flakes stacked in a face - to - face arrangement . Illite is present as curved sheets having short lath - like projections . These clay minerals originated after burial of the sandstones through crystallization from solutions or colloidal suspensions , regeneration of detrital clay minerals , and / or in - situ alteration of nonclay minerals . The textural and mineral characteristics of the Mesozoic sandstones indicate a considerable maturity and , hence , derivation from older sedimentary rocks . Several evidences indicate that they were derived , at least partly , from the Paleozoic rocks exposed to the south of the study area in Gebel Abu Haswa and Wadi Feiran . Direct contributions from the Basement Massif lying to the southeast of the study area were minor but are more obvious in certain stratigraphic intervals especially in the Qiseib and Malha Formations . The detrital clays were also inherited from weathering horizons on these source rocks . Kaolinite and illite originated by decomposition of feldspars and muscovite under favourable leaching conditions . Smectite - chlorite was formed by weathering of chlorites and / or low - temperature hydrothermal alteration of basic igneous rocks .

Weathering horizons on source rocks were transported primarily by streams which debouched their loads in the deltaic plains which were developed in the northern part of the region including the study area . The turbulence and sorting energy of these streams were moderate and the rate of deposition was more or less stable . Evidently , fluvial sedimentation dominated during deposition of the whole Mesozoic sequence . However , it was intermittently interrupted by beach and shallow marine conditions as a result of minor sea transgressions southwards and southeastwards . These transgressions were more profound during accumulation of parts of the Raqaba and Temmariya Formations in both sections and the Malha Formation at Um Bogma .

# **CHAPTER I**

## **INTRODUCTION**

## CHAPTER I

### INTRODUCTION

The Mesozoic sandstones are very widely distributed in Egypt . In the Western Desert , these rocks are largely developed in the south , extend to Lybia and may reach an aggregate thickness of 1000 to 2000 m . *Klitzsch et al . ( 1979 )* subdivided the Mesozoic sandstones in southwestern Egypt into six units ; three - major sandy units ( Basal Clastic , Desert Rose and Taref ) are separated by two finer grained intervals with a subsantially higher content of siltstone and shale ( Lingula Shale and Plant Bed ) . The uppermost part of the sequence is fine - grained and composed mainly of siltstones and shales ( Variegated Shale ) .

In the Eastern Desert , the Mesozoic sandstones cover in many places the eroded surfaces of the igneous and metamorphic rocks and extend to Sudan . *Ward & McDonald ( 1979 )* subdivided the Mesozoic sandstones in central Eastern Desert ( ~ 400 m thick ) into five major lithologic units ( from base to top ) : ( i ) trough cross - bedded , kaolinitic sandstones and conglomerate with massive , kaolinitic sandstone ; ( ii ) grey and red shale and thin sparsely fossiliferous sandstone ; ( iii ) tabular cross - bedded sandstone ; ( iv ) current ripple , laminated siltstone and lenticular sandstone ; and ( v ) laminated siltstone ( Variegated Shale ) .

In Sinai , the Mesozoic sandstones are well represented in the southern and westcentral parts . In most cases , they are well bedded , nearly horizontal in general , but sometimes show variable dippings and frequently show false - bedding . Their thickness varies greatly reaching altogether several hundreds of meters . The main exposures of the Mesozoic sandstone are underlain by the Lower Carboniferous sediments and overlain by the Cenomanian marls . In westcentral Sinai , *Ball ( 1916 )* reported the persence of ~ 500 m thick section of unfossiliferous sandstones " Nubian Sandstone " lying between the Carboniferous sandstones and the Cenomanian clays . This formation forms the lower half of the great scarp of El Tih from Gebel El Hemetia eastwards to far beyond Gebel Rueikna and extends southwards across the lower hill tract to the sandy plain of Debber El Qeri . It is encountered also in Wadi Thal a little below its head and in the upper feeders of Wadi Gharandal . On the southeastern flank of Gebel Abu Edeimat , the " Nubian Sandstone " crops out from under the Cenomanian and hence extends southwards as a narrow band flanking Gebels Sarabut El Gamal and Musaba Salama on their eastern sides , being limited to the west by the great fault which has its upthrow alongside the Campanian and Miocene strata . Sandstones of the formation are medium - grained , varying in colour at different localities from nearly white to various shades of