



***"Paleontological studies and sedimentological
evolution in Wadi El-Hitan District,
Fayoum Governorate, Egypt"***

**A Thesis
Submitted to the Faculty of Science
Cairo University**

By

**Gebely Abdel Maksoud Mahomoud Abu El-kheir
B. Sc. Geology- Cairo University- Fayoum Branch**

**Partial Fulfillment of the Requirement for
Master of Science in Geology**

Cairo 2010

Approval sheet

Title of the MSc. Thesis

***"Paleontological studies and sedimentological
evolution in Wadi El-Hitan District,
Fayoum Governorate, Egypt"***

Name of the Candidate

Gebely Abdel Maksoud Mahmoud Abu Elkheir

Submitted to

**The Faculty of Science, Cairo University
Geology Department**

Supervisors:

Prof. Dr. Mohammed Ibrahim El-Anbaawy

Sedimentology and Environmental geology,
Geology Department, Faculty of Science, Cairo University.

Prof. Dr. Mohammed Gameil

Paleontology, Geology Department, Faculty of Science Cairo University

Dr/ Mohsen Abdel Fattah

Stratigraphy, Geology Department, Faculty of Science, Cairo University

**Prof. Adel Abdel Aziz Sehim
Head of Geology Department,
Faculty of Science, Cairo University**

To My Father

To My Dear Mother' s Soul

To My Wife

To My Children

Note:

The present thesis is submitted to the faculty of science, Cairo University in the partial fulfillment of the requirement for the degree of Master of Science in (Geology).

Beside the research work materialized in this thesis, the author has attended eleven post-graduate courses for one year and successfully passed the final examination of Msc. Courses in the following topics:

1. Lithostratigraphy
2. Biostratigraphy
3. Macropaleontology
4. Micropaleontology
5. Paleoecology
6. Sedimentary Rocks
7. Sedimentation
8. Structure Geology
9. Photogeology & Remote Sensing
10. Statistics
11. German Language

He has passed successfully an examination in the above-mentioned topics; in October 2005.

Prof. Adel Abdel Aziz Sehim
Head of Geology Department,
Faculty of Science, Cairo University

Note:

All the referred Figures in the text are located at the end of each chapter of this thesis. The appendices are given at the end of the thesis.

ACKNOWLEDGMENTS

First thanks to God for the continuous and persistent supply with patience to produce this study. The author wishes to express his thanks to Prof. Dr. Adel Sehim, Head of Geology Department, Faculty of Science, Cairo University for the facilities offered from the Department. The author wishes to express his deep gratitude and his sincere appreciation to the main supervisor **Prof. Dr. Mohammed El Anbaawy**, prof. of sedimentology and environmental Geology, Geology Department, Cairo University who suggested the problem of this study, and helped very much in the fieldwork and critical reviewing the thesis. His sympathy and variable scientific discussion during the study is greatly appreciated and unforgettable. The author is greatly indebted to **Dr. Mohsen Abdul Fattah**, Geology Department, Cairo University for his great help for supervision and guidance during the fieldwork and also for the available discussion during the study.

The author is greatly indebted to **Prof. Dr. Mohammed Gameil**, Geology Department, Cairo University for his supervision, valuable advice, discussion, help and guidance.

The author wishes to express his deep gratitude to **Mr. Mohammed El Hakeem**, the director of the Egyptian Geological Museum for the great help in during the preparation of the whale skull specimen and studying it. In addition, I thank very much Mr. **Magdi Zakarya**, the general manager of the vertebrate department in the Geological Museum for his distinctive help. In addition, I thank very much Mr. **Medhat Said, Mr. Afifi Hassan, Mr. Yaser Abdulrazik** the geologists in the Egyptian Geological Museum for their great help.

The author thanks very much **Mr. Mohammed Magdy**, the technician in the Egyptian geological museum for his great help during the preparation of the whale specimens. The author also thanks very much **Dr/ Sayed Abdel Aziz-** Fayoum University- Geology Department for his help during the study.

The author thanks very much **Mr. Khaled Dieb**, my friend for his help during the study. The author thanks very Much **Mr. Ahmed Awad**, the geologist in Wadi El Rayan protected area. In addition, I thank very much **Mr. Taha Abdulaaty**, the driver of Qaroun protected area for his great help and guiding in the desert.

Finally, I thank very much Mrs. **Faten Mohammed** (Azhar University) for her assist in preparing maps by GIS Program.

Abstract

The present thesis aims to study the geological, geomorphological, and structural setting of the **Wadi El-Hitan area**, which represents the UNESCO world heritage site in the Western Desert, Fayoum, Egypt. The present study also aims to integrate the paleontological, sedimentological and sequence stratigraphical factors govern **the plaeoenvironment framework** of the Bartonian- Priabonian succession and their fossil contents in the Wadi El-Hitan area. **The taxonomic composition** and sequence stratigraphical position of the whale fossils were emphasized in this work. Rock and fossils samples were collected from four stratigraphic sections, namely; Qaret Gehannam, Minqar El Hut, Sandouk El Bornitta and North Wadi El-Hitan sections that representing the Middle – Late Eocene formations. These samples were petrographically and paleontologically investigated to reveal their composition, microfacies and **diagenetic characteristics**.

New **geomorphological and geological maps** were constructed. **Parasequences and sequence boundaries** were recognized based on the distribution of the lithostratigraphical, biostratigraphical and facies sequence characteristics of the Gehannam (Bartonian – early Priabonian), Birket Qaroun (Priabonian) and Qaser El Sagha (Priabonian) formations.

The Gehannam Formation includes mudstone – fossiliferous sandstone (MFS) indicating open marine shelf in initial regressive system tract, limestone– bioclastic sandstone (LBS) indicating shallow open shoreface in a regressive system tract and mangrove limy sandstone – mudstone sequence boundary (MSM) indicating lowstand system tract with limited subareal exposure and a restricted lagoonal local environment where it was subjected to paleometeoric diagenesis and weathering. The mangrove sequence boundary can be correlatable with the nearly Pr1 of the global eustatic sea level curve.

The Birket Qaroun Formation includes bioclastic mudstone- fine sandstone (BMS) indicating open marine shelf with storm deposits, thick mudstone – thin friable sandstone (TMS) indicating time of maximum marine sediment accommodation, burrowed limy – bioclastic sandstone – mudstone (BBS) indicating initial transgression with submarine barrier sand bars complex on shallow shelf to shallow

embayment environment with occasionally storm events, conglomeratic skeletal sandstone sequence boundary (CSS) indicating river system near shoreline where it was subjected to subaerial exposure with paleo-meteoric diagenesis and it can be correlatable with Pr2, cross bedded rippled friable sandstone- interbedded mudstone (CSM) indicating mixed fluviomarine system during the initial transgressive phase of sequence TA4.2, and bioclastic conglomerate sandstone – mudstone (BCS) indicating early transgressive tract with initial reworked nearshore over muddy embayment.

The lower part of the **Qaser El Sagha Formation** includes limestone- mudstone- marl parasequence (LMM) which indicating normal marine shallow shelf condition during early to moderate transgressive tract. Generally, the microfacies paleoecological investigations support the revealed the above paleoenvironment interpretation.

Adynamic paleogeographic model was developed in a sedimentological evolutionary steps, which related to eustatic global sea level change. However, this change is supported by tectonic subsidence and uplifting along WSW- ENE fault trend that divide the study area into northern sector including the North Wadi El-Hitan section, and southern sector including the rest of the sections. The observed shift between the local curves that representing the sea level cycles of the southern sections and those of the northern one, may reflect tectonic activity. The northern section depositional cycles are basically consistent with the global eustatic sea level while the southern ones are not.

It was found that most **vertebrate remains** of the Birket Qaroun Formation in the study sections, particularly those of the North Wadi El-Hitan section, occur in condensed stratigraphic intervals where the taxonomic composition changes with sequence position. Eight types of stratigraphic horizons (I, II, III, IV, V, VI, VII, VIII horizons) were recognized within the parasequence and sequence boundaries: MFS, LBS, MSM and CLM. It is documented that complete, partially articulated skeletons of *Basilosaurus isis*, *Dorudon atrox* and dugongs are abundant in IV, V and VII horizons respectively. The vertebrate contents in the rest of the horizons are not directly related to the sequence stratigraphic architecture or sea level change

controlling factors; however, other factors e.g. local coastal or embayment geomorphology and shallow shelf environment conditions between the transegressive and regressive phases that representing the sequence boundaries (e.g. MFS) may be involved. It was found that the most common whale types nearly in the all stratigraphic horizons are ***Basilosaurus isis*** and ***Dorudon atrox***, for this reason, their taxonomic composition and skeletal structure were described in some details.

The most important **diagenetic processes** that took place during multi stages of **diagenetic history** of the study limy- siliciclastic – carbonate stratigraphic intervals are: compaction, carbonate and iron oxide cementation, neomorphism and celecitization. These processes could be choronologically arranged as eodiagenetic stage (including marine diagenesis and hardground synsedimentary sea- floor cementation), mesodiagenetic stage during burial history and finally telediagenetic stage during uplifting and meteoric water intrusion the exposed sediments and vertebrate fossils. The celecitization process is very common in mangrove and bone fossils beds, which seems to be formed during eodiagenetic and paleoexposed stage.

List of content

Approval sheet	II
Notes	IV
Acknowledgments	V
Abstract	VII
List of Content	X
List of Figures	XIV
List of Tables	XXIV
List of Abbreviation	XXV
List of Appendices	XXVII

Chapter 1: INTRODUCTION

1-1 The study area	1
1-1-1 The Wadi El-Hitan district	1
1-1-2 Wadi El-Hitan protected area	2
1-2 The previous works	3
1-2-1 Stratigraphy and sedimentology	٣
1-2-2 - Paleontology	٦
1-3 Aim and methods of the study	7
1-3-1 Aim of the study	8
1-3-2 Methods and materials of the study	8

Chapter 2: GEOLOGICAL SETTING AND STRATIGRAPHY

2-1 Geomorphology:	10
2-1-1 Regional geomorphology	10
2-1-2 Geomorphology of the study area	10
2-2 Regional Stratigraphy	10
2-2-1 Lithostratigraphy	13
2-2-2 Biostratigraphy	14
2-3 Stratigraphy of the study area	16
2-3-1 Eocene rock units	16
2-3-2 Quaternary sediments	20

2-4 Tectonic setting	21
2-4-1 Regional tectonic aspects	21
2-4-2 Structural pattern	21

Chapter 3: FACIES SEQUENCES

3-1 Gehannam Formation	24
3-1-1 Mudstone- fossiliferous sandstone parasequence (MFS)	24
3-1-2 Limestone- bioclastic sandstone parasequence (LBS)	26
3-1-3 Mangrove limy sandstone- mudstone sequence boundary (MSM)	27
3-2 Birket Qaroun Formation	28
3-2-1 Bioclastic mudstone-fine sandstone parasequence (BMS)	28
3-2-2 Thick mudstone- thin friable sandstone parasequences (TMS)	29
3-2-3 Burrowed limy – bioclastic sandstone- mudstone parasequence (BBS)	30
3-2-4 Conglomeratic skeletal sandstone sequence boundary (CSS)	33
3-2-5 Cross bedded- rippled friable sandstone interbedded mudstone (CSM) parasequences	34
3-2-6 Bioclastic conglomerate sandstone- mudstone parasequence (BCS)	35
3-3 Qaser El Sagha Formation	37
Limestone- mudstone – marl parasequence (LMM)	37
3-3-1 Carolian limestone- mudstone cycle (CLM)	37
3-3-2 Fossiliferous limestone- marl cycle (FLM)	38

Chapter 4: PETROGRAPHIC CHARACTERISTICS

4-1 Siliclastic microlithofacies	40
4-4-1 Coarse siliciclastics microfacies	40
4.1.2 Fine siliciclastics microfacies	44
4-2 Carbonate microlithofacies	46
4-2-1 Sandy foraminiferal wackstone microfacies	46

4-2-2 sandy molluscan packstone microfacies	46
4-3 Mangrove – whale fossils	48
4-3-1 The mangrove root fossils	48
4-3-2 The whale bone fossils	48
4-3-3 The hosting sediments	49
4-4 Diagenetic features	50
4-4-1: Compaction and pressure dissolution	51
4-4-2 Carbonate cementation and neomorphism	51
4-4-3 Gluaconitization, celestitization and ferrugination	53
 Chapter 5: DESCRIPTION OF WHALE SKELETON FOSSILS	
5-1 Occurrences, extraction and taxonomy	55
5-1-1 Distribution of marine vertebrates in the Wadi El-Hitan area	55
5-1-2 The extraction of whale skeletons	59
5-1-3 Taxonomy	59
5-2 <i>Dorudon atrox</i>	60
5-2-1 Vertebral column	61
5-2-2 Fore limbs	66
5-2-3 Ribs	68
5-3 <i>Basilosaurus isis</i>	68
5-3-1 The skull	68
5-3-2 The vertebral column	74
5-3-3 Other parts of the skeleton	76
 Chapter 6: PALEOENVIRONMENTAL FRAMEWORK	
6-1 Geometry of Eocene formations	78
6-1-1 Regional correlation	78
6-1-2 Sequential correlation	79
6-2 Paleocological significances	81
6-2-1 Micro- and Marco- invertebrates	81
6-2-2 Mangrove- whale fossils	83
6-3 Evolutionary consequences	86

6-3-1 Sea level sequence and tectonic control	86
6-3-2 Paleogeographic evolution	89
6-3-3 Diagenetic environment and diagenetic sequence	93
chapter 7: SUMMARY AND CONCLUSION	
REFERENCES	100
APPENDICES	(at the end of the thesis)
ARABIC SUMMARY	

List of Figures

Chapter 1: INTRODUCTION

Fig. 1-1: Location map showing the study Wadi El Hitan area to the west of Fayoum Depression, Egypt.

Fig. 1-2: Regional satellite image showing the Fayoum Depression and the outline of the study area.

Fig. 1-3: Location map of the study fossil area (the study Wadi El Hitan area). Notice the rout from Wadi El Rayan to the area.

Fig. 1-4: Detailed Satellite Image of the study area approximately between $29^{\circ} 15'$ and $29^{\circ} 22' N$, $E: 30^{\circ} 01'$ and $30^{\circ} 11' E$.

Chapter 2: GEOLOGIC SETTING AND STRATIGRAPHY

Fig. 2-1: Regional topographic map of the Fayoum Depression and the study area.

Fig. 2-2: Topographic map of the study area showing the location of the investigated stratigraphic sections.

Fig. 2-3: Geomorphological map of the study area.

Fig. 2-4: Landscape of Wadi El Hitan showing the tableland, escarpment, isolated hills and Wadi plain landforms.

Fig. 2-5: General view of structural benches along the escarpment landform to the North of Wadi El Hitan.

Fig. 2-6: General view of the tectonic cuesta of Qaret Gehannam to the east of Wadi El Hitan.

Fig. 2-7: General view of the tectonic cuesta of Minqar El Hut.

Fig. 2-8: General view of the Sandouk El Bornitta isolated hill to southwest of Wadi El Hitan.

Fig. 2-9: General view of of some sand dunes (Ghard Gehannam at the east of Qaret Gehannam).

Fig. 2-10: General view of the rocky sandy bajada of the northeast of Wadi El-Hitan.

Fig. 2-11: General view of Wadi plain of Wadi El Hitan area.

Fig. 2-12: Satellite image for the Fayoum Depression, showing the four study stratigraphic section in the study area.

Fig. 2-13: Regional geological map of the Fayoum region including the study area. (modified after Swidan (1986).

Fig. 2-14: Geological map of the study area.

Fig. 2-15: Lithostratigraphic log of the Qaret Gehannam stratigraphic section.

Fig. 2-16: Lithostratigraphic log and description of the Minqar El hut stratigraphic section.

Fig. 2-17: Lithostratigraphic log of the Sandouk El Bornitta stratigraphic section.

Fig. 2-18: Lithostratigraphic log of the North Wadi El Hitan stratigraphic section.

Fig. 2-19: Qaret Gehannam stratigraphic section, showing the contact between the Gehannam, the Birket Qaroun and the Qaser El Sagha formations (Fms).

Fig. 2-20: Minqar El Hut stratigraphic section, showing the contact between the Gehannam, Birket Qaroun and Qaser El Sagha formations.

Fig. 2-21: Sandouk El Bornitta stratigraphic section, showing the contact between the Gehannam, Birket Qaroun and Qaser E Sagha formations.

Fig. 2-22: North Wadi El Hitan stratigraphic section, showing a part of Birket Qaroun Formation, notice the black shale beds (the steep dark face), underlying the thick mud cycle and overlying fine sandstone which topped by erosional surface with conglomeratic thin bed.

Fig.2-23: Major fault along the Minqar El Hut section.

Fig. 2-24: Minor fault crossing some part of the North Wadi El Hitan section.

Fig. 2-25: Irregular fracture in the mudstone beds of the North Wadi El Hitan section.

Fig. 2-26 Inclination of some bedding of Minqar El Hut section, representing a limb of the plunging syncline.

Chapter 3: FACIES SEQUENCES

Fig. 3-1: The lower part of the Qaret Gehannam stratigraphic section represents the parasequence (MFS) on the ground that overlain by the parasequence (LBS).

Fig. 3-2: The lower part of the Minqar El Hut stratigraphic section represents the parasequence (LBS).

Fig. 3-3: The lower part of the parasequence (LBS) at Minqar El Hut section, consisting of hummocky cross stratification.

Fig. 3-4: The bioclastic sandstone interval of the parasequence (LBS) at the Minqar El Hut section.