MANSOURA UNIVERSITY
Faculty of Science
Department of Geology

THE SENONIAN MACROFAUNA OF WEST-CENTRAL SINAI:

SYSTEMATICS AND STRATIGRAPHIC DISTRIBUTION

By

HESHAM MOHAMED ELEWA SALLAM

B.Sc. Geology-Chemistry (1997)

A thesis submitted to the Department of Geology – Faculty of Science – Mansoura University in partial fulfillment for the requirements of the degree "Master of Science" in Geology (Stratigraphy & Palaeontology)

(2002)

بسم الله الرحمن الرحيم

و اتقوا يوما ترجعون فيه الى الله ثم توفى كل نفس ماكسبت وهم لا يظلمون

سورة البقرة (281)

MANSOURA UNIVERSITY
Faculty of Science
Department of Geology

Title of Thesis: **THE SENONIAN MACROFAUNA OF WEST-CENTRAL SINAI: SYSTEMATICS AND STRATIGRAPHIC DISTRIBUTION**

Researcher Name: **Hesham Mohamed Elewa Sallam**

Supervisors		
Name	Profession	Signature
Prof. Dr. Mohamed Mahmoud Abed	Professor of Palaeontology	
Prof. Dr. Mahmoud Ahmed Kora	Professor of Stratigraphy and Palaeontology	
Dr. Hosni Hemdan Hamama	Associate Professor of Geology	

Chairperson of Geology Department

Prof. Dr. Adam El-Shahat

Faculty of Science, Mansoura University

REFEREES DECISION

Title of Thesis: **THE SENONIAN MACROFAUNA OF WEST-CENTRAL SINAI: SYSTEMATICS AND STRATIGRAPHIC DISTRIBUTION**

Researcher Name: **Hesham Mohamed Elewa Sallam**

Referees:

№.:	Name	Profession
1-		
2-		
3-		
4-		

Date of discussion:

Degree of thesis:

Referees signatures:

№.:	Name	Signature
1-		
2-		
3-		
4-		

To my dear parents

NOTE

The present thesis is submitted to the Faculty of Science, Mansoura University in partial fulfillment for the requirements of the degree of Master of Science in Geology (Palaeontology & Stratigraphy). Besides the research work materialised in this thesis, the candidate has attended nine post-graduate courses for one academic year in the following topics:

1. Stratigraphy of Egypt
2. General stratigraphy
3. Macrofossils
4. Microfossils
5. Field geology
6. English language
7. Statistics

He has successfully passed the final examination in these courses held in September 1998.

Chairperson of the Geology Department

Prof. Dr. Adam El-Shahat

Faculty of Science, Mansoura University

AKNOWLEDGEMENTS

Any success earned by this research deservedly belongs to almighty "Allah" who supported me with a considerable assistance and without this help my task would have much more difficult. ***Thanks Allah.***

I am sincerely grateful to **Prof Dr. Mohamed M. Abed***.* Professor of Macropaleontology, Geology Department, Faculty of Science, Mansoura University, for his faithful supervision.

This research and its preparation was influenced by the cumulative experience of **Dr. Hosni H. Hamama** , Associate Professor of Macropaleontology, Geology Department, Faculty of Science, Mansoura University, who helped me with his kind supervision, continuous encouragement and guidance**.**

I am also indebted to **all staff members** of the Geology Department, Faculty of Science, Mansoura University for their continuous help and encouragement.

Special thanks are due to my **parents,** my **sisters**, my **brothers**, my **wife** and my lovely daughter **Fatema Alzahraa**.

كلٌ كان له فضل علينا شكرناه عليه الا أ.د. **محمود احمد فوزه** فقد تركنا شكره لله. فاللهم

بارك له في ولده واهله وعلمه وماله.

Hesham Mohamed Sallam

CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF PLATES

CHAPTER SEVEN

SUMMARY AND CONCLUSIONS

In Sinai, Senonian deposits cover many parts of the several scarps and flat grounds in the central part of the peninsula. They extend from El- Themed-Nekhel stretch to a greater part of the El- Tih and El- Egma plateaus. Along the western escarpments, Coniacian to Maastrichtian strata are measured and studied in detail at four localities including: Wadi Feiran, Wadi Matulla, Wadi Abu Qada and Wadi Sudr.

Besides the field relationships and investigations during two field trips, the lithostratigraphic units are described depending on the carbonate-sand-mud composition of the collected samples (about 270) and the microlithofacies associations are studied in 80 thin sections. About 500 macro-invertebrate specimens of sponges, brachiopods, molluscans and echinoids are described systematically and biostratigraphically. The palaeobiogeographic relations and the geological history of the studied region are discussed according to the above mentioned tools. The work is organised in five chapters dealing with the lithostratigraphy, systematic palaeontology of the macrofauna, biostratigraphy, microfacies and geological history in addition to an introduction and this summary of conclusions. The details of the field and laboratory studies are given in 6 Tables, 3 Appendix-Tables, 20 Text-Figures and 33 Plates.

Lithostratigraphically; these deposits vary in thickness from about 165m at Wadi Feiran in the south to 296m at Wadi Sudr in the north. The outcrops are represented by mixed siliciclastics and carbonates followed upwards by a white carbonate section. This succession overlies conformably marine hard dolomitic limestones of the Turonian Wata Formation and underlies paraconformably Lower Paleogene calcareous shales and limestones of the Esna Shale and/or the Thebes Formation. It is generally accepted to include the Senonian succession in west-central Sinai into the Matulla Formation at base and the Sudr Chalk on top.

The **Matulla Formation** is a relatively soft unit characterised by quite distinctive lithology composed of mixed siliciclastics and carbonates in varying proportions. Generally, the carbonate content of the formation increases gradually from an average value of 29% in the southern sections (Wadi Feiran and Wadi Matulla) to 55% at Wadi Abu Qada and 63% at Wadi Sudr further north. This

composition reflects the considerable increase of limestones in the northern sections at the expense of clastics. Throughout the present investigation, it is possible to subdivide the Matulla Formation into three informal members; a lower "clastic-dominated" member, a middle "carbonate-dominated" member and an upper "shale-dominated" member.

The **lower member** is a clastic dominated unit directly overlying the Turonian carbonates of the Wata Formation. It ranges in thickness between 28 and 42.5m. Lithologically, it is composed mainly of intercalations of cross bedded sandstones, shales , limestones and dolostones. Its average carbonate-sand-mud composition is 38%, 19% and 43%, respectively. This unit is generally poorly fossiliferous with some plant remains.

The **middle member** is a carbonate-dominated unit with a maximum thickness of about 70m at Wadi Matulla and a minimum thickness of 29m at Wadi Feiran. A thickness of about 45m and 57m were measured at Wadi Abu Qada and Wadi Sudr, respectively. Lithologically, it is composed essentially of phosphatic limestones and dolostones tending to be sandy cross bedded, with few sandstone and shale interbeds. The average carbonate-sand-mud composition is 67%, 16% and 17%, respectively. In all the studied sections, the middle member is highly fossiliferous with echinoids, gastropods, ammonites, oysters and other bivalves in addition to a few sponges.

The **upper member** is a predominantly shaly unit overlying the brown fossiliferous limestones of the middle member and underlying the white Sudr Chalk. It ranges in thickness from about 13m at Wadi Feiran to 50m at Wadi Sudr. It reaches about 36m at Wadi Matulla and is reduced to 18m at Wadi Abu Qada. Lithologically, it is composed mainly of yellow-grey, fissile, laminated to thin bedded shales, partly calcareous, gypsiferous and phosphatic. This member contains kaolinitic bands and phosphatic sandstone thin beds with dark brown bone fragments, shark teeth and bivalve moulds. A snow white chalky limestone interval, about 10m thick, referred to as the first chalk or the lower chalk is recorded from the Wadi Sudr section. The average carbonate-sand-mud composition of this member is 30%, 8% and 62%, respectively.

In the present study, a Coniacian-Santonian age is concluded for the Matulla Formation. The lower member and most of middle member are Coniacian in age according to the presence of the ammonites; *Metatissotia fourneli* (BAYLE) and

Subtissotia africana (PERON) associated with the oyster; *Pycnodonte* (*Costeina*) *costei* (COQUAND). The upper member is Santonian in age due to the occurrence of *Pycnodonte* (*Phygraea*) *proboscideum* (ARCHIAC) and *Oscillopha dichotoma* (BAYLE).

The **Sudr Chalk** overlies the Matulla Formation and underlies unconformabley the Esna Shale and/or the Thebes Formation. The contact between the Sudr Chalk and the Matulla Formation is established on basis of lithological and palaeontological grounds. Lithologically, there is a sharp facies change from the shaly facies of the Matulla upper member to the snow white carbonates of Sudr Chalk lower member with many swellings and minor faultings creating an irregular surface . This is accompanied by the first appearance of large sized *Pycnodonte* (*Phygraea*) *vesicularis* (LAMARCK) at the base of the chalk. Along the measured profile at Wadi Sudr, the Sudr Chalk grades imperceptibly to the Eocene limestones of the Thebes Formation; the Esna Shale is not recorded there. All the boundaries of the studied formations Matulla, Sudr and Esna or Thebes are defined in the field.

This unit is made up almost wholly of snow white chalk but a few argillaceous intervals. Generally, the average carbonate content increases from 86-89% in the southern sections at Wadi Feiran and Wadi Matulla to 90-93% in the northern sections at Wadi Abu Qada and Wadi Sudr. In all the studied sections, the formation could be subdivided into its two members.

The lower **Markha Chalk Member** is 30m thick at Wadi Feiran, 61m thick at Wadi Matulla, about 57m at Wadi Abu Qada and increases to a maximum thickness of 94m at Wadi Sudr. It is composed of a monotonous chalky limestone succession usually snow white to pinkish, thick bedded with a few ferruginous sponge globules and tubes and common large sized *Pycnodonte* (*Phygraea*) *vesicularis* (LAMARCK). Some layers are glauconitic and/or phosphatic and others are silicified. The average carbonate content of this member in the studied sections ranges between 84 and 95% with a total average of about 92%.

The upper **Abu Zenima Chalk Member** is 55m thick at Wadi Feiran increases to 70m at Wadi Matulla, decreases again to 60m at Wadi Abu Qada and to 53m at Wadi Sudr. It is composed mainly of thin bedded pale yellow-grey argillaceous limestones. A pale yellow chalky limestone interval with oyster shell fragments is recorded at Wadi Feiran and Wadi Matulla. These limestones are

thicker at Wadi Sudr and contains many sponge tubes. This member is characterised by the common presence of calcite veins, small sized thin shelled brachiopods and sponge fragments. The carbonate content ranges between 86% and about 92% with a total average of about 88%.

In the present study, a Campanian-Maastrichtian age is concluded for the Sudr Chalk. The Markha Chalk Member is Campanian in age according to the presence of *Pycnodonte* (*Phygraea*) *vesicularis* (LAMARCK) and *Pycnodonte* (*Pycnodonte*) *hypoptera* (WANNER). The Abu Zenima Chalk Member is Maastrichtian in age due to the occurrence of the brachiopod *Terebratulina gracilis* (SCHLOTHEIM) near its base and the sponges *Schizorhabdus libycus* ZITTEL and *Ventriculites poculum* ZITTEL near its top.

The present **macrofaunal systematic** investigation led to the recognition of 75 species belonging to 55 genera of 41 families and 8 classes; including 16 sponges, 3 articulate brachiopods, 26 bivalves, 11 gastropods, 8 cephalopods and 11 echinoids. All the studied macrofossils are photographed and illustrated in 24 plates. Some demospongid sponges are studied in transverse, longitudinal and tangential thin sections under the polarising microscope. Throughout the present investigation, eleven species are described for the first time from Egypt. These include 9 sponges; *Verruculina* sp., *Carterella* sp., *Homalodora* sp., *Ragadinia* sp., *Hexactinella* sp., *Zittelispongia alcyonoides* SINTZOV, *Cephalites* sp., *Coeloptychium* sp. and *Porosphaera globularis* (PHILLIPS); and an articulate brachiopod *Gemmarcula* sp. in addition to the bivalve; *Pycnodonte* (*Phygraea*) *flicke* (PERVINQUIÈRE). Moreover, the brachiopod *Terebratulina chrysalis* (SCHLOTHEIM) was not recorded before from Sinai. The stratigraphic distribution of the studied macroinvertebrates is illustrated in faunal range charts and also the age ranges of the identified forms are shown and their geographic distribution in/and outside Egypt is given.

The **biostratigraphic** framework suggested here is based on the vertical distribution of the identified macrofauna and the age ranges of the specifically identified forms. The characteristics of the recognised biostratigraphic units are summarised below from older to younger:

I- Poorly fossiliferous interval: This interval is represented by the lower member of the Matulla Formation in all the studied sections in addition to the basal beds of the middle member of that formation at Wadi Sudr section. The stratigraphic

position of this interval between the Upper Turonian carbonates of the Wata Formation and the ammonite-bearing horizon (Middle-Late Coniacian) of the Matulla Formation suggests an Early Coniacian age.

II- *Metatissotia fourneli* Zone: This taxon range zone is recorded from the middle member of Matulla Formation in all the studied sections. An age ranging from Middle to Late Coniacian is suggested for this unit.

III- *Oscillopha dichotoma-Pycnodonte (Ph.) proboscideum* Zone: This zone is recorded from the upper beds of the middle member and all the upper member of the Matulla Formation at Wadi Feiran, Wadi Matulla and Wadi Abu Qada. At Wadi Sudr, this unit is recorded from the upper member only. A Santonian age is suggested for this unit.

IV- *Pycnodonte* (*Phygraea*) *vesicularis* Zone: This taxon range zone is recorded from the Markha Chalk Member of the Sudr Chalk in all the studied sections. A Campanian age is suggested for this unit.

V- *Terebratulina gracilis* Zone: This brachiopod zone is recorded from the lower part of the Abu Zenima Chalk Member of the Sudr Chalk in Wadi Feiran and Wadi Abu Qada sections. An Early Maastrichtian age is suggested for this unit.

VI- *Ventriculites poculum* Zone: This sponge zone is recorded from the upper part of the Abu Zenima Chalk Member of the Sudr Chalk, directly underlying the Esna Shale and/or the Thebes Formation in all the studied sections. A Late Maastrichtian age is suggested for this unit.

The **microfacies analysis** led to the recognition of 26 microfacies types in the Coniacian-Maastrichtian succession of west-central Sinai. The non-clastic facies are mostly limestones, representing about 71% of the total thickness. Eighteen limestone microfacies types are recognized in the studied Senonian succession and represented by lime mudstone (fossiliferous micrite), wackestone (sandy glauconitic-, foraminiferal-, ostracod-, miliolid-, shelly-, pelagic- and silty biomicrites), packstone (sandy biomicrite), grainstone (sandy-, oolitic- and foraminiferal biopelsparite), floatstone (silicified shelly-, and coated grain biomicrudite), rudstone (sandy shelly-, shelly- and biointrasparudite) and boundstone (framestone). The dolostones are included in two microfacies; fine-medium crystalline and fossiliferous dolostone. The clastic microfacies includes

sandstones (silty-, calcareous-, and phosphatic quartz arenite, and ferruginous subarkose) and shales (calcareous clayey- and calcareous silty shale).

The results obtained from the present field and laboratory investigations in west-central Sinai are correlated with similar studies carried out on the Senonian deposits in other parts of Egypt, north Africa and the Middle East. This is made to deduce the **palaeobiogeographical** relations and the **geological history** of west-central Sinai during the Coniacian-Maastrichtian time. Four important events took place in west-central Sinai during the Coniacian-Maastrichtian time and are summarised below.

1. The Early Coniacian lowstand: In the studied succession, the alternation of shales, sandstones and limestones which are thinly to cross-bedded and glauconitic indicates that the sea level was highly oscillating between the intertidal and the shallow subtidal conditions in the Early Coniacian. The clastic-dominated lower member of Matulla Formation is generally a poorly fossiliferous interval representing a lowstand systems tract. The presence of submarine hard grounds "*Thalassinoids*" in a successively younger stratigraphic levels from south to north reflects the northward retreat of the shoreline. This shallowing phase was associated with some tectonic instability in southern Sinai led to deposition of fresh feldspars in a subarkosic sandstone facies at Wadi Matulla.

2. The Late Coniacian-Early Santonian transgressive phase: The carbonate dominated middle member of Matulla Formation is highly fossiliferous with varied fauna including bivalves, gastropods, ammonites and echinoids, indicating deposition in more off-shore deeper water than the underlying and the overlying units. The limestones are partly cross-bedded coquinas with many abraded and worn bioclasts. High energy oyster bioherms and stromatoporoid framestone buildups were recorded from this unit in association with low energy shelly-, ostracod- and glauconitic biomicrite facies, locally interfingering with sandstones. The flourishing of large-sized oysters, nektonic ammonites and echinoids substantiates the dominance of shallow open marine conditions; shallow water indicators such as ooids and miliolid foraminifera are also recorded.

3. The Late Santonian deformation: In west-central Sinai, the Late Santonian is represented mostly by the upper member of Matulla Formation. It is a shale-dominated unit with thin phosphatic bands, bone fragments and shark teeth, reflecting generally a regressive phase. It yielded also the small-sized epifaunal

suspension feeder *Pycnodonte* (*Phygraea*) *proboscideum* (ARCHIAC) lived on soft substratum. At Wadi Sudr, ferruginous horizontal burrowings (hard ground) were recorded at the base of a chalky limestone bed suggesting a short pause in sedimentation, a disconformity surface or a sequence boundary. The softer chalky bed is a pelagic biomicrite wackestone characterising basinal and deep shelf margin environment. The irregular surface detected between the Matulla Formation and the Sudr Chalk reflects the worldwide deformation event at the Late Santonian.

4. The Campanian-Maastrichtian major transgression: With the beginning of the Campanian, the study area was continuously submerged with the deposition of pelagic lime mudstones and wackestones of the Sudr Chalk in a deep shelf or basinal environment. During the early part of this transgression, the area was covered by a shallow sea depositing sandy glauconitic biomicrites of the basal beds of the Markha Chalk Member. In this interval, frequent large-sized oysters were encountered representing essentially an association of the epifaunal suspension feeder gryphaeid *Pycnodonte.* This is followed by biointrasparudite rudstone microfacies deposited on slopes and shelf edges; thin phosphatic discontinuous bands and boulders associated with some sponge globules were recorded at Wadi Sudr.

During the Maastrichtian, the sea became considerably deeper and received little amounts of detritus. The basal beds of the Abu Zenima Chalk Member yielded well preserved small brachiopods of the *Terebratulina gracilis* Zone. It appeared that neither on the quiet sea floor nor after entombment in the chalk sediment were many shells moved or destroyed probably because the chalk is largely of biogenic origin. After a short regressive interval as evidenced by the presence of some pectinid and oyster fragments, the deep subtidal and basinal conditions continued. Water agitation was minimised to such an extent that almost nothing but fine grained bioclasts and clay minerals settled. The rise and fall of sea level in west-central Sinai during the Campanian-Maastrichtian time are not always in agreement with the global eustatic curve due probably to the effect of local tectonic movements.