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Original Article

Integrated Biostratigraphy and Sequence Stratigraphy of the Cenomanian-Turonian Successions at West Gabal Thelmet Area, North Eastern Desert, Egypt

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ABSTRACT

The exposed Cenomanian-Turonian succession at West Gabal Thelmet area has been measured and detailed examined for its foraminiferal and macrofaunal contents. Lithostratigraphically, this succession is classified into Galala, Abu Qada and Wata formations, from base to top, and it is underlain by Malha and overlain by Matulla formations with unconformity surfaces. Twenty - two foraminiferal species have been identified, of them seventeen species are planktonics and five are benthonics. On other hand, sixty-four macro-fossil species were identified; of them twenty-three belong to the Cephalopoda, eleven to the Gastropoda, Twenty-two to the Bivalvia and eight to the Echinoidea. The identified fauna is used, to establish two biostratigraphic schemes, one based on the foraminiferal assemblages, and the other on the macrofossils. The Integration between these two schemes is attempted, to reach a high-resolution stratigraphic scheme during the studied time interval. The foraminiferal assemblages are used, to classify the studied interval into one benthonic biozone of the Middle Cenomanian and three planktonic foraminiferal biozones: (one of the Latest Cenomanian, one of the Early Turonian; and one of the Early to Late Turonian), in addition to two barren intervals. Also, this interval is classified into seven macrofaunal biozones: one of the Middle Cenomanian; three of the Late Cenomanian; two of the Early Turonian; and one of the Late Turonian; in addition to two barren intervals intervene these established biozones. The integration between the lithologic characters, detailed field examination for the stratigraphic surfaces and the faunal biostratigraphic studies led to classify this interval into four 3rd depositional sequences bounded by five type- one sequence boundaries represented by unconformity surfaces. These four depositional sequences are two in the Cenomanian Galala Formation; one in the Lower Turonian Abu Qada Formation; and one in the Upper Turonian Wata Formation. The first and fourth depositional sequence are subdivided into transgressive and highstand systems tracts; while the second and third are represented by transgressive systems tracts only. The lowstand system tracts are missed in all the distinguished depositional sequences, due to the fast change in the relative sea level over the study area. The correlations of the recorded sequence boundaries in the studied section with those of the previous studies inside /outside Egypt were done.

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1. Introduction

The most previous biostratigraphic and paleoecologic studies of the Cenomanian –Turonian successions at North-astern Egypt, generally, and on the western side of the Gulf of Suez, specifically, were depended mainly on their macrofaunal contents only, and the most important ones include Kuss and Malchus 1989; Kassab (1994 & 1996); Lüning (1998a); Kassab & Obaidallah (2001); Aly and Abdel Gawad (2001); Kora *et al*. (2001); El-Hedeny & Nafee (2001); El-Hedeny (2002); Zakhera (2002); Zakhera & Kassab (2002); Hewaidy *et al*.(2003); Bauer *et al*. (2003); Khalil& Mashaly (2004); Abdel-Gawad *et al*. (2004); Zalat (2007); Khalil (2007); El Qot (2006 & 2008); Wanas (2008); Nagm (2009); Nagm *et al.* (2010 & 2011); El Qot and Afifi (2010); El-Sheikh *et al.*(2010); Saber (2012); Hewaidy *et al*.(2012); Saber *et al.* (2012) and Wilmsen & Nagm, E. (2012).

On the other hand, there are few publications on the foraminiferal or other groups of biostratigraphic microfossils classification of this time interval at those areas, in which most of them are Kuss *et al*. (1988), Ghorab, 1961; Ansary *et al.* (1962); Ansary &Tewfik (1966 & 1969); Galal & Nafae (2007); Samuel *et al*. (2009); Bauer *et al*. (2001 & 2002 &2003); Orabi (1992), Shahin (2007).

Tectonically, the Southern Galala Plateau occupies a critical site between the stable and unstable shelf regions of Egypt. So, it was affected by syn-sedimentary structural movements controlling the change in the amount of terrigenous influx during the deposition of these sediments and resulted in great facies changes, from its north to south, during the Late Cretaceous time, and accompanied with faunal assemblages reflecting special bottom and ecologic characters.

The present study deals with the biostratigraphy, paleoecology and sequence stratigraphy for the exposed Cenomanian -Turonian successions at west Gebel Thelmet area on the northern escarpment of Southern Galala Plateau and located at latitude 29° 04' N and longitude 32° 30' E (**Fig. 1**). This was done by integration between the detailed field lithologic description, critical search for the physical boundaries and bed-by-bed megafossil collection and detailed foraminiferal examination of the studied successions. The Cenomanian - Turonian rock units in the studied section were found rich in the well preserved and highly diversified macrofossils, in addition to some foraminiferal assemblages.

Therefore, the main targets of the present study are: 1)- High-resolution biostratigraphic classification during the Cenomanian –Turonian interval at West Gebel Thelmet area by the integration between two biostratigraphic schemes the first is based on foraminifera and the other on macrofossils.
2)- Sequence stratigraphic classification of the studied successions by integration between the lithologic, faunal, and structural parameters, to reach the behavior of the sea level changes during the Cenomanian –Turonian in the study area.

2. Lithostratigraphy

Depending on the lithologic characters established in the field and results of the included macrofaunal and foraminiferal examination, the studied Cenomanian -Turonian succession at West Gabal Thelmet section, is classified into Galala, Abu Qada and Wata formations, from base to top (**Fig. 2**).

This succession is unconformably underlain by the Lower Cretaceous (Aptian-Albian) Malha Formation (about 9m thick; Samples 1-5); and also unconformably overlain by the Upper Cretaceous (Coniacian – Santonian) Matulla Formation.

The Malha Formation was originally introduced by Abdallah & El-Adindani (1963) at its type area (Wadi Malha, near Abu Darag lighthouse, southeastern cliffs of the Northern Galala massif, along the western side of the Gulf of Suez, North Eastern Desert). At Wast Gabal Thelmet section, it consists of trough cross-bedded ferruginous sandstones, barren of any macro-fossils and foraminiferal assemblages, with silicified wood in its top part, indicating fluvial environment.

On the other hand, the Matulla Formation was originally introduced by Ghorab (1961) at its type area (Wadi Matulla, west Central Sinai). In the study area, the lowermost part of Matulla Formation only was studied (about 13 m thick; Samples 111 - 115), and it consists of thick cross-bedded, massive and highly ferruginous sandstone, with worm tubes completely barren from any macro-invertebrate fossils and foraminiferal assemblages.

The following is the detailed description of the studied Cenomanian -Turonian rock units at west Gabal Thelmet section from older to younger:

2.1. Galala Formation:

This rock unit was originally introduced from its type area (Galala Plateau, West Gulf of Suez) by Abdallah & El Adindani (1965). It represents the first major marine transgression during the Cretaceous time in the Gulf of Suez area, and it is well exposed and widely distributed forms mainly the beginning foot-slopes of the Galala Plateau scarp face.

At West Gabal Thelmet section, the Galala Formation attains about 50 m thick (Samples 6-35), and its age is assigned to Middle –Upper Cenomanian based on its ammonites and planktonic foraminiferal content. It may be equivalent to the Galala Formation at Southern Galala Plateau (Abu Khadrah *et al*., 1987); Northern Galala Plateau (Abd El Shafy & Atta, 1993); Ataqa and the two Galalas (Issawi *et al*., 1999). Also, it may be correlated with Atrash Formation at Wadi Qena area (Bandel *et al*., 1987).

In the study area, the Galala Formation unconformably overlies the fluviatile cross-bedded sandstone of the Aptian-Albian Malha Formation. Such contact is easily recognized in the field as it characterized by sharp, irregular and erosional surface, with the occurrence of paleo-soils, roots, wood- trunks and high iron oxidations.

On the other hand, the Galala Formation underlies with unconformity surface the Abu Qada Formation, in which such contact is flat and can be recognized by abrupt change of facies conditions, from hard limestone, with the occurrence of *Vascoceras cauvini* of Late Cenomanian age and marl, with the occurrence of *Vascoceras durandi* (Thomas and Peron), *Vascoceras proprium* (Reyment), *Choffaticeras* (*Choffaticeras*) *segne* (Solger), and *Choffaticeras* (*Choffaticeras*) *securiforme* (Eck) of Early Turonian age.

Depending on both lithologic description and faunal content, the Galala Formation at West Gabal Thelmet section is subdivided into informal members correlated with two formal members, Abu Had and Mellaha sandstone, from base to top, as follows:

2.1. A- The lower shale Member:

This unit may be equivalent to the Abu Had Member of the Raha Formation in Sinai (Ghorab, 1961). At West Gabal Thelmet section, the lower part of this member consists of highly fossiliferous shales, intercalated with fossiliferous marl and argillaceous limestone.

This interval attains about 25 m thick (Samples 6-18), and it yields rich megafossil content, represented mainly by (bivalves, gastropods and echinoids), in addition to very rare ammonites and benthic foraminifera.

On the other hand, the uppermost part of this member of about 7 m thick (Samples 19-23) consists of shale intercalated with limestone, barren of any macrofossils, but it includes some benthonic foraminiferal assemblages of Middle Cenomanian age (**Fig. 3**).

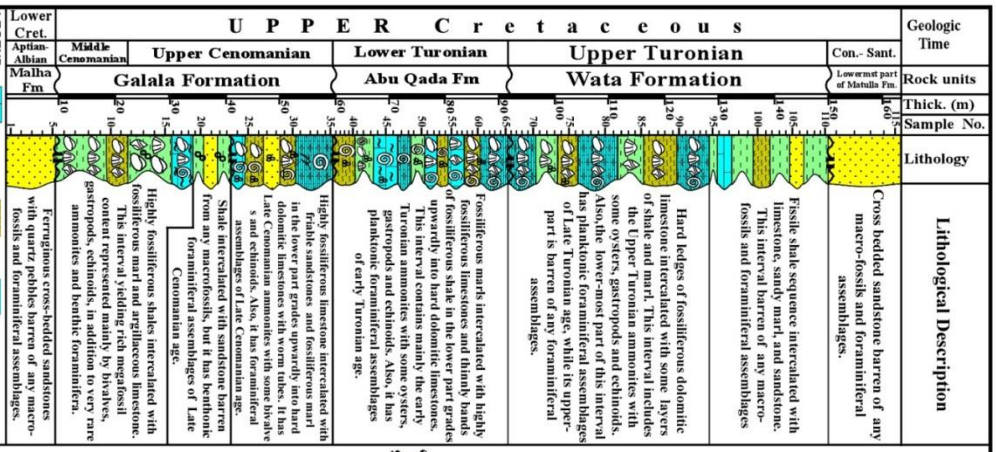


Fig. 2: Lithostratigraphic columnar section of West Gebel Thelmet area.

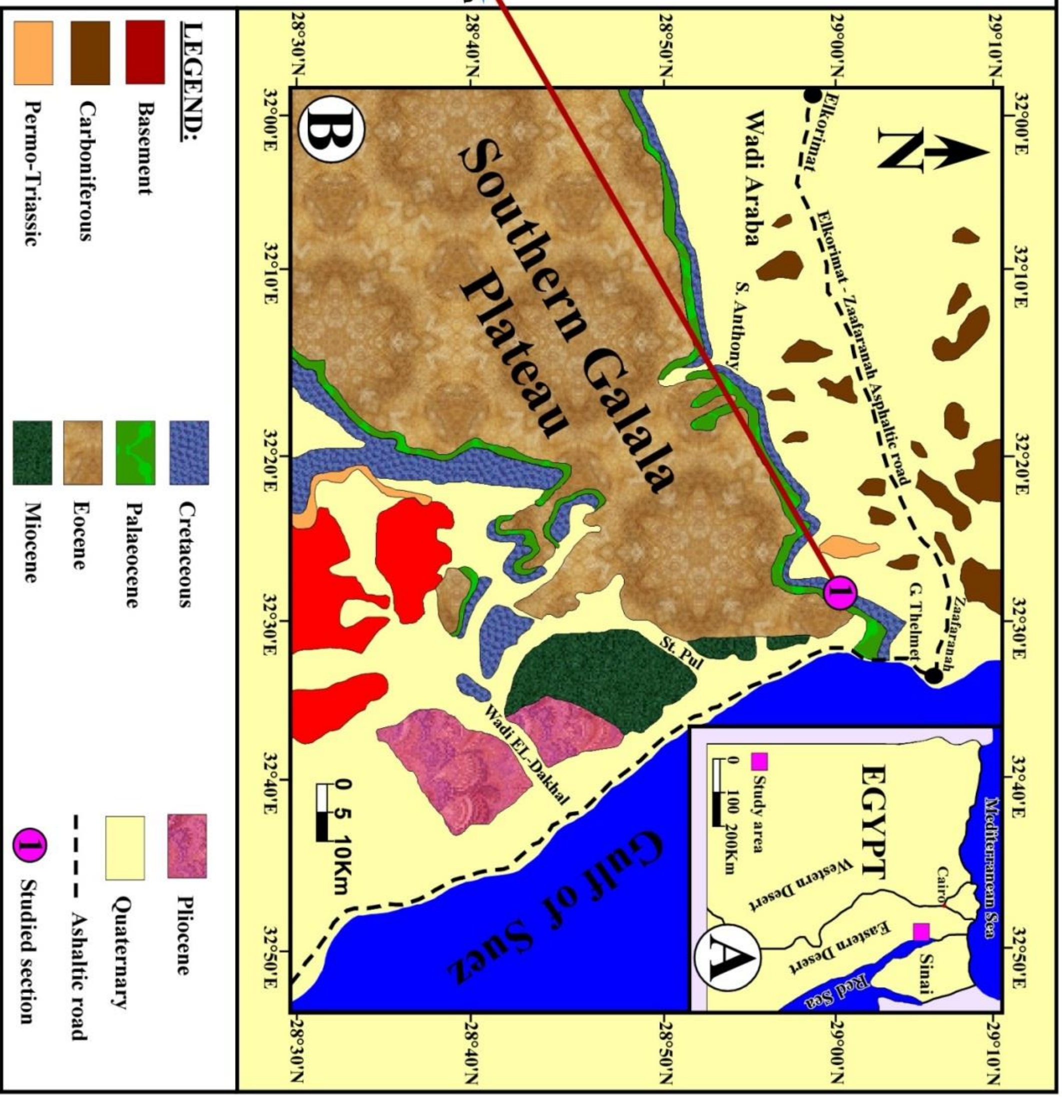


Fig. 1: Location (A) and Geological (B) maps of West Gebel Thelmet area, Northern escarpment of Southern Galala Plateau.

Area		Authors	Late Cretaceous: Turonian	Late Cretaceous: Cenomanian	Early Cretaceous: Allbian	Early Cretaceous: Aptian	Early Cretaceous: Barremian
Western Desert	Southern areas	Bottcher (1982)	Taref Fm.	Maghrabi Fm.	Sabaya Fm.	Abu Ballas Fm.	Six Hills Fm.
Western Desert	Northern areas	Aadland & Hassan (1972)	Abu Roash "B & F"	Abu Roash "G"; Bahariya Fm.	Kharita Fm.	Dahab Fm.; Alamein Fm.	Matruh Fm.; Alam El-Bueib Fm.
North Eastern Desert	Gabal Shabrawet	Al-Ahwani (1982)	Maghara El-Hadida Fm.	Galala Fm.	Malha Fm.		
North Eastern Desert	Gabal Shabrawet	El-Azabi (1999)	Abu Qada Fm.	Halal Fm.	Risan Aneiza Fm.		Malha Fm.
North Eastern Desert	West side of Wadi Araba	El-Shazly et al. (1979)	Duwi Fm.	Galala Fm.	Malha Fm.		
North Eastern Desert	Southern Galala	Abu Khadrah *et al.* (1987); Metwally *et al.* (1979)	Wata Fm.	Galala Fm.	Malha Fm.		
North Eastern Desert	Northern Galala	Abd El Shafy & Atta (1999)	Adabiya Fm.	Galala Fm.	Malha Fm.		
North Eastern Desert	Wadi Qena	Bandel *et al.* (1987)	Tarfa Fm.	Atrash Fm.	Malha Fm.		
North Eastern Desert	Ataqa & two Galalas	Issawi *et al.* (1999)	Maghara El-Hadida Fm.	Galala Fm.	Malha Fm.		
North Eastern Desert	Western Side of Gulf of Suez	Abdallah & El-Adindani (1963)	Wata Fm.	Galala Fm.	Malha Fm.		
Sinai Peninsula	Southwest Central Sinai	Cherif *et al.* (1989)	Wata Fm.	Raha Fm.: Ekma M.; Mukattab M.; Abu Had M.	Malha Fm.		
Sinai Peninsula	West Central Sinai	Kora *et al.* (1994)	Wata Fm.; Abu Qada Fm.	Raha Fm.: Mellaha Sand M.; Abu Had M.	Malha Fm.		
Sinai Peninsula	East Central Sinai	Ziko *et al.* (1993)	Wata Fm.	Galala Fm.: Shale Member; Carbonate Member; Clastic Member	Malha Fm.		
Sinai Peninsula	East Central Sinai	Abdel-Gawad *et al.* (2004a)	Wata Fm.; Buttum FM; Abu Qada Fm.	Raha Fm.	Malha Fm.		
Sinai Peninsula	North Sinai	Said (1971)	Abu Qada Fm.	Halal Fm.	Risan Aneiza Fm.		Malha Fm.
Sinai Peninsula	South west Sinai	Wanas (2008)	Abu Qada Fm.	Raha Fm.: upper unit; middle unit; lower unit	Malha Fm.		
Sinai Peninsula	East Central Sinai	Wanas (2008)	Abu Qada Fm.	Galala Fm.: upper unit; middle unit; lower unit	Malha Fm.		
Sinai Peninsula	North Sinai	Wanas (2008)	Abu Qada Fm.	Halal Fm.: upper unit; middle unit; lower unit	Risan Aneiza Fm.		Malha Fm.
Present study		West Gabal Thelmet area	Wata Fm.; Abu Qada Fm.	Galala Fm.	Malha Fm.		

Table 1: Correlation of the Cenomanian - Turonian lithostratigraphic units applied by different authors at different localities of Egypt with their equivalents at the studied area.

2.1. B- The upper carbonate Member:

This unit attains about 18 m thick (Samples 24-35), and it consists of highly fossiliferous limestone, intercalated with fossiliferous marl and fossiliferous friable sandstone of coastal marine environment in the lower part, grades upwardly into hard dolomitic limestones with worm tubes. It includes Late Cenomanian ammonites, with some bivalves and echinoids. Also, it has planktonic foraminiferal assemblages of Late Cenomanian age. The included sandstone unit in this member may be equivalent to the recorded Mellaha Sand Member in the Gulf of Suez and Sinai (Ghorab, 1961).

2.2. Abu Qada Formation:

This rock unit was originally introduced from its type area (Wadi Abu Qada, west Central Sinai) by Ghorab (1961). At West Gabal Thelmet section, the Abu Qada Formation attains about 34 m thick (Samples 36-65), and it consists of fossiliferous marls sequence intercalated with highly fossiliferous limestones and thin bands of fossiliferous shale in the lower part grades upwardly into hard dolomitic limestones. It contains mainly of Early Turonian ammonites, with some oysters, gastropods and echinoids. Also, it has planktonic foraminiferal assemblages of Early Turonian age.

In the study area, this rock unit may be equivalent to the lower part of Wata Formation at Southern Galala Plateau (Abu Khadrah *et al*.., 1987); the lower part of Maghara El- Hadida Formation at Ataqa and the two Galalas (Issawi *et al.*, 1999); the lower part of Adabiya Formation at Northern Galala Plateau (Abd El Shafy & Atta, 1993); and also with the lower part of Tarfa Formation at Wadi Qena area (Bandel *et al.*, 1987).

At West Gabal Thelmet section, the Abu Qada Formation unconformably overlies the Galala Formation and also unconformably underlies the Wata Formation. Such contacts can be easily recognized in the field, depending on the ammonite fauna.

The age of the Abu Qada Formation is assigned to Early Turonian, based on its ammonites and planktonic foraminiferal content. The most important recorded macrofaunal and foraminiferal assemblages in this rock unit are illustrated in **Figure. 3**.

2.3. Wata Formation:

This rock unit was originally introduced from its type area (Wadi Wata, west Central Sinai) by Ghorab (1961). At West Gabal Thelmet section, the Wata Formation attains about 57 m thick (Samples 66-110), and it consists of hard ledges of fossiliferous dolomitic limestone, intercalated with some layers of shale and marl. It includes the Upper Turonian ammonites with some oysters, gastropods and echinoids. Also, the lowermost part of this rock unit has planktonic foraminiferal assemblages of Late Turonian age, while its upper part is barren of any foraminiferal content.

In the study area, the Wata Formation may be correlated with the upper part of Wata Fm. at Southern Galala Plateau (Abu Khadrah et *al*.., 1987); the upper part of Maghara El- Hadida Fm. at Ataqa and the two Galalas (Issawi *et al.*, 1999); the upper part of Adabiya Fm. at Northern Galala Plateau (Abd El Shafy & Atta, 1993); and also with the upper part of Tarfa Fm. at Wadi Qena area (Bandel *et al.*, 1987).

At West Gabal Thelmet section, the Wata Formation unconformably overlies the Abu Qada Formation and its base is defined by the first appearance of the Upper Turonian ammonites, such as *Coilopoceras requienianum* d' Orbigny, and *Hoplitoides latefundates* (Zaborski). On the other hand, this rock unit unconformably underlies the Matulla Formation. Such a contact is defined by the change from the dominated carbonate facies of the Wata Formation at the base, to the dominated clastic facies of the studied lower mostpart of Matulla Formation at top.

At the study area, the age of the Wata Formation is assigned to Late Turonian, based on its ammonites, in addition to some recorded planktonic foraminiferal content (**Fig. 3**).

The correlation of the Cenomanian - Turonian lithostratigraphic units, that applied by various authors at the different localities of Egypt, with their equivalents at the studied area, are shown in (**Table.1**).

3. Faunal biostratigraphy

In the present study area, both the Malha Formation and the studied lowermost part of Matulla Formation were found barren from any foraminiferal and macrofaunal content and their ages are depending on their stratigraphic position. On the other hand, the exposed Cenomanian Turonian succession at West Gabal Thelmet section was found very rich in macro faunal content represented mainly by Bivalvia, Cephalopoda, Gastropoda and Echinoidea; in addition to some foraminiferal assemblages occur in sporadic intervals. Sixty-four macro-fossil species have been identified; of them twenty-two belong to the Bivalvia, twenty-three to the Cephalopoda, eleven to the Gastropoda and eight to the Echinoidea. On other hand, twenty-two foraminiferal species were identified, of which seventeen species are planktonics and five are benthonics.

Depending on examination of the vertical stratigraphic distribution of these identified fauna, two biostratigraphic schemes for the Cenomanian – Turonian succession at Gabal Thelmet section are established; the first is based on the foraminiferal assemblages and the other on the macrofossils. Integration between these two schemes is attempted to reach to high-resolution stratigraphic scheme, during the studied time interval.

The zonal marker species of both planktonic and benthonic foraminifera are photographed by (SEM) and shown on (**plate 1**). Also, the most dominated and index recorded macrofaunal species in the studied succession are photographed and illustrated on (**plate 2**).

3.1. Foraminiferal biostratigraphic zonation

At West Gabal Thelmet section, the sporadic occurrence of various species of the index genera of planktonic foraminifera, as *Helvetoglobotruncana, Whiteinella* and *Hedbergella;* in addition to some dominant and representative benthic genera, as *Thomasinella* and *Haplophrogmoides* have led to the recognition of four foraminiferal biozones belonging to the Cenomanian- Turonian interval; the earliest one of them is benthic of Late Cenomanian and the other three zones are planktonic: (one of Latest Cenomanian, one of Early Turonian and one of Early to late Turonian), in addition to two barren intervals.

The international biozonations schemes of Caron (1985) and Robaszynski *et al*. (1984) are followed here for the planktonics; while the identified benthonic foraminiferal biozone is local and controlled by environmental and ecological conditions.

The following is the description of the established foraminiferal biozones, as arranged from older to younger:

3.1.1- Barren interval -1:

The lowermost part of the Galala Formation is found barren of any foraminiferal assemblages. This interval attains about 12 m thick (Samples 6-11) and it may be assigned to Middle Cenomanian age, based on its included macrofaunal content, as it equivalent to the recorded *Ilymatogyra africana* macrofaunal biozone.

3.1.2- *Thomasinella aegyptia* Zone (Total range Zone):

In the study area, this benthonic foraminiferal biozone is defined as a biostratigraphic interval of the total range of *Thomasinella aegyptia* Omara. At West Gabal Thelmet section, this biozone is represented by the middle part of Galala Formation (Samples 12-23), and it attains about 20 m thick. It is assigned to Late Cenomanian age, based on its macrofaunal content, as it equivalent to recorded *Exogyra (Costagyra) olisiponensis* and *Neolobites vibrayeanus* macrofaunal biozones.

This zone is equivalent to *Thomasinella fragmentaria* Zone of Ansary *et al*. (1962) at Ezz El Orban area, Gulf of Suez region, Egypt. The most important benthonic foraminiferal species recorded from this zone are *Haplophrogmoides eggeri* Cushman, *Ammobaculites rowi* Banner, *Ammobaculites texanus* Cushman, *Thomasinella punica* Schlumberger, *Thomasinella fragmentaria* Omara and *Thomasinella aegyptia Omara*. On the other hand, we were not recorded any planktonic foraminiferal assemblages in this biozone (**Fig. 3**).

3.1. 3- *Helvetoglobotruncana praehelvetica / Whiteinella paradubia* Zone (Partial range Zone):

In the study area, the *Helvetoglobotruncana praehelvetica* Zone is defined, as a biostratigraphic interval extended from the first appearance of *Helvetoglobotruncana praehelvetica, Trujillo* and *Whiteinella paradubia Sigal*, at the base, to the first appearance of *Whiteinella archaeocretacea* Bolli at the top. At West Gabal Thelmet section, this biozone is represented by the upper part of Galala Formation (Samples 24-35), and it attains about 18 m thick. It is assigned to Latest Cenomanian, based on its index planktonic foraminiferal content, in addition to its macrofaunal content, as it equivalent to the recorded *Vascoceras cauvini* macrofaunal biozone.

The recorded *Helvetoglobotruncana praehelvetica/ Whiteinella paradubia* Zone may be equivalent to the upper part of *Rotalipora cushmani* Zone of Caron (1985) in the Tropical region; and Barr (1972) in Libya. It also equivalent to *Mantelliceras mantelli* Zone of Van Hinte (1978) in the Tethyan realm; Heterohelix *globulosa* Zone of Ghorab (1961) in the Gulf of Suez; *and Helvetoglobotruncana praehelvetica* Zone of Kora *et al*. (2001) in the Gulf of Suez. The most important planktonic foraminiferal species recorded from this zone are *Hedbergella delrioensis* (Carsey), *Helvetoglobotruncana praehelvetica,* Trujillo, *Hedbergella planispira* (Tappan) and *Globigerinelloides ultramicra* Subbotina. On the other hand, we were not recorded any benthonic foraminiferal assemblages in this zone (**Fig. 3**).

3.1. 4- *Whiteinella archaeocretacea* Zone (Total range Zone):

In the study area, this biozone is defined, according to Bolli (1966), as a biostratigraphic interval of the total range of the marker species *Whiteinella archaeocretacea* Passagno. At West Gabal Thelmet section, *Whiteinella archaeocretacea* biozone is represented by the lower part of Abu Qada Formation (Samples 36-50), and it attains about 17 m thick. It is assigned to Early Turonian based on its planktonic foraminiferal assemblages, in addition to its macrofaunal content, as it equivalent to the recorded *Vascoceras proprium* and the lower part of *Choffaticeras (Choffaticeras) segne* Zones.

This biozone is equivalent to *Whiteinella archaeocretacea* Zone of Caron (1985) in the Tropical region, *Praeglobotruncana helvetica* Zone of Barr (1972) in Libya, *Guembelina globulosa* Zone of Ansary *et al*. (1962) in the Gulf of Suez and *Discorbis turonicus* zone of Ghorab (1961) in the Gulf of Suez. At West Gabal Thelmet section, the foraminiferal content of *Whiteinella archaeocretacea* Zone is characterized by the proliferation of heterohelicids and hedbergellids. On the other hand, we were not recorded any benthonic foraminiferal assemblages in this biozone. The most important planktonic foraminiferal species recorded from this zone are *Guembelitria cenomana* Keller, *Heterohelix reussi* (Cushman), *Heterohelix moremani* (Cushman), *Heterohelix globulosa* Ehrenberg, *Globigerinelloides ultramicra* Subbotina, *Helvetoglobotruncana praehelvetica,* Trujillo, , *Helvetoglobotruncana helvetica* Bolli, *Praeglobotruncana stephani* Gandolfi, *Whiteinella archaeocretacea* Passagno, *Whiteinella paradubia*

Sigal, *Whiteinella baltica* Douglas & Rankin, *Praeglobotruncana delrioensis* (Plummer), *Praeglobotruncana gibba* Klaus, *Hedbergella delrioensis* (Carsey), *Hedbergella planispira* (Tappan), *Hedbergella simplex* (Morrow) and *Hedbergella flandrini* Prothault.

In the studied section the Cenomanian/Turonian boundary (C/T) is cited between the top of Latest Cenomanian *Helvetoglobotruncana praehelvetica* Zone and the base of Lower Turonian *Whiteinella archaeocretacea* Zone (**Fig. 3**).

3.1.5- *Hedbergella flandrini / Whiteinella baltica* Zone (Partial range Zone):

In the study area, this biozone is defined, as a biostratigraphic interval extended from the last appearance of *Whiteinella archaeocretacea* Bolli, at the base, to the last appearance of both *Hedbergella flandrini* Prothault and *Whiteinella baltica* Douglas & Rankin, at the top. At West Gabal Thelmet section, this biozone is represented by the upper part of Abu Qada Formation and extends to the lower most part of the Wata Formation (Samples 51-76), and it attains about 28 m thick. It is assigned to Early - Late Turonian, based on its index planktonic foraminiferal assemblages, in addition to its macrofaunal content, as it equivalent to the recorded upper part of *Choffaticeras (Choffaticeras) segne*, in addition to *Coilopoceras requienianum* macrofaunal biozones.

Rare planktonic foraminiferal species were recorded from this zone and represented only by *Whiteinella baltica* Douglas & Rankin, *Praeglobotruncana delrioensis* (Plummer) and *Hedbergella flandrini* Prothault. In the studied section the Early / Late Turonian boundary is cited within this biozone and matches with Abu Qada and Wata formational boundary, and depending on the recorded macrofaunal biozones, it is located between *Choffaticeras (Choffaticeras) segne* and *Coilopoceras requienianum* biozones. On the other hand, we were not recorded any benthonic foraminiferal assemblages in this zone.

The vertical distribution charts of the identified foraminiferal species with their equivalent zones and the suggested ages at the studied section are illustrated on (**Fig. 3**).

3.1. 6- Barren interval - 2:

The uppermost part of the Wata Formation is found barren of any foraminiferal assemblages. This interval attains about 46m thick, and it may be assigned to the Latest Turonian age, based on its stratigraphic position, between the *Hedbergella flandrini / Whiteinella baltica* Zone of late Turonian age at the base and extends to Matulla Formation of coniacian to santonian age, at the top.

The Turonian / Coniacian-Santonian boundary is difficult to cite in the study area on foraminiferal basis, due to the absence of the planktonic foraminiferal elements. This boundary is cited mostly at the top of the Wata Formation on the basis of vertical facies change from the dominated carbonate facies of Wata Formation, at the base to the dominated clastic facies of the studied lower most part of Matulla Formation, at the top and, also it was accompanied with the complete extinction of the top Turonian ammonite taxa, such as the top of *Coilopoceras requienianum* Zone. The correlation of the Cenomanian-Turonian foraminiferal biozones established at West Gabal Thelmet area and those previously established inside/ outside Egypt are shown on (**Table. 2**).

Age		Tropical region: Caron (1985)	Libya: Barr (1972)	Israel: Lipson-Benitah (1997)	Gulf of Suez: Ghorab (1961)	Gulf of Suez: Ansary et al. (1962)	Gulf of Suez: Ansary& Tewfik (1969)	Gulf of Suez: El-Shanawi & Sultan (1972)	Sinai: South western Sinai, Shahin (1988) Benthonic	Sinai: South western Sinai, Shahin (1988) Planktonic	Sinai: Eastern central Sinai, Shahin &Kora (1991)	Present study: West Gaba Thelmet area
Turonian	Late	*M. sigali* / *H. helvitica*	*Praeglobotruncana helvitica*	*Marginotruncana helvitica*	*Discobis turonicus*	*Guembilina globulosa*	Barran	*Heterohelix globulosa*	Barran	*Heterohelix globulosa*	*H. helvitica*	*Hedbergella flandrini / Whiteinella baltica*
	Early	*Whiteinella archaeo-cretacea*									*Whiteinella archaeocretacea*	*Whiteinella archaeocretacea*
Cenomanian	Late	*Rotalipora cushmani*	*Rotalipora cushmani*	*Rotalipora cushmani*	*Heterohelix globulosa*	Barren	*Thomasinella punica* / *Thomasinella fragmentaria*	Barren / *Thomasinella punica*	*Thomasinella punica*	*Rotalipora cushmani*	*Paraglobotruncana Hedbergella*	*Helvetoglobotruncana praehelvetica*
	Middle	*Rotaipora reicheli*	*Rotalipora appennica*	*Rotalipora Globotruncanides*	Barren	*Thomasinella aegyptia*	Barren	Barren	*Thomasinella aegyptia*	*Rotaipora reicheli*	*Thomasinella*	*Thomasinella aegyptia*
	Early	*Rotaipora botzeni*		*Rotaipora botzeni*	*Thomasinella aegyptia*	*Thomasinella fragmentaria*			*Thomasinella fragmentaria*	*Rotaipora botzeni*	*Daxia*	Barren interval

Table. 2: Correlation of the Cenomanian-Turonian foraminiferal biozones established at West Gabal Thelmet area and those previously established in -out side of Egypt.

Age	Wright& Kennedy (1981) Europe	Kassab& Obaidallah (2001) Wadi Feiran, Sinai	Kora *et al.* (2001) Gulf of Suez Region	El-Hedeny (2002) Sinai	Zakhera&Kassab (2002) West central Sinai	Hewaidy *et al.* (2003) Eastern Desert	Khalil& Mashaly (2004) W. Sinai	Abdel- Gawad *et al.* (2004) Sinai	Khalil (2007) Sinai: Ammonite	Khalil (2007) Sinai: Bivalva	Abdel- Gawad *et al.*(2004) & El Qot (2008) North Eastern Desert	Nagm *et al.* 2010 North Eastern Desert	El Qot and Afifi (2010) Sinai	Present study West Gabal Thelmet area
Turonian	*Romaniceras deverianum*	*Coilpoceras requienianum*	*Coilpoceras requienianum*	*Coilpoceras requienianum*	*Coilpoceras requienianum*	*Coilpoceras requienianum*	*Coilpoceras requienianum*	*Coilpoceras requienianum*	*Coilpoceras requienianum*	Barren interval	*Coilpoceras requienianum*	*Coilpoceras requienianum*	*Coilpoceras requienianum*	*Coilpoceras requienianum*
	Coilgnoniceras woollgari	*Choffaticeras segne*		*Choffaticeras segne*	*Choffaticeras segne*	*Hoplitoides ingens*	*Vascoceras proprium/ Choffaticeras segne*	*Ch. sinatticum-Thomasites rolandi*	*Choffaticeras segne*		*Choffaticeras segne*	*Choffaticeras spp.*	*Choffaticeras luciae*	*Choffaticeras segne*
	Mammites nodosides			*Vascoceras cauivini*	*Mammites nodosides*	*Choffaticeras Luciae*		*Ch.segne- V. hartti*					*Choffaticeras segne*	
	Waitinoceras coloradoense	*Vascoceras proprium/ Vascoceras obseum*	*Mammites nodosides-Choffaticeras segne*		*Pseudaspidoceras flexuosum/ V.proprium*	*Choffaticeras segne-Vascoceras pioti-V. proprium*		*Ch. securiforme -Ch.quassi*	*Vascoceras proprium*	*Pycnodonte(Ph.) vesiculosa-Rastellum carinatum*		*Vascoceras proprium*	*Choffaticeras securiforme*	*Vascoceras proprium*
Cenomanian	*Neocardioceras juddii*	*Vascoceras cauivini*	*Exogyra(C.) olisiponensis*		*Vascoceras cauivini*	*Vascoceras cauivini*	*Exogyra (C.) olisiponensis*	*Vascoceras cauivini-Pseudaspidoceras pseudonodosides - Rubroceras alatum*	*Vascoceras cauivini*	*Exogyra(C.) olisiponensis*	*Vascoceras cauvini*	*Vascoceras cauvini*	*Vascoceras cauivini*	*Vascoceras cauivini*
	Metoiceras geslinianum	*Neolobites vibrayeanus*	*Ilymatogyra (A.) africana-Neolobites vibrayeanus*	*Neolobites vibrayeanus*	*Metoiceras geslinianum*		*Ilymatogyra (A.) africana-Neolobites vibrayeanus*		*Metoiceras geslinianum*	*Ilymatogyra (A.) africana-*	*Neolobites vibrayeanus/ Thomalites sornayi*	*Metoiceras geslinianum*	*Neolobites vibrayeanus*	*Neolobites vibrayeanus* *Exogyra (C.) olisiponensis*
	Calycoceras guerangeri				*Neolobites vibrayeanus*	*Neolobites vibrayeanus*	*Amphidonte(C.) flabellatum*		*Neolobites vibrayeanus*	*Amphidonte(C.) flabellatum*		*Neolobites vibrayeanus*		*Ilymatogyra (A.) africana*

Table. 3: Correlation of the Cenomanian-Turonian macrofaunal biozones established at West Gabal Thelmet area with those previously established in -outside of Egypt

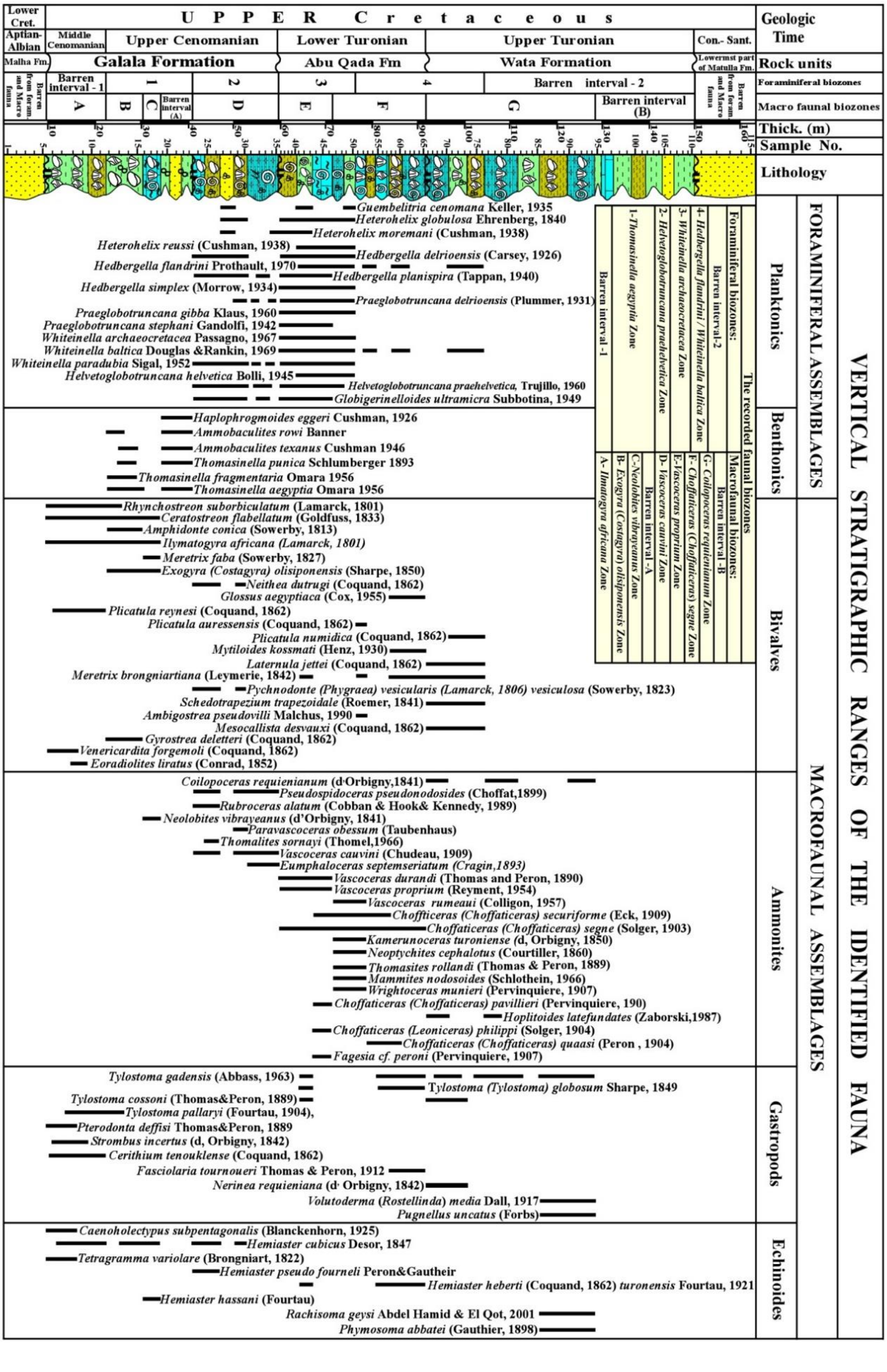
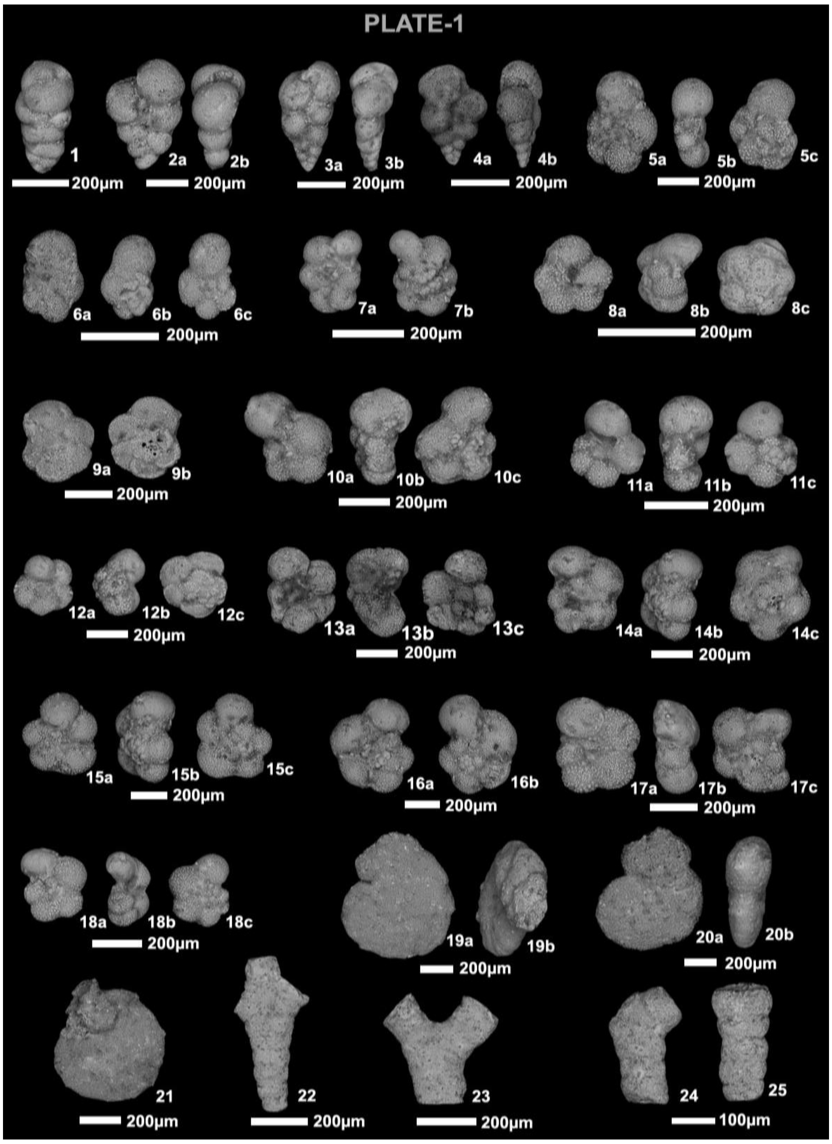
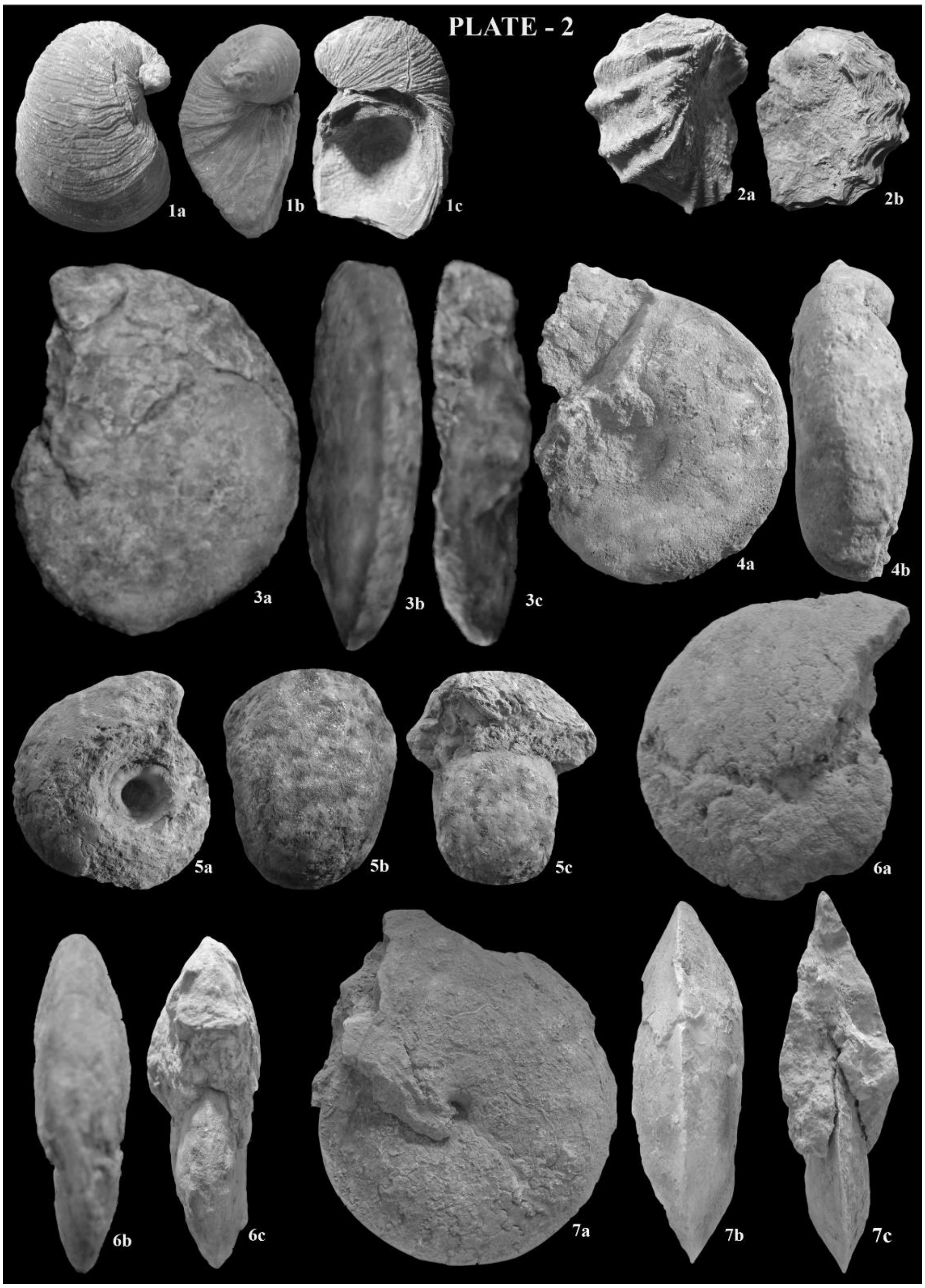


Fig. 3: The vertical distribution charts of the identified foraminiferal and macrofaunal assemblages with their equivalent zones and suggested ages at West Gebel Thelmet section.



<u>**Explanation of PLATE – 1**</u>

1- *Guembelitria cenomana* Keller, 1935, sample 38, Abu Qada Formation; **2- *Heterohelix globulosa* Ehrenberg, 1840**, sample 42, Abu Qada Formation; **3- *Heterohelix moremani* (Cushman)**, sample 37 , Abu Qada Formation; **4- *Heterohelix reussi* (Cushman)**, 1938, sample 40, Abu Qada Formation; **5- *Hedbergella flandrini* Prothault, 1970**, sample 49, Abu Qada Formation; **6- *Hedbergella simplex* (Morrow, 1934)**, sample 44, Abu Qada Formation; **7- *Hedbergella planispira* (Tappan)**, sample 38, Abu Qada Formation; **8- *Hedbergella delrioensis* (Carsey),** sample 39, Abu Qada Formation; **9- *Praeglobotruncana gibba* Klaus, 1960**, sample 38, Abu Qada Formation; **10- *Praeglobotruncana stephani* Gandolfi, 1942**, sample 37, Abu Qada Formation; **11- *Praeglobotruncana delrioensis* (Plummer),** sample 49, Abu Qada Formation; **12- *Whiteinella baltica* Douglas & Rankin, 1969,** sample 72, Wata Formation. **13- *Whiteinella paradubia* Sigal, 1952, sample 30, uppermost Galala Formation; 14 & 15- *Whiteinella archaeocretacea* Passagno, 1967**, sample 42, Abu Qada Formation; **16- *Helvetoglobotruncana helvetica* Bolli, 1945,** sample 39, Abu Qada Formation; **17- *Helvetoglobotruncana praehelvetica,* Trujillo, 1960**, sample 26, Galala Formation; **18 - *Globigerinelloides ultramicra* Subbotina, 1949,** sample 29, Galala Formation; **19- *Ammobaculites rowi* Banner,** sample 12 , Galala Formation; **20- *Ammobaculites texanus* Cushman 1946,** sample 14, Galala Formation; **21- *Haplophrogmoides eggeri* Cushman, 1926**, sample 19 , Galala Formation; **22- *Thomasinella fragmentaria* Omara 1956,** sample 13, Galala Formation; **23- *Thomasinella aegyptia* Omara 1956**, sample 15, Galala Formation; **24 & 25- *Thomasinella punica* Schlumberger 1893**, sample 14, Galala Formation.



Explanation of PLATE – 2

1- *Ilymatogyra africana* (Lamarck, 1801), sample 6, Galala Formation, X1; 2- *Exogyra* (*Costagyra*) *olisiponensis* (Sharpe, 1850), sample 12, Galala Formation, X0.5; 3**- *Neolobites vibrayeanus* (d'Orbigny, 1841),** sample 17, Galala Formation, X0.5.**4- *Vascoceras cauvini* (Chudeau, 1909),** sample 32, topmost part of Galala Formation, X0.5; **5-*Vascoceras proprium* (Reyment, 1954)**, Abu Qada Formation, sample 28, X1; **6- *Choffaticeras* (*Choffaticeras*) *segne* (Solger, 1903),** sample 38, Abu Qada Formation, X0.5; **7- *Coilopoceras requienianum* (d'Orbigny, 1841),** sample 80, Wata Formation, X0.5.

3.2. Macrofaunal biostratigraphic zonation

The vertical distributions of the identified macrofaunal assemblages, specially Bivalvia and Cephalopoda are helped in classification of the Cenomanian –Turonian interval, at West Gabal Thelmet section, into seven macrofaunal biozones: one of the Middle Cenomanian; three of the Late Cenomanian; two of the Early Turonian; and one of the Late Turonian; in addition to two barren intervals intervene these established zones.

These seven distinguished macrofaunal biozones are described in the following paragraphs, from older to younger:

3.2. A- *Ilymatogyra africana* Zone (Partial range Zone):

In the present studied area, the *Ilymatogyra africana* Zone is defined as a biostratigraphic interval extended from the first appearance of *Ilymatogyra (Afrogyra) africana* (Lamarck) at the base to the first appearance of *Exogyra (Costagyra) olisiponensis* (Sharpe) at the top. At West Gabal Thelmet section, this biozone is represented by the lowermost part of Galala Formation (Samples 6-11) and it attains about 12 m thick. It is assigned to Middle Cenomanian age and it is correlated with *Exogyra africana* Zone of Awad & Issawi (1974) in Egypt general zonation; and also equivalent to *Ilymatogyra africana* Zone of Kora and Hammama (1987) in Southeastern Sinai.

This biozone is characterized by rich megafossil assemblages and the most dominant of them include the bivalves: *Rhynchostreon suborbiculatum* (Lamarck), *Ceratostreon flabellatum* (Goldfuss), *Ilymatogyra africana* (Lamarck) *Plicatula reynesi* Coquand, *Venericardita forgemoli* (Coquand), and *Eoradiolites liratus* (Conrad); the gastropods: *Tylostoma pallaryi* (Fourtau), *Cerithium tenouklense* (Coquand), *Strombus incertus* (d, Orbigny) and *Pterodonta deffisi* Thomas & Peron; in addition to the echinoids: *Hemiaster cubicus* Desor, *Tetragramma variolare* (Brongniart), and *Caenoholectypus subpentagonalis* (Blanckenhorn).

3.2. B- *Exogyra (Costagyra) olisiponensis* Zone (Partial range Zone):

In the present studied area, the *Exogyra (Costagyra) olisiponensis* Zone is defined as a biostratigraphic interval extended from the first appearance of *Exogyra (Costagyra) olisiponensis* (Sharpe) at the base to the first appearance of *Neolobites vibrayeanus* (d'Orbigny) at the top.

At West Gabal Thelmet section, this biozone is represented by the upper lower part of Galala Formation (Samples 12-15), and it attains about 10 m thick. It is assigned to early Late Cenomanian age and it is correlated with lower part of the recoded *Thomasinella aegyptia* benthic foraminiferal biozone.

This zone may be equivalent to the *Exogyra* (*Costagyra*) *olisiponensis* Zone of Kora &Hammama (1987) in Southeastern Sinai, Abdel Gawad (1999) in Sinai, Khalil& Mashaly (2004) in west Sinai and Khalil (2007) in Sinai. The most dominant macrofaunal assemblages recorded from this biozone include the bivalves: *Rhynchostreon suborbiculatum* (Lamarck), *Ceratostreon flabellatum* (Goldfuss), *Amphidonte conica* (Sowerby), *Ilymatogyra africana* (Lamarck), *Exogyra (Costagyra) olisiponensis* (Sharpe) and *Gyrostrea deletteri* (Coquand); the gastropods: *Tylostoma pallaryi* (Fourtau); in addition tothe echinoids: *Hemiaster cubicus* Desor.

3.2. C- *Neolobites vibrayeanus* Zone (Total range Zone):

In the present studied area, the *Neolobites vibrayeanus* Zone is defined as a biostratigraphic interval represented by the extension of the total range of the marker species *Neolobites vibrayeanus* (d'Orbigny). At West Gabal Thelmet section, this biozone comprises the middle part of Galala Formation (Samples 16-18), and it attains about 3 m thick. It is assigned to early Late Cenomanian age and it is correlated with middle part of the recorded *Thomasinella aegyptia* benthic foraminiferal biozone.

The *Neolobites vibrayeanus* Zone is widely known from the lower Upper Cenomanian in Egypt, Jordan, Negev, Tunisia, Algeria and Morocco (e.g., Awad and Issawi, 1974; Lewy *et al*., 1984; Charriere *et al*., 1998; Kora *et al*., 2001; Kassab & Obaidallah; 2001; Aly and Abdel Gawad, 2001; Aly et al., 2008; Hewaidy *et al*., 2003; and Nagm *et al*., 2010).

The most dominant macrofaunal assemblages recorded from this biozone include the bivalves: *Ceratostreon flabellatum* (Goldfuss), *Ilymatogyra africana* (Lamarck), *Meretrix faba* (Sowerby) and *Exogyra (Costagyra) olisiponensis* (Sharpe); the echinoids: *Hemiaster cubicus* Desor and *Hemiaster* *hassani* (Fourtau); in addition to only one zonal marker species of ammonites: *Neolobites vibrayeanus* (d'Orbigny).

3.2. D- Barren interval (A):

At West Gabal Thelmet, the lower upper part of Galala Formation is found barren of any macrofaunal assemblages (Samples 19-23), and it attains about 7 m thick. This interval may be assigned to Late Cenomanian age based on its stratigraphic position between the *Neolobites vibrayeanus* Zone of early Late Cenomanian age at the base and *Vascoceras cauvini* Zone of Latest Cenomanian age at the top. On the other hand, it is correlated with upper part of the recorded *Thomasinella aegyptia* benthic foraminiferal biozone.

3.2. E- *Vascoceras cauvini* Zone (Total range Zone):

In the present studied area, the *Vascoceras cauvini* Zone is defined as a biostratigraphic sequence represented by the interval of total range of the marker species *Vascoceras cauvini* (Chudeau). At West Gabal Thelmet section, this biozone comprises the topmost part of Galala Formation (Samples 24-35), and it attains about 18 m thick. It is assigned to the Latest Cenomanian age and is correlated with the recorded *Helvetoglobotruncana praehelvetica / Whiteinella paradubia* planktonic foraminiferal biozone.

This zone is equivalent to *Vascoceras cauvini* Zone of Kassab (1991) in North Eastern Desert, and *Vascoceras cauvini* Zone of Kassab & Obaidallah (2001) in South Sinai. It is also equivalent to the *Exogyra (Costagyra) olisiponensis* Zone of Kora & Hamama (1987) in Southeastern Sinai and *Exogyra (Costagyra) olisiponensis/ Pycnodonte vesiculosum* Zone of Hewaidy *et al*. (2003) in West Wadi Araba, North Eastern Desert..

This biozone is characterized by rich megafossil assemblages, and the most dominant of them include the ammonites: *Pseudospidoceras pseudonodosides* (Choffat), *Rubroceras alatum (*Cobban, Hook & Kennedy), *Paravascoceras obessum* (Taubenhaus), *Thomalites sornayi* (Thomel), *Vascoceras cauvini* (Chudeau), and *Eumphaloceras septemseriatum* (Cragin); bivalves: *Neithea dutrugi* (Coquand) and *Pychnodonte (Phygraea) vesicularis* (Lamarck) *vesiculosa* (Sowerby); in addition to the echinoids: *Hemiaster cubicus* Desor and *Hemiaster pseudofourneli* Peron & Gauthier.

3.2. F- *Vascoceras proprium* Zone (Lineage zone):

In the present studied area, the *Vascoceras proprium* Zone is defined as a biostratigraphic interval extended from the last occurrence of the *Vascoceras cauvini* (Chudeau), at the base, to the last occurrence of the *Vascoceras proprium* (Reyment), at the top. At West Gabal Thelmet section, this biozone is represented by the lower part of Abu Qada Formation (Samples 36-46), and it attains about 14 m thick. It is assigned to Early Turonian age and it is correlated with the lower part of *Whiteinella archaeocretacea* planktonic foraminiferal biozone.

This zone is equivalent to the *Vascoceras proprium* Zone of Meister *et al*. (1992) in Niger, *Vascoceras pioti* Zone of Lewy *et al.* (1984) in Negev, *Vascoceras proprium* /*Vascoceras obessum* Zone of Kassab (2001) in South Sinai and Zakhera (2001) in west Central Sinai, and also equivalent to *Vascoceras pioti* /*Vascoceras proprium* Zone of Hewaidy *et al.*, (2003) in west Wadi Araba, North Eastern Desert..

This biozone is characterized by rich megafossil assemblages, and the most dominant of them include the ammonites: *Vascoceras durandi* (Thomas and Peron), *Vascoceras proprium* (Reyment), *Choffaticeras (Choffaticeras) segne* (Solger), *Choffticeras securiforme* (Eck), *Choffaticeras (Choffaticeras) pavillieri* (Pervinquiere), *Choffaticeras (Leoniceras) philippi* (Solger), and *Fagesia cf. peroni* (Pervinquiere); the gastropods: *Tylostoma gadensis* (Abbass), *Tylostoma (Tylostoma) globosum* Sharpe, and *Tylostoma cossoni* Thomas & Peron; bivalves: *Meretrix brongniartiana* (Leymerie); in addition to the echinoids: *Hemiaster heberti* (Coquand).

3.2. G- *Choffaticeras (Choffaticeras) segne* Zone (Lineage Zone):

In the present studied area, the *Choffaticeras (Choffaticeras) segne* Zone is defined as a biostratigraphic interval extended from the last occurrence of the *Vascoceras proprium* (Reyment), at the base, to the last occurrence of the *Choffaticeras (Choffaticeras) segne* (Solger), at the top. At West Gabal Thelmet section, this biozone is represented by the upper part of Abu Qada Formation (Samples 47-65), and it attains about 20 m thick. It is assigned to Early Turonian age and is correlated with the upper part of *Whiteinella* *archaeocretacea* and the lower part of *Hedbergella flandrini / Whiteinella baltica* planktonic foraminiferal biozones.

This zone is equivalent to the *Acteonella salamonis* and *Meretrix faba –Arca tumida* Zones of Awad & Issawi (1974) in Egypt. It is also equivalent to: *Choffaticeras (Choffaticeras) segne* Zone of Kassab & Obaidallah (2001) in Southern Sinai, Aly and Abdel Gawad (2001) in west Central Sinai, and Hewaidy *et al*., (2003) in West Wadi Araba, North Eastern Desert. This biozone is characterized by rich megafossil assemblages, and the most dominant of them include the bivalves: *Glossus aegyptiaca* (Cox), *Plicatula auressensis* (Coquand), *Mytiloides kossmati* (Henz), *Meretrix brongniartiana* (Leymerie), *Ambigostrea pseudovilli* Malchus; ammonites: *Vascoceras rumeaui* (Colligon), *Choffticeras securiforme* (Eck), *Choffaticeras* (Choffaticeras) *segne* (Solger), *Kamerunoceras turoniense* (d'Orbigny), *Neoptychites cephalotus* (Courtiller), *Thomasites rollandi* (Thomas & Peron), *Mammites nodosoides* (Schlothein), *Wrightoceras munieri* (Pervinquiere), and *Choffaticeras (Choffaticeras) quaasi* (Peron); gastropods: *Tylostoma gadensis* (Abbass), *Tylostoma (Tylostoma) globosum* Sharpe and *Fasciolaria tournoueri* Thomas & Peron, in addition to the echinoids: *Hemiaster heberti* (Coquand).

3.2. H- *Coilopoceras requienianum* Zone (Total range Zone):

In the present studied area, the *Coilopoceras requienianum* Zone is defined as a biostratigraphic sequence represented by the interval of the total range of the marker species *Coilopoceras requienianum* (d' Orbigny). At West Gabal Thelmet section, this biozone represented by the lower part of Wata Formation (Samples 66-94), and it attains about 35 m thick. It is assigned to Late Turonian age and it is correlated, with the upper part of *Hedbergella flandrini / Whiteinella baltica* planktonic foraminiferal biozone, in addition to the lower part of (barren interval - 2). This zone is equivalent to the *Coilopoceras inflatum* Zone of Meister *et al*. (1992) in Niger, *Coilopoceras* sp. Zone of Abdel Gawad (1999) in Sinai, *Coilopoceras requienianum* Zone of Kassab & Obaidallah (2001) in South Sinai and *Coilopoceras requienianum* Zone of Kora *et al*. (2001) from the Gulf of Suez, and also equivalent to *Coilopoceras requienianum* Zone of Hewaidy *et al.* (2003) in West Wadi Araba, North Eastern Desert.

This biozone is characterized by rich megafossil assemblages, and the most dominant of them include the bivalves: *Plicatula numidica* (Coquand), *Laternula jettei* (Coquand), *Meretrix brongniartiana* (Leymerie), *Schedotrapezium trapezoidale* (Roemer), and *Mesocallista desvauxi* (Coquand); the ammonites: *Hoplitoides latefundates* (Zaborski) and *Coilopoceras requienianum* (d' Orbigny); the gastropods: *Tylostoma gadensis* (Abbass), *Tylostoma (Tylostoma) globosum* Sharpe, *Tylostoma cossoni* Thomas & Peron, *Nerinea requieniana* (d' Orbigny), *Volutoderma (Rostellinda) media* Dall and *Pugnellus uncatus* (Forbes); in addition to the echinoids: *Phymosoma abbatei* (Gauthier) and *Rachisoma geysi* Abdel Hamid & El Qot.

3.2. I- Barren interval (B):

At West Gabal Thelmet, the uppermost part of Wata Formation is found barren of any macrofaunal assemblages (Samples 95-110), and it attains about 22 m thick. This interval may be assigned to the Latest Turonian age, based on its stratigraphic position, as it directly overlies the *Coilopoceras requienianum* Zone of Late Turonian age at the base, and extended to the studied lowermost part of Matulla Formation, which may be of Coniacian age at the top.

The correlation of the Cenomanian-Turonian macrofaunal biozones established at West Gabal Thelmet area, with those previously established inside/ outside Egypt, are shown on (**Table 3**).

4. Sequence stratigraphy

The sequence stratigraphy has been approved to be a useful tool in correlating and interpretating the depositional systems in the space and time. So, the establishing of sequence stratigraphic framework for the studied Cenomanian -Turonian succession at West Gabal Thelmet area is used to explain the observed lateral and vertical facies changes, as well as to detect the sequence boundaries and the relationships of global events on the nature of contacts, that separate them in the northern escarpment of Southern Galala Plateau.

This sequence stratigraphic classification is based on the detailed examination of both the included macro- and foraminiferal contents, in addition to the main lithologic characters. The age and paleoenvironmental contrast indicated by the fossil assemblages from above and below the boundary, are both a function of the magnitude of relative sea-level fall.

Therefore, the integration between the lithologic characters, the detailed field examination for the stratigraphic surfaces, in addition to the faunal biostratigraphic studies helped in classification the Cenomanian – Turonian interval at West Gabal Thelmet section into four third-order depositional sequences (reflecting four depositional cycles in the relative sea level changes during this time) bounded by five type- one sequence boundaries represented by unconformity surfaces, which associated with vertical borings, incised valley fill deposits, dolomitization, biozonal lack and predominantly abrupt facies changes at the base of the transgressive systems tracts.

These four depositional sequences are two in the Cenomanian Galala Formation; one in the Lower Turonian Abu Qada Formation; one in the Upper Turonian Wata Formation. The first and fourth depositional sequences are subdivided into transgressive and highstand systems tracts; while the second and the third ones are represented by a transgressive system tract only. The lowstand system tract is missed in the all distinguished deposition sequences due to the fast change in the relative sea level over the study area.

The distinguished depositional sequences and correlation of the recorded sequence boundaries in the studied section, with those of the previous studies inside /outside Egypt, were illustrated on (**Figs. 4 &5**). The detailed description of the recorded depositional sequences and their bounding unconformity surfaces are discussed below and arranged, from older to younger, as follows:

4. A- The first sequence boundary (SB1):

This sequence boundary (SB1) coincides with the Malha / Galala formational boundary in the study area. It is widely distributed in the Eastern Desert and Sinai, and easily recognized in the field, as it represented by sharp, irregular and erosional contact surface, with the occurrence of paleosols, roots, wood trunks and high iron oxidations, marking the sharp boundary between the fluvio-marine sandstones of the Lower Cretaceous (Aptian - Albian) Malha Formation and the overlying siliciclastic / carbonate deposits of the Cenomanian Galala Formation, as representing the beginning of the transgressive phase. This sequence boundary (SB1) may correlate with the global sequence boundary Ce4 of Hardenbol *et al*. 1998. It is also recorded in Jordan as CeJo3 by Schulze *et al*., 2003& 2005 and Wendler *et al*., 2010.

4. B- Depositional sequence-1(DS1):

At West Gabal Thelmet section, this depositional sequence (DS1) represents the oldest depositional sequence in the studied interval. It comprises the (Middle- early Late Cenomanian) lower and middle parts of the Galala Formation. It attains about 32m thick, (Samples 6-23). It is bounded at base by the first sequence boundary (SB1), which separates the fluvio-marine sandstone of the Aptian-Albian (Malha Formation) from the overlying Cenomanian (Galala Formation) and topped by the second sequence boundary (SB2).

This depositional sequence is classified into a transgressive system tract (TST1) at base and a highstand system tract (HST1) at top; while the basal lowstand systems tract is missing due to the fast relative sea level rise over the study area and the transgressive surface coincides with the sequence boundary (SB1).

4. B. 1. Transgressive system tract- 1 (TST1):

At West Gabal Thelmet section, this transgressive systems tract (TST1) lies directly above the sequence boundary (SB1). It comprises the lower part of the Galala Formation, and attains about 25 m thick, (Samples 6-18). It covers the interval of the Middle Cenomanian *Ilymatogyra africana*, the early Late Cenomanian *Exogyra (Costagyra) olisiponensis* and the early Late Cenomanian *Neolobites vibrayeanus* macrofaunal zones. It also comprises the Middle Cenomanian (Barren interval -1) of foraminiferal biozones, in addition to the Late Cenomanian *Thomasinella aegyptia* benthonic Zone.

It is represented by retro-gradational parasequence sets of highly fossiliferous shales, intercalated with fossiliferous marl and argillaceous limestone. This (TST1) may be equivalent to Abu Had Member in Sinai; and it is characterized by rich and diverse megafossil, content, including a ratio of about (40 - 60 %) of bivalves represented mainly by: *Rhynchostreon suborbiculatum* (Lamarck), *Ceratostreon* *flabellatum* (Goldfuss), *Ilymatogyra africana* (Lamarck), *Exogyra (Costagyra) olisiponensis* (Sharpe), *Plicatula reynesi* Coquand, *Venericardita forgemoli* (Coquand), *Eoradiolites liratus* (Conrad), *Amphidonte conica* (Sowerby), *Meretrix faba* (Sowerby) and *Gyrostrea deletteri* (Coquand); of about (20-10%) gastropods represented mainly by: *Tylostoma pallaryi* (Fourtau), *Cerithium tenouklense* (Coquand), *Strombus incertus* (d, Orbigny) and *Pterodonta deffisi* Thomas & Peron; of about (40 -10%) echinoids represented mainly by: *Hemiaster cubicus* Desor, *Hemiaster hassani* (Fourtau),*Tetragramma variolare* (Brongniart) and *Caenoholectypus subpentagonalis* (Blanckenhorn); in addition to very rare ammonites of about (20%) and represented only by *Neolobites vibrayeanus* (d'Orbigny) in its upper part.

Also, this interval includes some arenaceous benthic foraminiferal assemblages in its upper part such as *Thomasinella aegyptia* Omara, *Thomasinella fragmentaria* Omara, *Thomasinella punica* Schlumberger, *Ammobaculites texanus* Cushman, *Ammobaculites rowi* Banner and *Haplophrogmoides eggeri* Cushman. The main species in the lower part of this (TST1) are *Ceratostreon flabellatum* (Goldfuss), *Ilymatogyra africana* (Lamarck) and *Exogyra (Costagyra) olisiponensis* (Sharpe) of bivalves, which are abundant and build shell banks and occur mostly in-situ and well preserved shells, reflecting the clear nature of the marine water. The rather fine-grained sediments imply deposition under low water energy, most likely below the normal wave base in slightly restricted parts of the shallow shelf.

Also, the presence of arenaceous benthic foraminifera in the middle part of this interval denotes a tidal flat environment (Bandy & Arnal, 1960), with less saline environment, which may be the near shore areas. The high density and diversity of the fauna from the base to the top in this (TST) suggest a rising in the relative sea level which indicates a transgressive phase and the environment was prevailed during the deposition of this (TST1), fluctuated between restricted to open shallow lagoonal environment, from its base to top.

4. B. 2. Maximum flooding surface-1 (MFS1):

The maximum flooding surface (MFS1) in this depositional sequence (DS1) coincides with the last occurrence of ammonites and it lies on the top of the early Late Cenomanian *Neolobites vibrayeanus* macrofaunal Zone, as it acts the acme of this transgressive phase within this depositional sequence (DS1).

4. B. 3. Highstand system tract-1 (HST1):

At West Gabal Thelmet section, this (HST1) directly overlies the (TST1) and is topped by the second sequence boundary (SB2) by a wide distributed hard ground. It represents the lower-upper part of Galala Formation and it attains about 7 m thick (samples 19 - 23). It may be assigned to Late Cenomanian age, based on its stratigraphic position between the *Neolobites vibrayeanus* Zone of the early Late Cenomanian age, at the base, and *Vascoceras cauvini* Zone of Latest Cenomanian age at the top, and it also correlated with upper part of the recorded *Thomasinella aegyptia* benthic foraminiferal biozone.

This (HST1) is represented by pro-gradational parasequence sets of reducing shallow lagoonal shale, intercalated with very fine sandstone, barren of any macrofaunal assemblages, but it contains very rare arenaceous benthonic genera as represented by *Thomasinella*, *Ammobaculites* and *Haplophrogmoides*. These characters supposed to be deposited in near-shore environment of high energy agitated conditions representing a regressive phase of the sea level indicating from the abrupt changing in the faunal content.

4.2. C. The second sequence boundary (SB2):

At West Gabal Thelmet section, this sequence boundary (SB2) separates the depositional sequence -1 (DS1) from the depositional sequence - 2 (DS2), representing the top of the coastal marine friable sandstones and shale, that cuts erosionally the upper carbonate unit of the Galala Formation below the *Vascoceras cauvini* Zone, reflecting a sedimentary break and most likely primarily denotes the effect of a major fall in the eustatic sea level, that characterized the middle part of the Late Cenomanian time (Haq *et al*., 1987 & 1988; Hardenbol *et al*., 1998; Wilmsen, 2003 and Schulze *et al*., 2005).

At West Gabal Thelmet section, this sequence boundary (SB2) is characterized by an abrupt facies change from the shallower lagoonal facies below to the deep subtidal facies above.

This sequence boundary (SB2) may be correlated with the sequence boundary (Ce5) of Hardenbol *et al*. 1998) and also recorded in Jordan as (CeJo4), by Schulze *et al*., 2003& 2005; and Wendler *et al*., 2010. On the other hand, it is recorded by different authors in the Eastern Desert specifically and Egypt generally (e.g. El-Sabbagh, 2008).

4.2. D. Depositional sequence - 2 (DS2):

At West Gabal Thelmet section, this depositional sequence (DS2) represents the topmost part of Galala Formation. It is bounded at base by the second sequence boundary (SB2), which separates the shallower lagoonal facies of the middle part of Galala Formation from the overlying deep subtidal facies of the topmost part of Galala Formation and topped by the second sequence boundary (SB3).

This depositional sequence (DS2) is represented only by the following transgressive system tract (TST2); while the basal lowstand system tract is missing, due to the fast relative sea level rise over the study area and the transgressive surface coincides with the sequence boundary (SB2). Also, the top highstand system tract is eroded and coincides with the third sequence boundary (SB3).

4.2. D. 1. Transgressive system tract - 2 (TST2):

At West Gabal Thelmet section, this transgressive system tract (TST2) lies directly above the sequence boundary (SB2). It comprises the uppermost part of Galala Formation, and attains about 18m thick (Samples 24-35).

It covers the interval of the Latest Cenomanian *Helvetoglobotruncana praehelvetica / Whiteinella paradubia* Zone planktonic foraminiferal Zone and the *Vascoceras Cauvini* macrofaunal Zone. It is represented by retro-gradational parasequence sets of shallow to deep subtidal highly fossiliferous limestone, intercalated with friable sandstones and fossiliferous marl in the lower part, grades upwardly into fossiliferous hard dolomitic limestones.

This (TST2) is characterized by rich and diverse megafossil assemblages, especially ammonites, which represent ratio of about (70 - 90%) and found in bank, especially in its upper part, as represented mainly by Vascoceras *cauvini* (Chudeau), in addition to *Pseudospidoceras pseudonodosides* (Choffat), *Rubroceras alatum (*Cobban, Hook & Kennedy), *Paravascoceras obessum* (Taubenhaus), *Thomalites sornayi* (Thomel) and *Eumphaloceras septemseriatum* (Cragin). Also, this (TST2) includes ratio of about (20- 5%) of bivalves as represented mainly by: *Neithea dutrugi* (Coquand) and *Pychnodonte (Phygraea) vesicularis* (Lamarck) *vesiculosa* (Sowerby); in addition to ratio of about (10 - 5%) of echinoids represented mainly by *Hemiaster cubicus* Desor, and *Hemiaster pseudofourneli* Peron & Gauthier.

On the other hand, this interval was found barren from any benthonic foraminiferal assemblages, but it contains some assemblages of planktonic foraminiferal assemblages represented mainly by: *Helvetoglobotruncana praehelvetica* Trujillo, *Hedbergella delrioensis* (Carsey), *Guembelitria cenomana* Keller, *Heterohelix moremani* (Cushman), *Heterohelix globulosa* Ehrenberg, *Globigerinelloides ultramicra* Subbotina, *Praeglobotruncana delrioensis* (Plummer) and *Whiteinella paradubia* Sigal.

The lithologic characters and dominance of both ammonites and planktonic foraminifera in this interval indicate a rise in the relative sea level, which indicates a transgressive phase and shallow to deep subtidal environments, with low energy and below storm wave-base were prevailed during the deposition of this (TST2).

4.2. E. The third sequence boundary (SB3):

At West Gabal Thelmet section, this sequence boundary (SB3) separates the depositional sequence -2 (DS2) from the depositional sequence - 3 (DS3), and represented by a clear hiatus coinciding with the Cenomanian / Turonian boundary.

It is easily recognized in the field, as it separates the transgressive cycle of the topmost Galala Formation with *Vascoceras cauvini* Zone at the base, from the transgressive cycle of the Abu Qada Formation with *Vascoceras proprium* at the top. According to the recorded foraminiferal biozones, this sequence boundary (SB3) lies between the Latest Cenomanian *Helvetoglobotruncana praehelvetica / Whiteinella paradubia* and the Early Turonian *Whiteinella archaeocretacea* planktonic foraminiferal biozones.

This hiatus is recorded in many parts of Egypt and Negev (Bartov *et al*., 1980; Bandel *et al*., 1987; and Bauer *et al*., 2003). Also, an abrupt drop of the $d^{13}C$ coincident with the upper part of the OAE2 excursion below the C/T boundary marks a major hiatus, with the Early Turonian sediments (El-Sabbagh, 2008).

4.2. F. Depositional sequence - 3 (DS3):

At Gebel Qabeliat section, this depositional sequence (DS3) comprises the lower Turonian Abu Qada Formation and it is bounded at the base by the third sequence boundary (SB3) and topped by the fourth sequence boundary (SB4). This sequence falls within the *Whitenella archaeocretacea* planktonic foraminiferal Zone and the *Vascoceras proprium* and *Choffaticeras* (*Ch.*) *segne* ammonite biozones.

In the present studied area, it is represented only by transgressive system tract (TST3), as indicated by the presence of large ammonites and planktonic foraminifera; while the basal lowstand system tract is missing, due to the fast relative sea level rise over the study area and the transgressive surface coincides with the sequence boundary (SB3). Also, the top highstand system tract is eroded and coincides with the fourth sequence boundary (SB4).

4.2. F. 1. Transgressive system tract - 3 (TST3):

At the present studied section, this transgressive systems tract (TST3) includes the whole thickness of the Abu Qada Formation, which is represented by 34 m thick (samples 36-65).

It comprises *Vascoceras proprium* and *Choffaticeras (Choffaticeras) segne* macrofaunal biozones and also *Whiteinella archaeocretacea*, in addition to the lower part of *Hedbergella flandrini / Whiteinella baltica* planktonic foraminiferal biozone. It is represented by retro-gradational parasequence sets of deep subtidal fossiliferous marls, intercalated with highly fossiliferous limestones and thinnly bands of fossiliferous shale in the lower part, graded upwardly into hard dolomitic limestones.

This (TST3) is characterized by very rich and diverse megafossil assemblages, especially the ammonites, which are considered the major component and act with a ratio of about 85 % and represented mainly by the following species: *Kamerunoceras turoniense* (d'Orbigny), *Neoptychites cephalotus* (Courtiller), *Thomasites rollandi* (Thomas & Peron), *Mammites nodosoides* (Schlothein), *Wrightoceras munieri* (Pervinquiere), *Vascoceras durandi* (Thomas & Peron), *Vascoceras proprium* (Reyment), *Vascoceras rumeaui* (Colligon), *Choffaticeras (Choffaticeras) segne* (Solger), *Choffticeras securiforme* (Eck), *Choffaticeras (Choffaticeras) pavillieri* (Pervinquiere), *Choffaticeras (Leoniceras) philippi* (Solger), *Choffaticeras (Choffaticeras) quaasi* (Peron) and *Fagesia cf. peroni* (Pervinquiere).

Also, this (TST3) includes a ratio of about 6% of bivalves represented mainly by: *Glossus aegyptiaca* (Cox), *Plicatula auressensis* (Coquand), *Mytiloides kossmati* (Henz), *Meretrix brongniartiana* (Leymerie), *Ambigostrea pseudovilli* Malchus; and a ratio of about 6% of gastropods represented mainly by: *Fasciolaria tournoueri* Thomas & Peron, *Tylostoma gadensis* (Abbass), *Tylostoma (Tylostoma) globosum* Sharpe, and *Tylostoma cossoni* Thomas & Peron; in addition to a ratio of about 5% echinoids represented mainly by *Hemiaster heberti* (Coquand).

On the other hand, this interval was found barren from any benthonic foraminiferal assemblages, but it contains some assemblages of planktonic foraminiferal assemblages, represented mainly by: *Guembelitria cenomana* Keller, *Heterohelix reussi* (Cushman), *Heterohelix moremani* (Cushman), *Heterohelix globulosa* Ehrenberg, *Globigerinelloides ultramicra* Subbotina, *Helvetoglobotruncana praehelvetica*, Trujillo, , *Helvetoglobotruncana helvetica* Bolli, *Praeglobotruncana stephani* Gandolfi, *Whiteinella archaeocretacea* Passagno, *Whiteinella paradubia* Sigal, *Whiteinella baltica* Douglas & Rankin, *Praeglobotruncana delrioensis* (Plummer), *Praeglobotruncana gibba* Klaus, *Hedbergella delrioensis* (Carsey), *Hedbergella planispira* (Tappan), *Hedbergella simplex* (Morrow) and *Hedbergella flandrini* Prothault.

These characters indicate a rise in the relative sea level, which reflects a transgressive phase and a deep subtidal environment, was prevailed during the deposition of this (TST3).

4.2. G. The Fourth sequence boundary (SB4):

At West Gabal Thelmet section, this sequence boundary (SB4) separates the depositional sequence -2 (DS3) from the depositional sequence - 4 (DS4) and represented by a sedimentary hiatus (Hiatus-4) coinciding with the Lower Turonian Abu Qada / Upper Turonian Wata formational boundary.

It is easily recognized in the field, as it separates the hard dolomitic limestone of the topmost Abu Qada Formation, with *Choffaticeras (Choffaticeras) segne* Zone at the base, from the hard dolomitic limestone of the lower part of Wata Formation, with *Coilopoceras requienianum* Zone at the top, representing an unconformity surface, due to absence of the *Hoplitoides ingens* Zone of the earliest Late Turonian. According to the recorded foraminiferal biozones, this sequence boundary (SB3) lies within *Hedbergella flandrini / Whiteinella baltica* planktonic foraminiferal biozone.

4.2. H. Depositional sequence-4 (DS4):

It represents the youngest depositional sequence in the study area. This depositional sequence (DS4) attains about 55 m thick (Samples 66-110), and it comprises the whole Wata Formation of the Late Turonian age. It is bounded at the base by the fourth Sequence boundary (SB4) and topped by the fourth sequence boundary (SB5).

This depositional sequence is classified into a transgressive system tract (TST4) at the base and a highstand system tract (HST4) at the top; while the basal lowstand system tract is missing due to the fast relative sea level rise over the study area and the transgressive surface coincides with the sequence boundary (SB4).

4.2. H. 1. Transgressive system tract-4 (TST4):

At West Gabal Thelmet section, this Transgressive system tract - 4 (TST4) includes the lower part of the Wata Formation, which is represented by 35 m thick (samples 66-94). It comprises the *Coilopoceras requienianum* macrofaunal and also the upper part of *Hedbergella flandrini / Whiteinella baltica* planktonic biozone of Late Turonian age. It is represented by retro-gradational parasequence sets of slightly deep subtidal hard ledges of fossiliferous dolomitic limestone, intercalated with some layers of shale and marl.

This (TST2) includes some megafossil assemblages, represented by the Upper Turonian ammonites and act with ratios ranges (from about 30% in its lower part to 15% in its upper part) and represented mainly by *Hoplitoides latefundates* (Zaborski) and *Coilopoceras requienianum* (d' Orbigny)*;* bivalves ratios ranges (from about 50% in its lower part to 15% in its upper part) and represented mainly by: *Plicatula numidica* (Coquand), *Laternula jettei* (Coquand), *Meretrix brongniartiana* (Leymerie), *Schedotrapezium trapezoidale* (Roemer) and *Mesocallista desvauxi* (Coquand); with gastropods ratios ranges (from about 10% in its lower part to 35% in its upper part) and represented mainly by: *Tylostoma gadensis* (Abbass), *Tylostoma (Tylostoma) globosum* Sharpe, *Tylostoma cossoni* Thomas & Peron, *Nerinea requieniana* (d' Orbigny), *Volutoderma (Rostellinda) media* Dall and *Pugnellus uncatus* (Forbes); in addition to echinoids ratios ranges (from about 10% in its lower part to 35% in its upper part) and represented mainly by: *Phymosoma abbatei* (Gauthier) and *Rachisoma geysi* Abdel Hamid & El Qot.

On the other hand, this interval was found barren from any benthonic foraminiferal assemblages, but its lowermost part contains rare planktonic foraminiferal assemblages of Late Turonian, represented only by: *Whiteinella baltica* Douglas & Rankin, *Praeglobotruncana delrioensis* (Plummer) and *Hedbergella flandrini* Prothault; while the upper part of this (TST4) is barren of any foraminiferal assemblages.

These characters indicate a rise in the relative sea level which indicates on transgressive phase and a slightly deep subtidal environment was prevailed during the deposition of this (TST4).

4.2. H. 2. Maximum flooding surface-4 (MFS4):

The maximum flooding surface (MFS4) is cited on the last occurrence of ammonites and it also coincides with the abrupt facies change from the slightly deep subtidal facies during the deposition of the lowermost part of the Wata Formation below, to reducing shallow lagoonal facies during the deposition of the upper part of the Wata Formation above.

4.2. H. 3. Highstand system tract-4 (HST4):

This is the highest interval in the depositional sequence-4 (DS4). At West Gabal Thelmet section, this highstand system tract (HST4) comprises the upper part of Wata Formation. It attains about 22 m thick (samples 95-110). It may be assigned to the Latest Turonian age, based on its stratigraphic position, as it directly overlies the *Coilopoceras requienianum* Zone of Late Turonian age at the base, and extended to study the lowermost part of Matulla Formation, which may be of Coniacian age at the top. This (HST4) is represented by pro-gradational parasequence set of reducing shallow lagoonal fissile shale sequence, intercalated with limestone, sandy marl and sandstone barren from any macro-fossils and foraminiferal assemblages.

These characters indicate a drop in the relative sea level, which indicates a regressive phase and a reducing shallow lagoonal environment, was prevailed during the deposition of this (HST4).

This (HST4) is topped by the fifth sequence boundary (SB5), which is represented by sharp contact and clearly defined at the Wata/Matulla formational boundary, due to the vertical radical lithologic change, from carbonate facies of the Upper Turonian Wata Formation to siliciclastic facies of the lower Matulla Formation. A faunal break separates the regressive cycle of the Upper Turonian Wata succession from the overlying transgressive cycle of the Coniacian/Santonian lower Matulla Formation above.

The correlation between these recorded four depositional sequences and their sequences boundaries in the West Gabal Thelmet area, with those of the previous study, are shown on (Fig. 5).

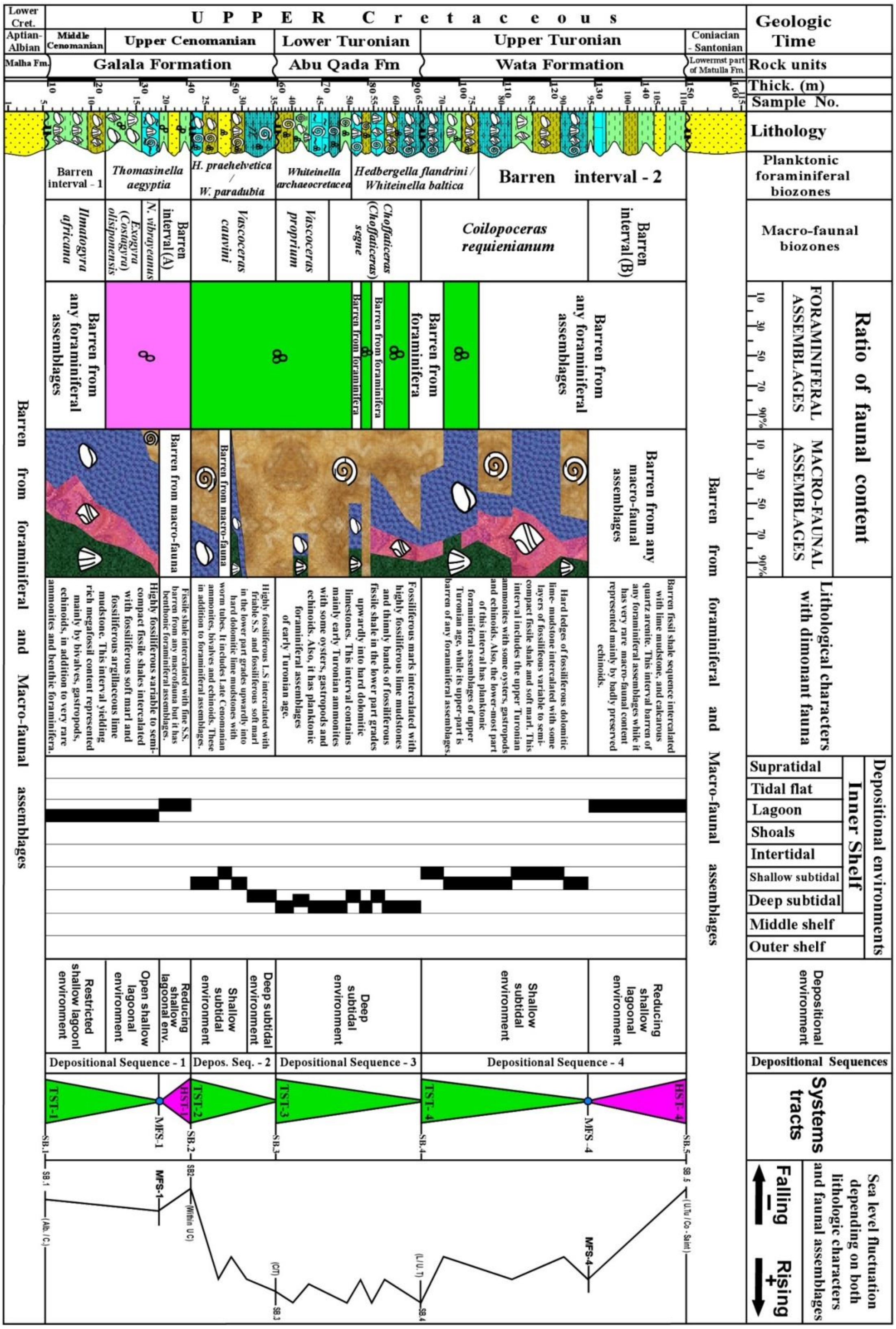


Fig. 4:Integration between both faunal biozonation, their included faunal ratio, lithological characters, depositional environments and depositional sequences West Gebel Thelmet section.

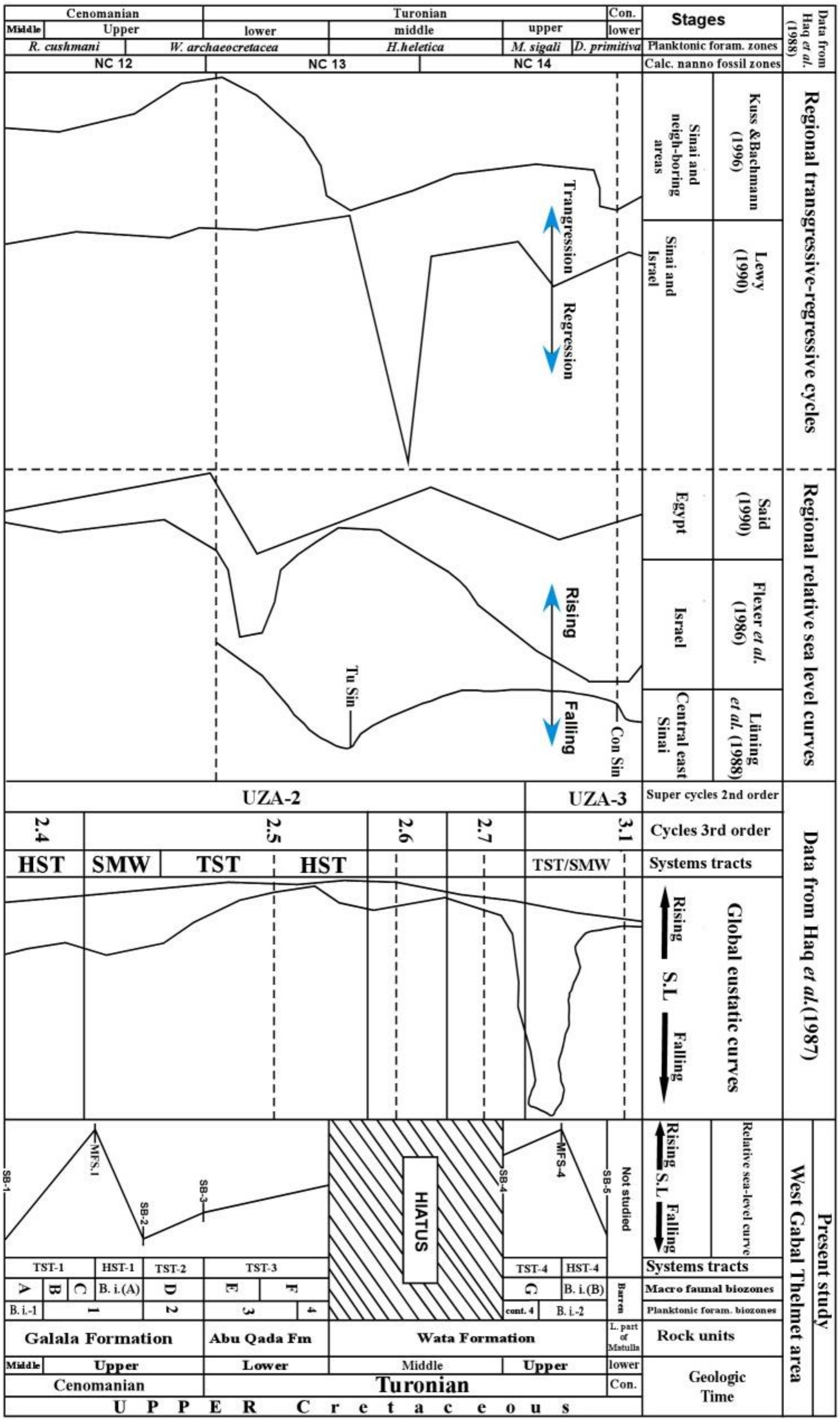


Fig. 5: Correlation of the relative sea-level curve for the Cenomanian - Turonian succession at West Gabal Thelmet area, north escarpment of Southern Galala Plateau with those previously applied by some authors inside/ outside of Egypt.

5. Summary and Conclusions

1- The present study deals with the lithostratigraphy, biostratigraphy and sequence stratigraphy of the Cenomanian -Turonian succession exposed at West Gabal Thelmet section, which is located at the northern escarpment of Southern Galala Plateau, North Eastern Desert, Egypt. This study is based mainly on its lithologic characters, in addition to examine its faunal contents.

2- Lithostratigraphically, this succession is classified into Galala, Abu Qada, and Wata formations, from base to top, and it is underlain by the Malha and overlain by the Matulla formations with unconformity surfaces. These rock units are fully described and are found very rich with their macrofaunal in addition to some foraminiferal assemblages.

3- Twenty - two foraminiferal species have been identified, of them seventeen species are planktonics and five are benthonics. On other hand, sixty-four macro-fossil species were identified; of them twenty - three belong to the Cephalopoda, eleven to the Gastropoda, twenty - two to the Bivalvia and eight to the Echinoidea.

4- The identified fauna are used to establish two biostratigraphic schemes, one based on the foraminiferal assemblages and the second is based on macrofossils. The foraminiferal assemblages are used to classify the studied interval into one benthonic biozone of Middle Cenomanian and three planktonic foraminiferal biozones: (one of the Latest Cenomanian, one of the Early Turonian; and one of Early to Late Turonian), in addition to, two barren intervals. Also, this interval is classified into seven macrofaunal biozones: one of the Middle Cenomanian; three of the Late Cenomanian; two of the Early Turonian; and one of the Late Turonian; in addition to two barren intervals intervene these established zones. The Integration between these two schemes is attempted, to reach high-resolution stratigraphic scheme during the studied time interval.

5- Sequence stratigraphically, the integration between lithologic characters, detailed field examination for the stratigraphic surfaces and faunal biostratigraphic studies, led to classify this interval into four 3^{rd} depositional sequences, bounded by five type - one sequence boundaries represented by unconformity surfaces. These four depositional sequences are two in the Cenomanian Galala Formation; one in the Lower Turonian Abu Qada Formation; one in the Upper Turonian Wata Formation. The first and fourth depositional sequence are subdivided into transgressive and highstand systems tracts; while the second and third are represented by transgressive systems tracts only. The lowstand system tract is missed in all the distinguished depositional sequences, due to the fast change in the relative sea level over the study area.

6- The correlations of the recorded sequence boundaries in the studied section, with those of the previous studies inside /outside Egypt, were done.

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