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Biostratigraphy Of The Cretaceous Rocks Located Between Wadi Um Lug And Wadi Qiseib In The Northern Galala, North Eastern Desert, Egypt.

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Abstract:
The Cretaceous rocks exposed between Wadi Um Lug and Wadi Qiseib in the Northern Galala, North Eastern Desert, are investigated and described for their lithologies and foraminiferal content. The studied Cretaceous succession (Lat. 29° 31' 58.6" N and Long. 32° 22' 2.7" E) is measured and sampled for 41 rock samples. Lithologically, the Cretaceous sequence is differentiated into two rock units which are; Malha Formation (Albian) and Galala Formation (Cenomanian). The micropaleontological (foraminiferal) study helps in the recognition of five foraminiferal biozons which are stratigraphically arranged as following: Ammodiscus kiowensis Total Range Zone in the Lower Cretaceous (Albian), in addition to Haplophragmoides eggeri - Trochammina sukhnaensis Assemblage Zone, Ismailia spp.- Daxia spp. Assemblage Zone, Ammobaculoides plummerae - Haplophragmoides gilberti Assemblage Zone and Nezzazata spp. - Trochospira ssp. Assemblage Zone in the Upper Cretaceous (Cenomanian).

Key words: *biostratigraphy, Cretaceous, Northern Galala, North Eastern Desert, Egypt.*

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I. Introduction

The Cretaceous rocks in the Northern Galala and the western side of the Gulf of Suez are well exposed and characterized by their distinctive colors, facies, stratigraphic setting and definitely their fossil content. All of these characteristics make it easy to distinguish the Cretaceous rocks from their stratigraphically older and younger neighboring rocks. Although the Cretaceous rocks in the Northern Galala have received a lot of studies since those of Sadek (1926), Farag (1948), Fawzi (1959), Abdallah and El Adindani (1963), Metwally et al. (1995), Kuss et al. (2000), Abd Elshafy et al.(2002), Ismail et al.(2007), Mahfouz et al. (2018) and Shahin and El baz (2021), there are some areas still need more detailed studies especially micropaleontological studies, one of them is the area of the present study, which includes some Cretaceous successions that haven't been studied for their foraminiferal content yet. The present work is concerned with the description and investigation of the Cretaceous rocks in the study area, in order to determine their rock units. This is accompanied by the main aim in this work, which is conducting a foraminiferal study in the Cretaceous rocks in the study area to discriminate their biostratigraphic units.

II. Materials And Methods

The study area is located between Wadi Um Lug and Wadi Qiseib in the Northern Galala, North Eastern Desert (Fig. 1). For the present study, one complete stratigraphic section (S1) with coordinates (Lat. 29° 31' 58.6" N and Long. 32° 22' 2.7" E) has been selected, measured and sampled for 41 rock samples (Fig. 2), all of the collected rock samples were carefully described, they are all fragmented, washed and dried in preparation for investigating their foraminiferal content.

Fig. 1. Location map of the study area showing the location of studied sections.

All the recorded foraminiferal species were identified and systematically classified based on the classification of Loeblich and Tappan (1988), they have been persuaded stratigraphically throughout the studied section to detect their ranges and relative abundance and they are all photographed using the scanning electron microscope (SEM).

III. Lithostratigraphy

The lithostratigraphic investigations of the Cretaceous rocks in the study area has resulted in the recognition of two main rock units, and these rock units are from base to top:

Malha Formation (Albian), Abdallah et al. (1965).

This rock unit represents the Lower Cretaceous rocks in the Northern Galala and along the western side of the Gulf of Suez. In the present study, the Malha Formation attains a thickness of 13m. and consists mainly of sandstones with minor beds of siltstones and claystones that occupy the upper parts of the formation. The sandstones dominate the lithology of the Malha Formation and appear with various colors such as pale yellow, brown, reddish white, grayish white and light to dark violet and ranges in compaction from friable sandstones in the lower part of the formation to moderately and highly compacted sandstones in the upper part. The base the Malha Formation is not detected in the study area while its upper boundary is conformably overlain by the Galala Formation (Fig. 3). The studied exposed part of the Malha Formation is assigned to the Albian age.

Galala Formation (Cenomanian), Awad and Abdallah (1966).

This rock unit represents the Upper Cretaceous rocks in the study area (Fig. 4). Lithologically , it can be differentiated into a thick lower clastic part consisting mainly of shales and marls with some few carbonate beds and an upper carbonate part consisting mainly of limestone. The Galala Formation is rich in macro- and microfaunal content and attains a thickness of 86m. The Galala Formation is underlain by the Malha Formation while it is uncovered at its upper boundary. Based on its foraminiferal content, the Galala Formation is assigned in the present study to the Cenomanian.

IV. Biostratigraphy

The micropaleontological study and the investigation of the foraminiferal content in the present study revealed the presence of **(**108**)** species which found to belong to 39 genera, 15 Subfamilies, 18 families and 14 superfamilies of the suborders: Textulariina and Lagenina. The recorded foraminiferal species were all identified and figured in plates (1-3).

Depending on the vertical ranges and relative abundance of the recorded foraminiferal species, the studied Cretaceous rocks could be subdivided into five biozones (Fig. 5). one biozone in the Lower Cretaceous and the other four biozones in the Upper Cretaceous. Stratigraphically they are arranged as following:

A- Lower Cretaceous Biozone

1- *Ammodiscus kiowensis* Zone

Type: Range zone.

Age: Albian.

Origin of name: Because of the correspondence of its ranges with the boundaries of the zone and its fair amount, the typical Albian species *Ammodiscus kiowensis* Loeblich and Tappan was selected as a zonal index.

Locality: S1 section.

Thickness: 2 m.

Boundaries: This zone is limited to the total rang of *Ammodiscus kiowensis* Loeblich and Tappan where the beginning and end of this zone is marked by the first and last appearance of *Ammodiscus kiowensis* Loeblich and Tappan.

Biostratigraphic position: This zone is represented in the topmost part of the studied Albian succession, it conformably overlies the first barren zone which represents the basal part of the studied Lower Cretaceous succession. The upper boundary of this zone lies under the first Cenomanian zone *Haplophragmoides eggeri – Trochammina sukhnaensis* Zone.

Characteristic species: This zone includes typical Albian species such as *Ammodiscus kiowensis* Loeblich and Tappan, *Miliammina awunensis* Tappan, *Miliammina manitobensis* Wickenden, *Ammodiscus cretaceous* (Reuss) and *Trochammina depressa* Lozo.

Correlation: This zone can be correlated in Egypt with the upper part of *Gonorbina conica – Gavelinella* Zone of Ibrahim(2001) in the Southern Galala; upper part of *Gaudryina textilaroides* Zone of Shahin(2000) in Sinai and upper part of *Gavelinella infracretacea* Zone of El Wakeel(2014) in the western part of the Western Desert (Table 1).

B - Upper Cretaceous Biozones

1- *Haplophragmoides eggeri - Trochammina sukhnaensis* Zone

Type: Assemblage zone.

Age: Cenomanian.

Origin of name: After *Haplophragmoides eggeri* Cushman and *Trochammina sukhnaensis* Atta which considered as the most characteristic species in the zone.

Locality: S1 section.

Thickness: 6.5 m.

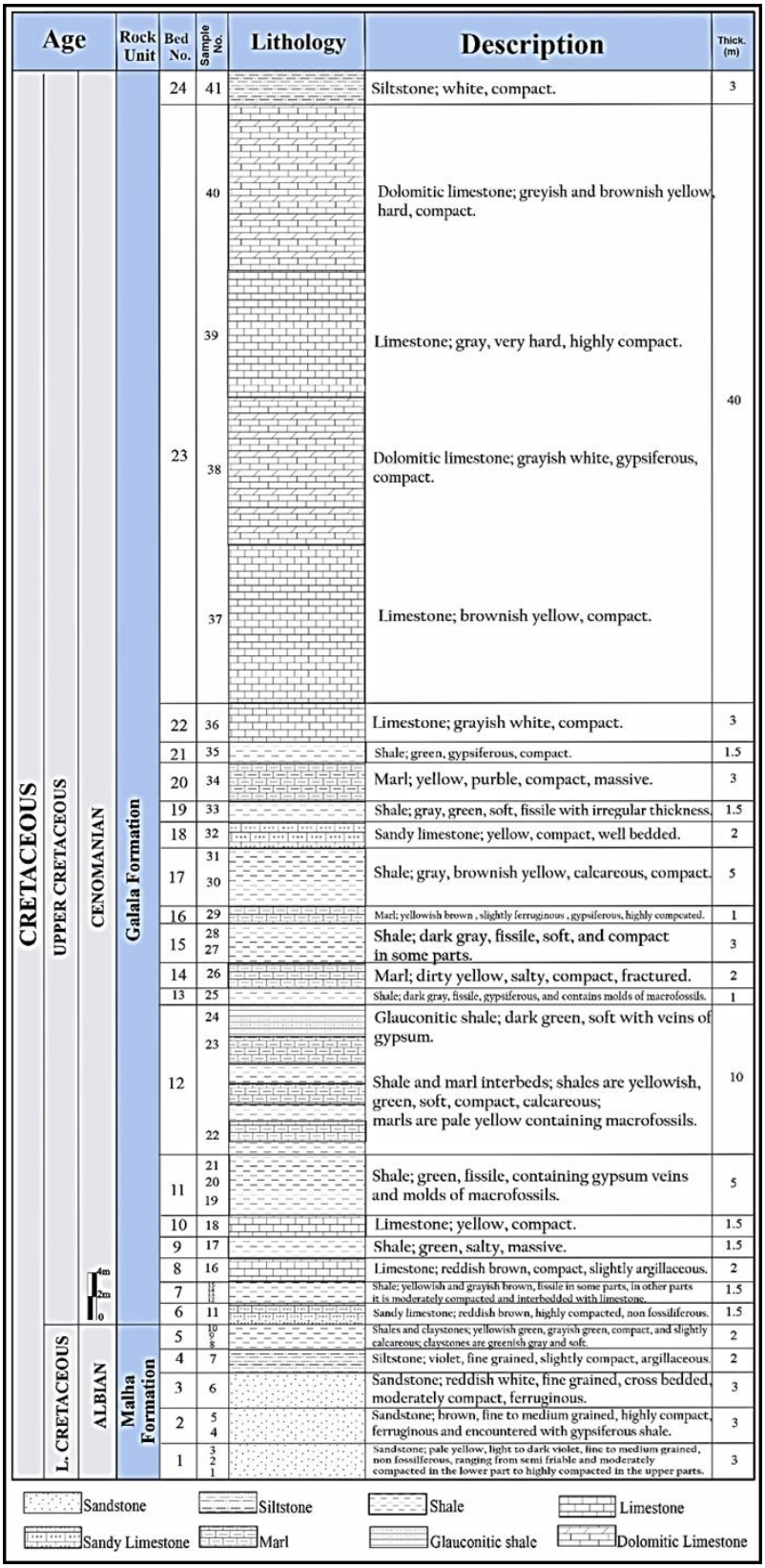

Fig. 2. Lithostratigraphic succession of the studied Cretaceous sediments in S1 section.

Fig. 3. Field photograph shows the Malha Formation and the contact between the Malha and the Galala Formations.

Fig. 4. Field photograph shows the Galala Formation.

Table 1. Tentative biostratigraphic correlation for the Lower Cretaceous foraminiferal biozones.

Age	El Wakeel (2014) West of Western Desert	Shahin (2000) Sinai	Ibrahim (2001) Southern Galala	Atta (1992) Northern Galala	Present study
Albian	*Gavelinella infracretacea* Z.	*Gaudryina textilaroides* Z.	*Gonorbina conica* - *Gavelinella* Z.		*Ammodiscus Kiowensis* Z.
				Haplophragmoides topagrukensis Z.	
		Flabellammina aegyptiaca- *Paleogaudryina textilaroides* Z.	*Trochammina wetteri*- *Ammobaculites texanus* Z.		
				Ammodiscus Kiowensis Z.	
	Hedbergella retroflea- *Gavelinella cenomanica* Z.				
		Gyroidina infracretacea- *Psilocitharella arguta* Z.	Unexposed	*Polychamina pawpawensis* – *Buccicrenata subgoodlandensis* Z.	

Boundaries: The lower boundary of this zone is marked by the disappearance of the previous Albian *Ammodiscus kiowensis* Zone and the first appearance of the Cenomanian index forms such as *Haplophragmoides eggeri* Cushman, *Ammomarginulina blanckenhorni* Said and Kenawy and *Ammobaculites subcretaceous* Cushman and Alexander while the disappearance of *Trochammina sukhnaensis* Atta and *Ammobaculites* cf. *subplanatus* Cushman and Deaderick at the upper boundary defines the end of this zone.
Biostratigraphic position: This zone conformably overlies the previous *Ammodiscus kiowensis* Zone while its topped at its upper boundary with *Ismailia* spp. – *Daxia* spp. Assemblage Zone.
Characteristic species: This zone is characterized by many Cenomanian index species such as *Haplophragmoides eggeri* Cushman, *Trochammina sukhnaensis* Atta, *Haplophragmoides calcula* Cushman and Waters, *Ammobaculites rowei* Banner, *Ammomarginulina blanckenhorni* Said and Kenawy, *Ammobaculites coprolithoformis* Schwager, *Haplophragmoides howardensis* Stelck and Wall, *Haplophragmoides Formosum* Bolin and *Ammobaculites albertensis* Stelck and wall.
Correlation: In Egypt, this zone is equivalent to *Flabellamina alexanderi-Daxia cenomana* Zone from the Gulf of Suez (Shahin and Elbaz, 2021); lower part of *Rotalipora brotzeni* Zone and *Thomasinella fragmentaria* Zone in South western Sinai (Shahin, 2007); lower part of *Daxia cenomana* Zone in Sinai (Kora *et al*., 1994) and *Thomasinella fragmentaria* Zone (Ansary *et al*., 1962) at the Gulf of Suez (Table 2)**.**

2- *Ismailia* spp. - *Daxia* spp. Zone

Type: Assemblage zone.
Age: Cenomanian.
Origin of name: *Ismailia* species and *Daxia* species are the most characteristic forms in this zone besides their relatively high abundance, so they were chosen to be the index forms in this zone.
Locality: S1 section.
Thickness: 17.5 m.
Boundaries: The lower and upper boundaries of this zone are marked by the first and the last appearance of *Ismailia* spp. and *Daxia* spp.
Biostratigraphic position: This zone overlies the prior *Haplophragmoides eggeri* - *Trochammina sukhnaensis* Zone and underlies the following Cenomanian *Ammobaculoides plummerae* - *Haplophragmoides gilberti* Assemblage Zone.
Characteristic species: This zone is characterized by the existence of many index forms such as *Ismailia neumannae* El-Dakkak, *Ismailia aegyptica* El-Dakkak, *Daxia cenomana* Cuvillier and Szakall, *Daxia cenomana* cf. Cuvillier and Szakall, *Charentia cuvillieri* Neumann, *Haplophragmoides bahariyaensis* Abdel-Kireem and Sultan, *Haplophragmoides Colusaensis* Cushman and Goudkoff, *Insculptarenula texana* (Cushman and Waters), *Insculptarenula* sp, *Bathysiphon vitta* Nauss, *Lingulina furcillata* Berthelin, *Lingulina sadeki* Said and Barakat, *Arenobulimina pseudalbiana* Barnard and Banner, *Haplophragmoides howardensis* Stelck and Wall and *Ammobaculites albertensis* Stelck and wall.
Correlation: This zone can be correlated in Egypt with the uppermost part of *Thomasinella Fragmentaria* Zone, *Ismailia neumannae* Zone and the lower part of *Nezzazata simplex-Trochospira avenmelichi* Zone (Shahin and Elbaz, 2021) from the Gulf of Suez; lower part of *Rotalipora reicheli* Zone and upper part of both *Rotalipora brotzeni and Thomasinella fragmentaria* Zones from Sinai (Shahin, 2007); middle part of *Daxia cenomana* Zone (Kora et al., 1994) from Sinai; *Dorothia oxycona* Zone (Atta, 1992) from the Northern Galala and the lower part of *Thomasinella aegyptia* Zone (Ansary et al.,1962) from the Gulf of Suez (Table 2)**.**

3- *Ammobaculoides plummerae - Haplophragmoides gilberti* Zone

Type: Assemblage zone.
Age: Cenomanian.
Origin of name: *Ammobaculoides plummerae* Loeblich and *Haplophragmoides gilberti* Eicher are the most remarkable species in this zone as their occurrence coincides with the lower and upper boundaries of the zone.
Locality: S1 section.
Thickness: 11 m.
Boundaries: The lower boundary of this zone is appointed by the disappearance of *Daxia* spp. and other characteristic species of the previous zone and the first appearance of *Ammobaculoides plummerae* Loeblich, *Haplophragmoides gilberti* Eicher and *Ammobaculoides mosbyensis* Eicher while the Upper boundary is marked by the disappearance of *Haplophragmoides gilberti* Eicher.
Biostratigraphic position: This zone rests on the previous *Ismailia* spp. – *Daxia* spp. Zone and underlies the second Barren zone in S1 section.
Characteristic species: *Ammobaculoides plummerae* Loeblich, *Ammobaculoides mosbyensis* Eicher, *Haplophragmoides gilberti* Eicher, *Ammobaculites coprolithoformis* Schwager, *Ammobaculites subcretaceous* Cushman and Alexander, *Ammobaculites Junceus* Cushman and Applin , *Ammobaculites viriosus* Loeblich and Tappan, *Ammobaculites cobbani* Leoblich and Tappan, *Ammobaculites Cuyleri* Tappan, *Ammobaculites*

glaessneri Said and Barakat, *Ammobaculites gratus* Cushman and Applin, *Ammobaculites humei* Nauss, *Sculptobaculites goodlandensis* Cushman and Alexander and *Buccicrenata subgoodlandensis* (Vanderpool).
Correlation: This zone can be correlated in Egypt with the upper part of *Nezzazata simplex- Trochospira avenmelichi* Zone and the lower part of *Hedbergella delrioensis- Praeglobotruncana delrioensis* Zone (Shahin and Elbaz, 2021) from the Gulf of Suez; *Rotalipora reicheli* Zone, upper part of *Thomasinella fragmentaria* Zone and lower part of *Thomasinella aegyptia* Zone from Sinai (Shahin, 2007); middle part of *Daxia cenomana* Zone (Kora et al., 1994) from Sinai and *Thomasinella aegyptia* Zone (Ansary et al.,1962) from the Gulf of Suez (Table 2)**.**

4- *Nezzazata* spp. - *Trochospira* ssp. Zone

Type: Assemblage zone.
Age: Cenomanian.
Origin of name: According to their high abundance and the matching of their ranges with the boundaries of the zone, *Nezzazata* spp. and *Trochospira* ssp. were selected to be the index species in this zone.
Locality: S1 section.
Thickness: 1.5 m.
Boundaries : The index species *Nezzazata convexa* (Smout), *Nezzazata gyra conica* (Smout), *Trochospira ovnimelechi* Hamaoui, *Merlingina cretacea* Hamaoui and *Acruliammina longa* (Tappan) suddenly appear and disappear, marking the lower and upper boundaries of this zone.
Biostratigraphic position: This zone overlies the prior *Ammobaculoides plummerae - Haplophragmoides gilberti* Zone and underlies last barren zone in the studied succession.
Characteristic species: *Nezzazata convexa* (Smout), *Nezzazata gyra conica* (Smout), *Trochospira ovnimelechi* Hamaoui, *Merlingina cretacea* Hamaoui and *Acruliammina longa* (Tappan).
Correlation: This zone can be correlated in Egypt with the upper part of *Hedbergella delrioensis - Praeglobotruncana delrioensis* Zone (Shahin and Elbaz, 2021) from the Gulf of Suez; lower part of *Rotalipora cushmani* Zone and lower part of *Thomasinella aegyptia* Zone from South western Sinai (Shahin, 2007) (Table 2**)**.

Fig.
1-*Bathysiphon vitta* Nauss

2- *Ammodiscus cretaceous* (Reuss)

3- *Ammodiscus kiowensis* Loeblich and Tappan

4-*Miliammina awunensis* Tappan

5- *Miliammina manitobensis* Wickenden

6- *Haplophragmoides calcula* Cushman and Waters

7- *Haplophragmoides eggeri* Cushman

8- *Haplophragmoides formosum* Bolin

9- *Haplophragmoides bahariyaensis* Abdel-Kireem and Sultan

10- *Haplophragmoides colusaensis* Cushman and Goudkoff

11- *Haplophragmoides howardensis* Stelck et Wall

12- *Haplophragmoides gilberti* Eicher

13- *Daxia cenomana* Cuvillier and Szakall

14- *Daxia* cf. *cenomana* Cuvillier and Szakall

15- *Ammobaculites albertensis* Stelck and wall

16- *Ammobaculites coprolithoformis* Schwager

17- *Ammobaculites rowei* Banner

18- *Ammobaculites subcretaceous* Cushman and Alexander

19- *Ammobaculites junceus* Cushman and Applin

20- *Ammobaculites viriosus* Loeblich and Tappan

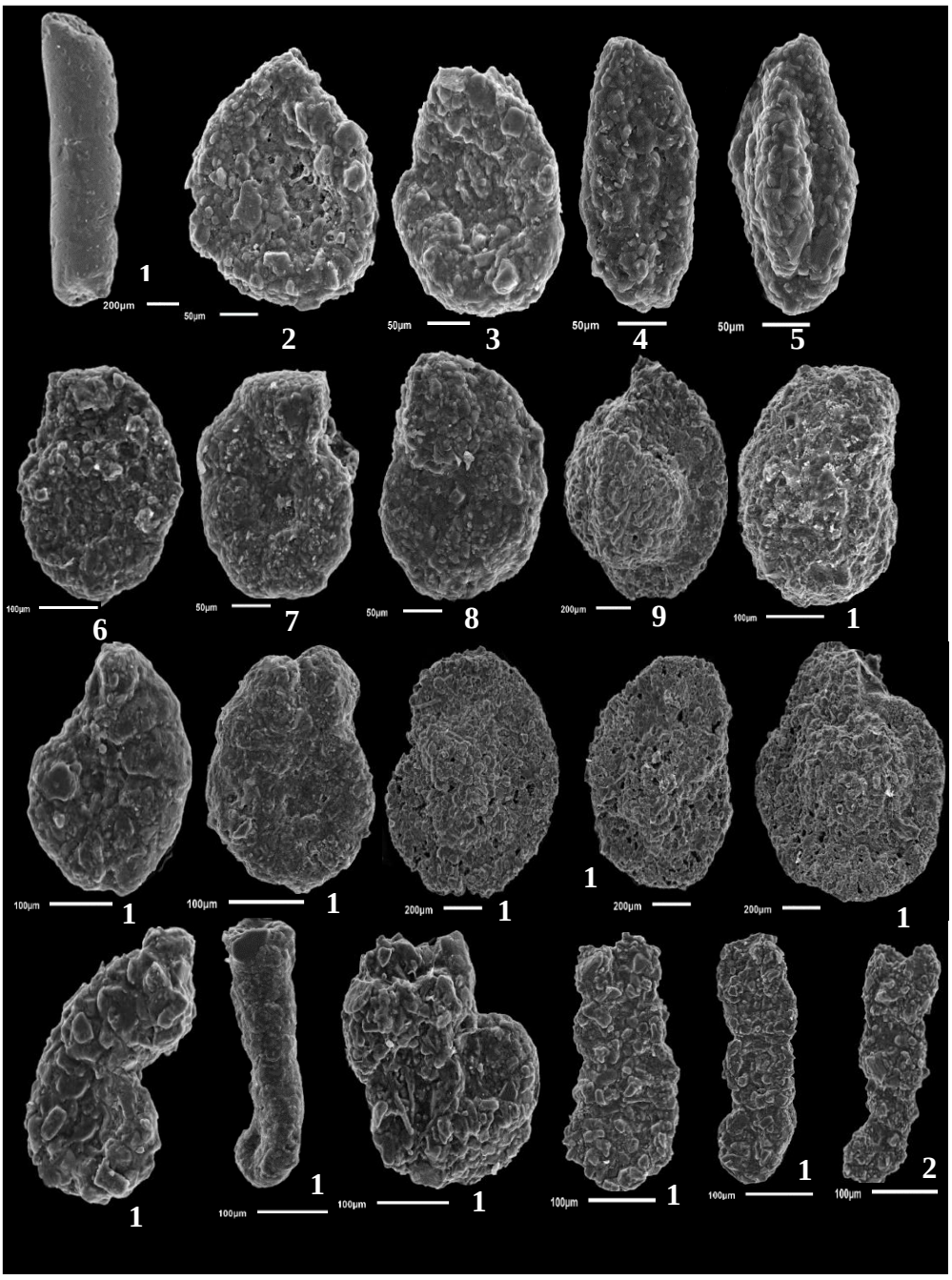

Fig.

1- *Ammobaculites cobbani* Leoblich and Tappan

2- *Ammobaculites cuyleri* Tappan

3- *Ammobaculites glaessneri* Said and Barakat

4- *Ammobaculites gratus* Cushman and Applin

5- *Ammobaculites humei* Nauss

6- *Ammomarginulina blanckenhorni* Said and Kenawy

7- *Sculptobaculites goodlandensis* Cushman and Alexander

8- *Acruliammina* cf. *longa* (Tappan), a-ventral view, b-dorsal view

9- *Merlingina cretacea* Hamaoui, a-side view, b-apertural view

10- *Nezzazata convexa* (Smout), a-ventral view, b-dorsal view

11- *Nezzazata gyra conica* (Smout)

12- *Trochospira ovnimelechi* Hamaoui, a-ventral view, b-dorsal view

13- *Charentia cuvillieri* Neumann

14- *Ismailia aegyptica* El-Dakkak

15- *Ismailia neumannae* El-Dakkak, a-side view, b, c-apertural view

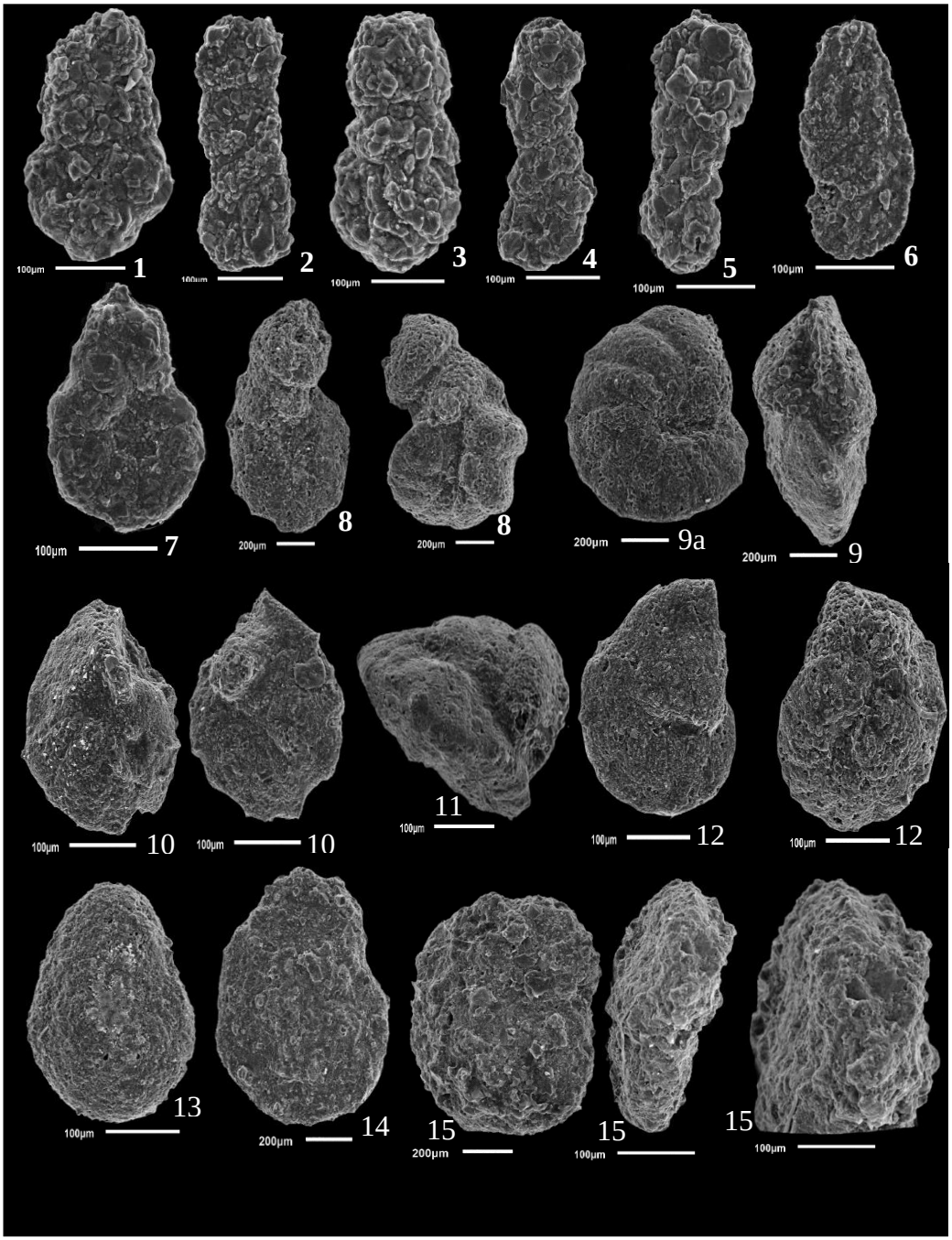
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Fig.

1- *Buccicrenata subgoodlandensis* (Vanderpool)

2- *Ammobaculoides plummerae* Loeblich

3- *Ammobaculoides mosbyensis* Eicher

4- *Insculptarenula texana* (Cushman et Waters), a-dorsal view, b-ventral view

5- *Insculptarenula* sp.

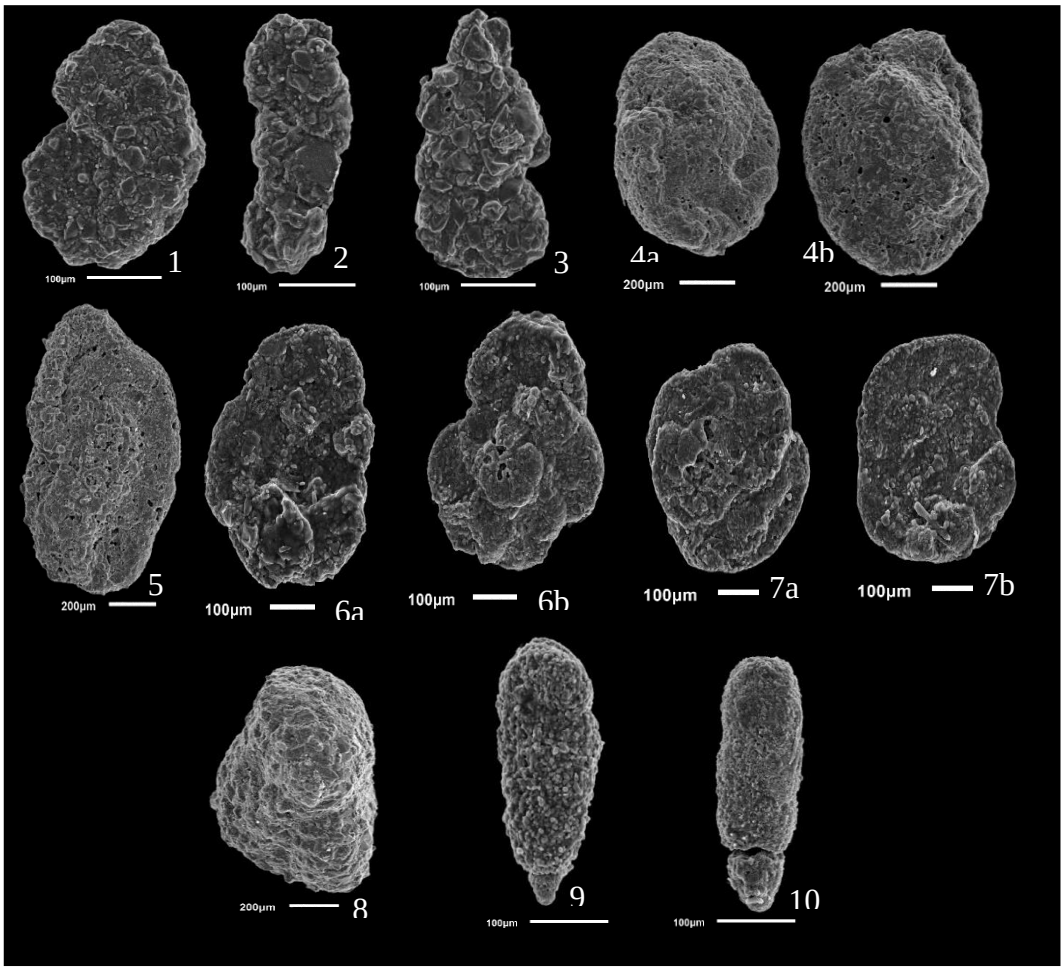
6- *Trochammina depressa* Lozo, a-ventral view, b-dorsal view

7- *Trochammina sukhnaensis* Atta, a-dorsal view, b-ventral view

8- *Arenobulimina pseudalbiana* Barnard and Banner

9- *Lingulina furcillata* Berthelin

10- *Lingulina sadeki* Said and Barakat



V. Conclusion

The investigation of the foraminiferal content in the Cretaceous rocks exposed between Wadi Um Lug and Wadi Qiseib led to the identification of 108 foraminiferal species which were all followed historically and geographically, arranged taxonomically and photographed by SEM. Depending on the vertical ranges and relative abundance of the identified species, **5** biozones have been recognized throughout the Cretaceous succession in the study area, with one biozone is comprised in the Lower Cretaceous (Albian), while four biozones are included in the Cenomanian. In an ascending order, the recognized biozones are arranged as following: *Ammodiscus kiowensis* Total Range Zone, *Haplophragmoides eggeri - Trochammina sukhnaensis* Assemblage Zone, *Ismailia* spp.- *Daxia* spp. Assemblage Zone, *Ammobaculoides plummerae - Haplophragmoides gilberti* Assemblage Zone and *Nezzazata* spp. - *Trochospira* ssp. Assemblage Zone. The established biozones were all correlated with other Cretaceous biozones from neighboring regions in Egypt in order to join their boundaries and detect their stratigraphic extension.

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