

Calcareous Nannofossil Biostratigraphy of Sarmord Formation (Lower-Upper Cretaceous) in Bekhme Anticline, Kurdistan Region – Northeastern Iraq

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Abstract

The calcareous nannofossil biostratigraphy has been studied in the Sarmord Formation (Lower - Upper Cretaceous) at an exposed section in the southern limb of the Bekhme anticline, Kurdistan Region, northeastern Iraq. Lithologically, the formation consists of marl, marly limestone, and limestone represented by 52 samples. These rocks contain inadequate benthic foraminiferal fauna, green algae, echinoderms, and some bioclasts. 83 species of nannofossils belonging to 37 genera were identified. The relative abundance of calcareous nannofossils throughout the section varied from moderate to good. Six distinct zones and two subzones can be identified based on the stratigraphic distribution of the calcareous nannofossils. These are from ancient to recent:

Speetonia colligate Interval Zone (Part) (CC4)*Lithraphidites bollii* Interval Zone (CC5)*Micrantholithus hoschulzii* Partial range Zone (CC6)*Chiastozygus litterarius* Interval Zone (CC7)*Hayesites irregularis* Interval Subzone (CC7a)*Rhagdiscus angustus* Interval Subzone (CC7b)*Prediscosphaera columnata* Interval Zone (CC8)*Eiffellithus turriseiffeli* Interval Zone (CC9)

The Calcareous nannofossil zones have been correlated with other zonal schemes extending from the late Early Hauterivian to the Early Cenomanian.

Keywords:

Biostratigraphy, Calcareous nannofossil, Sarmord Formation, Bekhme anticline.

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1. Introduction

The sedimentary sequence included in the present study crops out at the core of the Berat anticline within the High Folded zone exposed beside the main road to Bekhma Dam tunnel. The section is chosen at Bekhme Gorge, approximately 90 Km northeast of Erbil City at Latitude 36° 41' 46" N and Longitude 44° 17' 08" E (Fig. 1). The studied sequences are restricted between the Chia Gara

Formation at the bottom and the Qamchuqa Formation at the top. There has been some debate regarding the classification of these sequences in terms of lithostratigraphy. They have been attributed either to the Balambo Formation in some studies (Al-Hamdani, 1991; Abdullah, 2022), or to the Sarmord Formation by others (e.g., Ali, 2010), or even referred to by a compound name like the Balambo-Sarmord Formation (Balaki, 2019). In our current study, we have chosen to refer to these sedimentary sequences as the Sarmord Formation.

This decision is made because the sequences lack fossils indicating deep marine sedimentation, and instead, the fossil components suggest sedimentation in marine shelf environments.

The Sarmord Formation was initially defined by Wetzel (1950) in Bellen et al. (1959) in the northern Iraqi region of the Surdash Anticline in Sulaimani Governorate. Lithologically, it is composed of marly neritic limestones, buff weathering, and brown and bluish marls. It has a thickness of approximately 455 m and is assigned an age of Valanginian-Aptian.

Karim et al. (2021) reported that the Sarmord Formation requires further study due to ambiguity surrounding its definition, age, and stratigraphic and territorial distribution. They conducted their study in the Qaywan section and determined that the Formation is of Valanginian to Barremian age. Al-Abassi et al. (2023) noted that the Chia Cara Formation underlies the Sarmord Formation unconformably in the Amadia and Barsarin sections, while the Balambo Formation underlies it conformably in the Gara section. Additionally, they found that the upper boundary of the Sarmord Formation is conformable with the Qamchuqa Formation in the Gara and Amadia sections, and with the Balambo Formation in the Barsarin section.

Regarding the study section, it has a thickness of about 164 m. The lower part consists of medium to thick bedded brownish marly limestone, alternating rhythmically with thin to medium beds of marl and friable shale. The middle part is composed of medium to thick bedded yellow limonitic limestone interbedded with friable shale, with some marl and marly limestone. This interval is followed by medium-grained, medium to thick-bedded limestone, intercalated with shale and some marl beds.

The modern sequences of the formation comprise crushed limestone that contains *Thalassinoides* intercalated with green marl (Fig.7). The *Thalassinoides* consist of branches of cylindrical or (Y) shape burrow system with unlined sharp walls, straight or curved commonly penetrate in firm, unlithified substrates (Myrow, 1995), the average length of each burrow system is 5-10cm with a diameter range between 1-2 cm, these structures remained open after being vacated by the trace-maker, thus allowing material from subsequent depositional events to accumulate therein (MacEachern et al., 2007), so it was observed that there is a clear difference like sediment fillings the

burrows from the sediments surrounding it. The ichnogenus *Thalassinoides* exemplifies the Glossifungites Ichnofacies, which reflects the colonization of firm substrates. Firm grounds were formed when semi-consolidated muds were exhumed by mass wasting and erosive bottom currents (Sávra et al., 2001).

Stratigraphically, the lower boundary of the Sarmord Formation is seen to be gradational and conformable with the Chia Cara Formation, which is exposed near the deepest cut of the river in the Bekhme Gorge with no field evidence of unconformity (Balaki, 2019). The upper boundary is conformable with the Qamchuqa Formation. Additionally, several studies have emphasized the importance of investigating this formation to confirm its stratigraphic status, as it is one of the less explored formations in Iraq

The goal of this work is to identify the main calcareous nannofossil zones and compare them to regional and international standards and to determine morphology, biostratigraphic distributions, and abundances. As a result, the proposal of new chronostratigraphic and biostratigraphic frameworks for the Sarmord Formation was suggested.

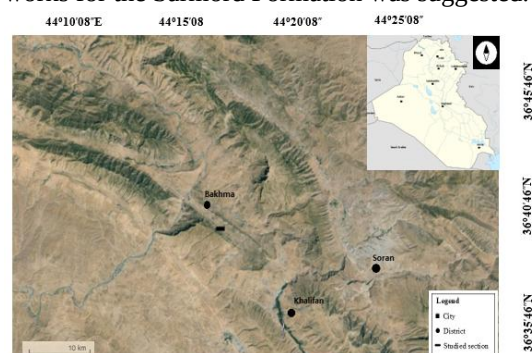


Fig. 1: Location map of studied section

2. Field Description of the Studied Section

In the area under investigation, the Sarmord Formation typically consists of limestone, marl, and marly limestone successions with varying thicknesses. The lower part is composed of medium to thick-bedded brownish marly limestone, which alternates rhythmically with thin to medium beds of marl and friable shale (Fig. 2). The middle part contains medium-thick beds of limestone interbedded with friable shale, marl, and marly limestone (Figs. 3 and 4).

The upper part of the formation is characterized by reddish limestone intercalated with shale and some marl beds (Fig. 5), along with dark gray

marly limestone and crushed limestone containing *Thalassinoides* at its uppermost part (Fig. 7).



Fig. 2. Field photograph showing bedded brownish marly limestone alternating with thin beds of marl and friable shale at the bottom of the Sarmord Formation in Bekhme Gorge.



Fig. 3: Marly limestone beds within the middle part of the studied Sarmord Formation



Fig. 4: Thick limestone beds, interbedded with friable shale, marl, and marly limestone within the central part of the studied section of the Sarmord Formation



Fig.5: Field photograph showing reddish medium to thick bedded limestone, intercalated by shale and some marl beds in the upper part of the studied section of the Sarmord Formation



Fig. 6: Field photograph showing the location of the top contact of the Sarmord Formation (grey marl) alongside the Qamchuqa Formation (thick brownish limestone beds) at the northeastern part of the Bekhme Gorge.



Fig. 7. Field photograph showing:?? Trace fossils (*Thalassinoides*) at the uppermost marly limestone bed of the Sarmord Formation at its upper contact with the Qamchuqa Formation

3. Methodology

Fifty-two samples were collected from the studied section with an inter-sample distance ranging between 2 and 5 meters. These samples were processed using the simple smear slide technique. These smear slides were viewed at 1000x magnification using a polarizing microscope.

4. Results

Calcareous nannofossils are valuable tools for biostratigraphy; they provide a comprehensive framework for biostratigraphy from the Lower Cretaceous succession being studied. As a result, they are effective for chronostratigraphic correlation. Additionally, calcareous nannofossils are useful for biostratigraphically correlating marine strata over long distances. A total of 83 species of calcareous nannoplankton from 37 genera were identified through biostratigraphic analysis of treated samples from the research area. The distribution chart of these species is displayed in Fig. 8. All identified species are shown in plates (1-8).

The biostratigraphy of the measured sections is based on the ranges and assemblages of calcareous nannoplankton datum events. In this study, six zones and two subzones are identified through the stratigraphic distribution of calcareous nannofossils depending on the CC zonation of Sissingh (1977). These biozones have been compared with worldwide biozones (Fig. 9) and local studies (Fig. 10). The biozones are listed below from ancient to recent:

1- Speetonia colligate Interval Zone (CC4) (Part)

Definition and Correlation: The lower boundary of this subzone is not determined in this study, while the upper boundary is determined by the late appearance of *Speetonia colligate*, with a thickness of 14 meters represented by samples (1-5). This zone is equivalent to the *Speetonia colligate* subzone (CC4b) of (Sissingh, 1977) and coincides with NC4b according to (Roth, 1978). Additionally, it is correlated with BC8, BC9, and the lower part of BC10 (Bowen et al., 1998). This subzone belongs globally to the *Cretarhabdus loriei* Interval Zone and defines the interval as late Early Hauterivian to Late Hauterivian.

Discussion: This zone is characterized by the prevalence of the following species

(*Cyclagelosphaera argoensis*, *Eiffellithus striatus*, *Eprolithus antiquus*, *Helenea quadrata*, *Lithraphidites bollii*, *Rucinolithus windleyae*). The presence of these species is an indicator of the Hauterivian.

As for the formation's contact boundaries, the lower contact with the Chia Cara Formation is conformable.

2- Lithraphidites bollii Interval Zone (CC5)

Definition and Correlation: The biostratigraphic interval is defined by the range of the nominated taxon between the last appearance of *Speetonia colligate* at the bottom and the last occurrence of *Cacicalathina oblongata* at the top. This interval has a thickness of 23 meters, represented by samples (5-13). This zone coincides with the *Lithraphidites bollii* Interval Zone (CC5) of (Sissingh, 1977) and is also correlated with NC5a by (Roth, 1978); it is correlated with the upper part of BC10, BC11, BC12, BC13, and the lower part of BC14 by (Bowen et al., 1998). This interval has been defined as the Early Barremian.

Discussion: This zone is characterized by the prevalence of *Assipetra infracretacea*, *Assipetra terebrodentarius*, *Calcicalathina oblongata*, *Cyclagelosphaera deflandrei*, *Ellipsagelosphaera supergesta*, *Haqius circumradiatus*, *Helenea chiesta*, *Nannoconus minutus*, *Pickelhaube furtiva*.

3- Micrantholithus hoschulzii Partial range Zone (CC6)

Definition and Correlation: The biostratigraphic interval is characterized by the partial range of the nominated taxon between the last occurrence of *Cacicalathina oblongata* at the base and the first occurrence of *Hayesites irregularis* at the top. This zone is recorded with a thickness of 16 meters, represented by samples (13-16); it is equivalent to the *Micrantholithus hoschulzii* Partial Range Zone (CC6) of (Sissingh, 1977) and coincides with NC5b of (Roth, 1978). It is correlated with the upper part of BC14, BC15, BC16, and BC17 (Bowen et al., 1998). The Late Barremian is the interval defined by this zone.

Discussion: This zone is characterized by the prevalence of *Diazomatolithus lehmanii*, *Nannoconus minutus*, *Rhagodiscus asper*, *Watznaueria barnesia*, *Watznaueria biporta*, and *Watznaueria fossacincta*.

4- *Chiastozygus litterarius* Interval Zone (CC7)

Definition and Correlation: There are two subzones within this zone depending on the subzonal marker. The first is the *Hayesites irregularis* Interval Subzone (CC7a), which represents the interval from the first occurrence of the nominated taxon *Hayesites irregularis* at the base to the first occurrence of *Eprolithus floralis* at the top. It has a thickness of 27 meters, represented by samples (16-23). This subzone coincides with the *Hayesites irregularis* Interval Subzone (CC7a) by Sissingh (1977) and coincides with NC6 by Roth (1978). It is correlated with the BC18, BC19, and the lower part of BC20 by (Bowen et al., 1998). This subzone has defined the interval as the early Aptian.

Discussion: This subzone is characterized by the prevalence of *Assipetra terebrodentarius*, *Braarudosphaera batilliformis*, *Cretarhabdus conicus*, *Cretarhabdus delicatus*, *Cyclagelosphaera margerelii*, *Diazomatolithus lehmanii*, *Haqius circumradiatus*, *Hayesites irregularis*, *Microrostaurus chiastius*, *Micrantholithus hoschulzii*, *Micrantholithus obtusus*, and Barremian/Aptian boundary is also marked by the beginning of first occurrence of *Nannoconus truittii frequens* and *Nannoconus troelsenii*.

The second subzone is the *Eprolithus floralis* Interval Subzone (CC7b), which represents the duration between the initial appearance of *Eprolithus floralis* and the initial appearance of *Prediscosphaera columnata*. With a thickness of 12 meters, it is represented by samples (23-28). This subzone coincides with the *Rhagodiscus angustus* Interval Subzone (CC7b) according to (Sissingh, 1977) and also aligns with NC7 according to (Roth, 1978). Additionally, it is compatible with the upper part of BC20, BC21, and the lower part of BC22 according to (Bowen et al., 1998). This subzone is defined from the Late Aptian.

Discussion: This subzone is characterized by the prevalence of *Assipetra terebrodentarius*, *Diazomatolithus lehmanii*, *Eprolithus floralis*, *Haqius circumradiatus*, *Micrantholithus hoschulzii*, *Nannoconus minutus*, *Nannoconus elongatus*, and *Watznaueria barnesiae*.

5- *Prediscosphaera columnata* Interval Zone (CC8)

Definition and Correlation: The interval zone determined by the first appearance of *Prediscosphaera columnata* to the first appearance of *Eiffellithus turriseiffeli*, with a thickness of 26 meters,

represented by samples (28-39). This zone corresponds to the *Prediscosphaera columnata* Interval Zone (CC8) as defined by Sissingh (1977) and coincides with NC8 and NC9 as defined by Roth (1978), as well as being compatible with the upper part of BC22, BC23, BC24, BC25, and BC26 as defined by Bowen et al. (1998). This zone represents an Early to Late Albian age.

Discussion: This subzone is characterized by the prevalence of *Assipetra terebrodentarius*, *Braarudosphaera pseudobatilliformis*, *Calcicalathina alta*, *Cyclagelosphaera margerelii*, *Nannoconus steinmannii*, *Nannoconus troelsenii*, and *Prediscosphaera columnata*.

6- *Eiffellithus turriseiffeli* Interval Zone (CC9)

Definition and Correlation: The lower boundary of this zone is defined by the first occurrence of *Eiffellithus turriseiffeli* to the initial appearance of *Lithraphidites acutus*. It has a thickness of 46 meters, as represented by samples (39-50). This zone corresponds to the *Eiffellithus turriseiffeli* Zone (CC9) as described by Sissingh (1977) and aligns with the lower part of NC10 according to Roth (1978). Additionally, it correlates with BC27a and, as noted by Bowen et al. (1998), indicates a Late Albian to Early Cenomanian age.

Discussion: This subzone is characterized by the prevalence of *Assipetra terebrodentarius*, *Calcicalathina alta*, *Diazomatolithus lehmanii*, *Eiffellithus turriseiffeli*, *Eprolithus floralis*, *Hayesites albiensis*, *Hayesites irregularis*, *Nannoconus dislocates*, *Nannoconus minutus*, *Pickelhaube furtiva*, *Watznaueria barnesiae*.

As for the upper contact is conformable with the Qamchuqa Formation.

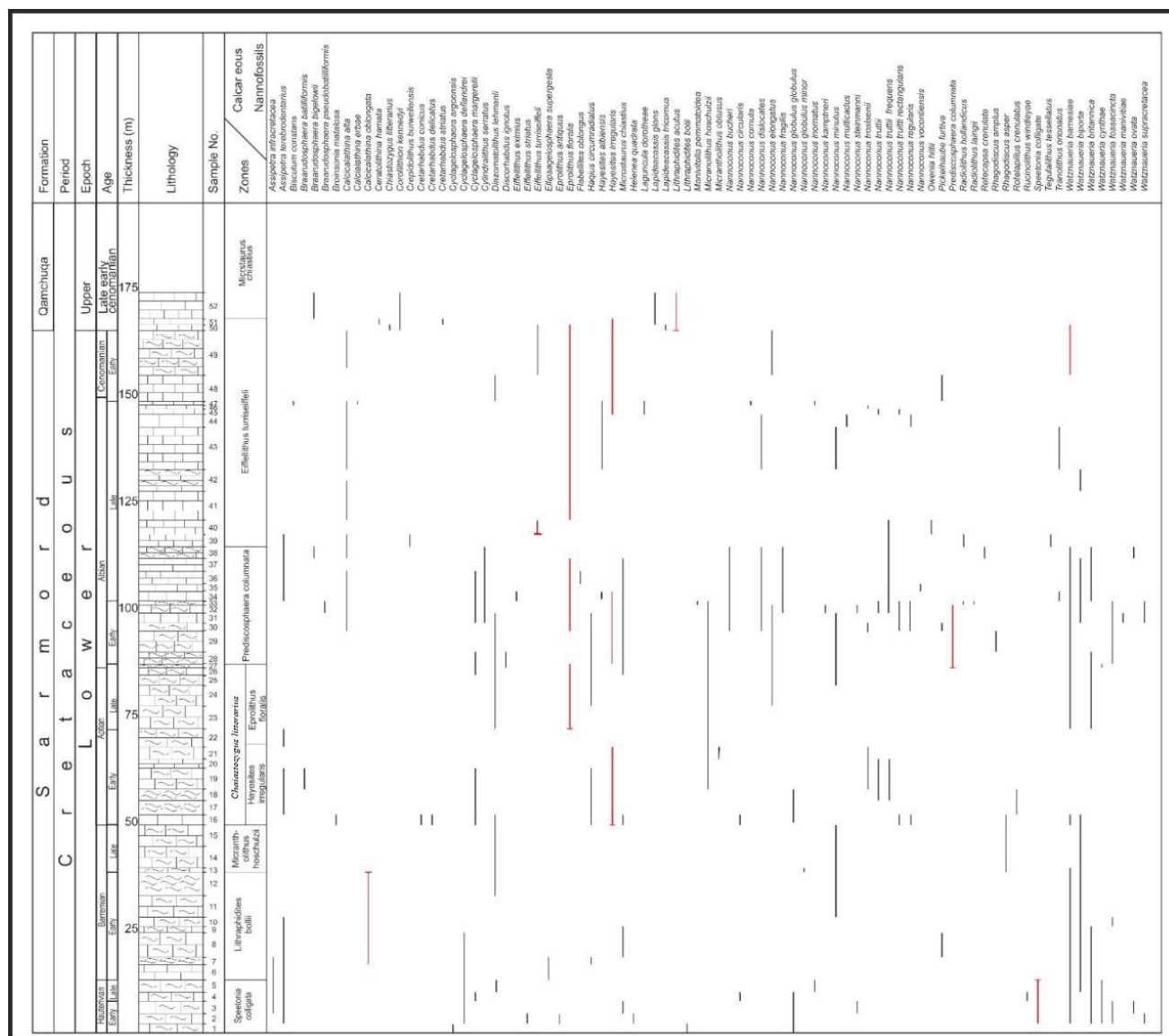


Fig. 8: Distribution of calcareous nannofossils in the Sarmord Formation on the Bekhme Anticline.

Gradstein, et al., 2023	Period	Epoch	Age		Present Study	Sissingh, 1977 Europe, Tunisia		Roth, 1978 Cosmopolitan	Bown et al., 1998 Boreal Realm		
100.5	Cretaceous	Lower-Upper	Albian - Cenomanian	Late Albian- Early Cenomanian	<i>Eiffellithus turriseiffeli</i>	<i>Eiffellithus turriseiffeli</i> CC9	<i>Prediscosphaera spinosa</i> CC9b	NC10	BC27	b	
							<i>Hayesites albiensis</i> CC9a			a	
				Early - Late Albian	<i>Prediscosphaera columnata</i>	<i>Prediscosphaera columnata</i> CC8	<i>Tranolithus phacelosus</i> CC8b	NC9	BC26	b	
							<i>Braarudosphaera africana</i> CC8a		NC8	BC25	a
			Aptian	Late	<i>Eprolithus floralis</i>	<i>Chasmodon linearis</i> CC7	<i>Rhagodiscus angustus</i> CC7b	NC7	BC24	BC23	
									<i>Hayesites irregularis</i>	<i>Hayesites irregularis</i> CC7a	NC6
				Early	<i>Chasmodon linearis</i>		<i>Hayesites irregularis</i> CC7a	NC6			BC21
									<i>Chasmodon linearis</i>	<i>Hayesites irregularis</i> CC7a	NC6
				Barremian	Late		<i>Micrantholithus hoschulzii</i>	<i>Micrantholithus hoschulzii</i> CC6			
									<i>Lithraphidites bollii</i>	<i>Lithraphidites bollii</i> CC5	NC5a
Early	<i>Lithraphidites bollii</i>	<i>Lithraphidites bollii</i> CC5	NC5a		BC13	BC12					
					<i>Lithraphidites bollii</i>	<i>Lithraphidites bollii</i> CC5	NC5a		BC11		c
Hauterivian	Late		<i>Speetonia colligata</i>	<i>Cretarhabdus koriei</i> CC4				<i>Speetonia colligata</i> CC4b	NC4b		BC10
					Early		<i>Speetonia colligata</i>			<i>Cretarhabdus koriei</i> CC4	<i>Speetonia colligata</i> CC4b
<i>Speetonia colligata</i>	<i>Cretarhabdus koriei</i> CC4	<i>Speetonia colligata</i> CC4b	NC4b					BC7	b		
					<i>Speetonia colligata</i>	<i>Cretarhabdus koriei</i> CC4	<i>Speetonia colligata</i> CC4b	NC4b	BC6		a
<i>Speetonia colligata</i>		<i>Cretarhabdus koriei</i> CC4	<i>Speetonia colligata</i> CC4b	NC4b					BC5 part		BC5 part

Gradstein, et al., 2023	Period	Epoch	Age		Present Study		Al-Khafaf & Al-Mutwali, 2019		Al-Miamary et al.,2020	Karim et al., 2021
100.5	Cretaceous	Lower-Upper	Albian - Cenomanian	Late Albian- Early Cenomanian	<i>Eiffellithus turrisseiffeli</i>		Not studied		Not studied	Not studied
113.0				Early – Late Albian	<i>Prediscosphaera columnata</i>		Not studied			
121.4			Aptian	Late	<i>Chiaztozygus litterarius</i>	<i>Eprolithus floralis</i>		<i>Chiaztozygus litterarius</i>	<i>Eprolithus floralis</i>	Not studied
				Early		<i>Hayesites irregularis</i>				<i>Hayesites irregularis</i>
125.77			Barremian	Late	<i>Micrantholithus hoschulzii</i>		<i>Micrantholithus hoschulzii</i>		Not studied	
				Early	<i>Lithraphidites bollii</i>		<i>Lithraphidites bollii</i>			
			Hauterivian	Late	<i>Speetonia colligata</i>		<i>Speetonia colligata</i>		Not studied	CC5
				Early						CC4

Fig. 10: Calcareous nannofossil biostratigraphic correlation of the Sarmord Formation with other local studies.

5. Conclusion

The current study focuses on the Sarmord Formation in the Bekhme Anticline. This formation is comprised of marl, marly limestone, and limestone. Through biostratigraphic study, the identification of 83 species of calcareous nannoplankton from 37 genera was achieved. The age of the formation, extending from the Late Early Hauterivian to the Early Cenomanian, was determined by finding six zones and two subzones. These are from ancient to recent:

Speetonia colligata Interval Zone (Part) (CC4), *Lithraphidites bollii* Interval Zone (CC5), *Micrantholithus hoschulzii* Partial range Zone (CC6), *Chiaztozygus litterarius* Interval Zone (CC7), *Hayesites irregularis* Interval Subzone (CC7a), *Rhagdiscus angustus* Interval Subzone (CC7b),

Prediscosphaera columnata Interval Zone (CC8), *Eiffellithus turrisseiffeli* Interval Zone (CC9).

6. Conflict of Interest

The authors declare that they have no conflict of interest.

7. Funding Statement

This research received no external funding.

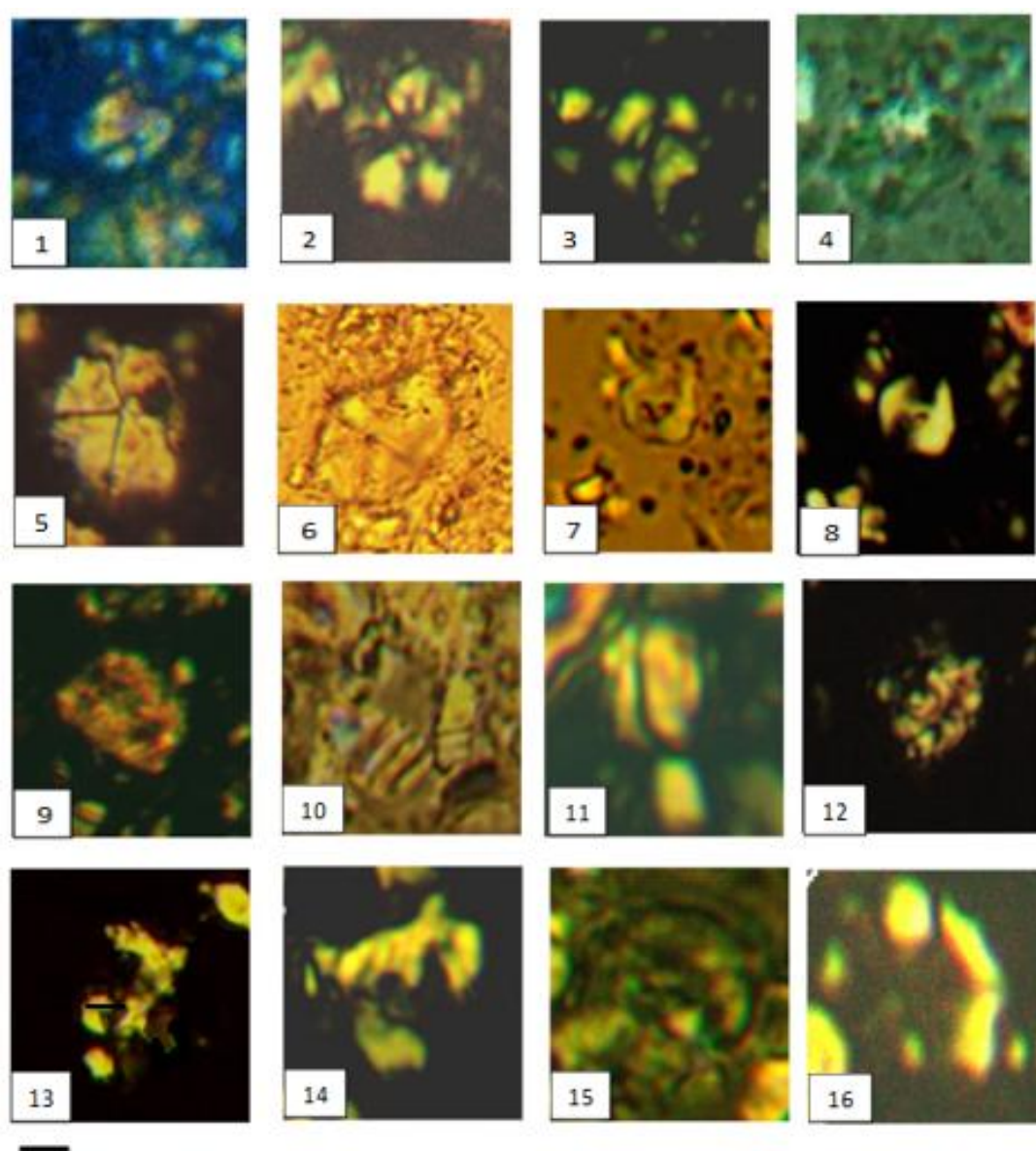
8. Author Contributions

Inas H. Al-Khafaf: First Author: Conception of the research idea; writing the complete research methodology, including the conclusions; preparation of the figures and plates presented in the research paper.

Co-Author: Majid M. Al-Mutwali Second Author: Conception of the research idea; writing the introduction; review and supervision.

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Calcareous nannofossils from the Sarmord Formation, cross-polarized light (XPL) and plane-polarized light (PPL). The magnification is 1000X. The Scale bar is 5µm.

Plate 1- 1-*Assipetra infractetacea* (Thierstein, 1973) Roth, 1973, sample 6, 2- *Assipetra terebrodentarius* (Applegate et al. in Covington and Wise, 1987) Rutledge and Bergen in Bergen, 1994, sample 2, 3- *Biscutum constans* (Górka, 1957) Black in Black and Barnes, 1959, sample 30, 4- *Braarudosphaera batilliformis* Troelsen Quadros, 1971, sample 19, 5- *Braarudosphaera bigelowii* (Gran and Braarud, 1935) Deflandre, 1947, sample 38, 6- *Braarudosphaera pseudobatilliformis* Alves et al. 2017, sample 32, 7,8- *Broinsonia matulosa* (Stover, 1966) Burnett in Gale et al., 1996, sample 16, 9,10 *Calcicalathina alta* Perch-Nielsen, 1979, sample 30, 50, 11- *Calcicalathina erbae* Bergen 1998, sample 47, 12- *Calcicalathina oblongata* (Worsley, 1971) Thierstein, 1971, sample 12, 13,14 *Ceratolithina hamata* Martini, 1967, sample 51,50, 15- *Chiastozygus literarius* (Górka, 1957) Manivit, 1971, sample, 50, 16- *Corollithion kennedyi* Crux, 1981, sample 50.

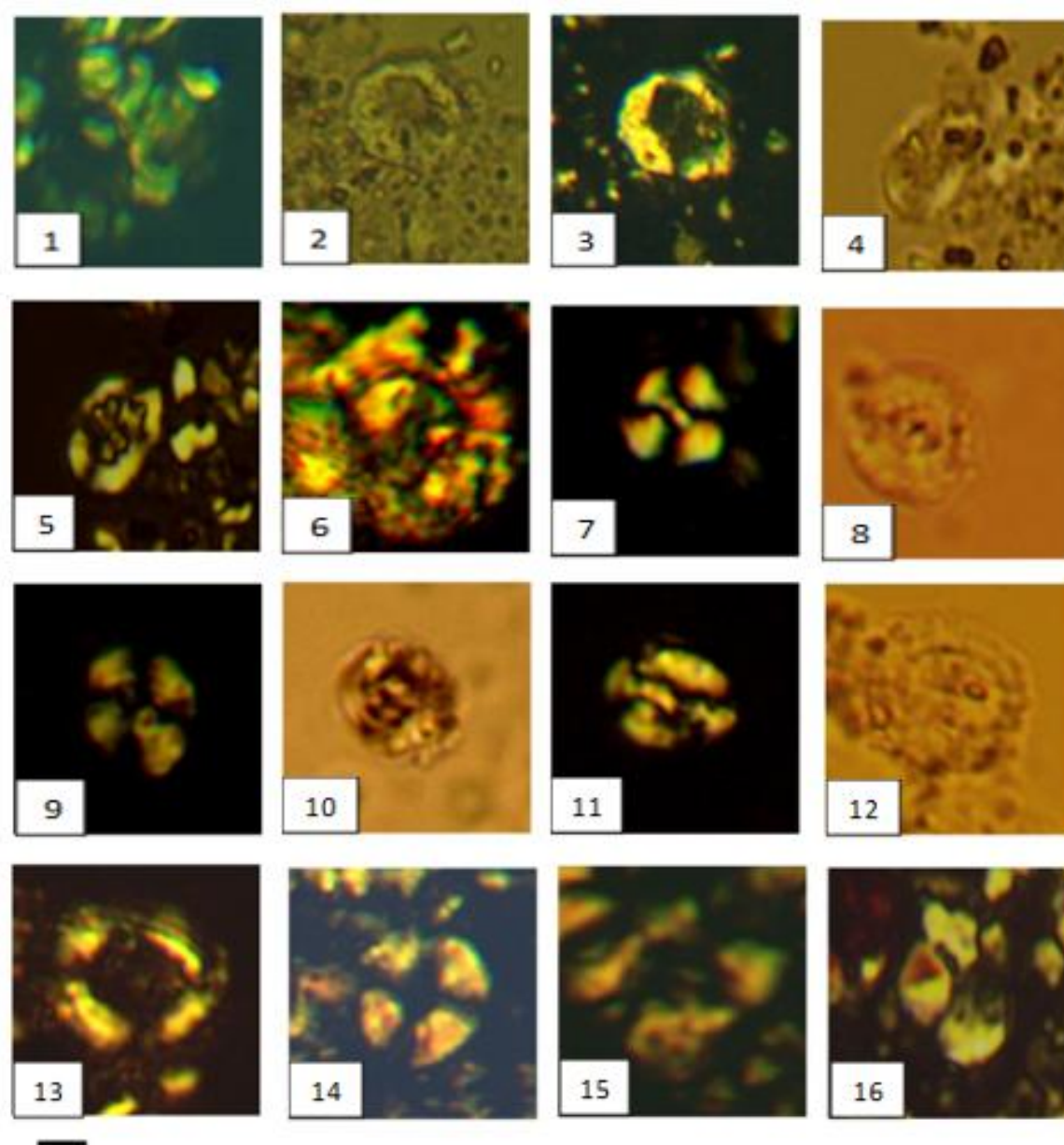


Plate 2. The Scale bar is 5µm 1- *Crepidolithus burwellensis* Black 1972, sample 39, 2,3- *Cretarhabdus conicus* Bramlette and Martini, 1964, sample 16, 4,5- *Cretarhabdus delicatus* Applegate, Covington, and Wise in Covington and Wise, 1987, sample 16, 6- *Cretarhabdus striatus* (Stradner, 1963) Black, 1973, sample 50, 7- *Cyclagelosphaera argoensis* Bown, 1992, sample 1, 8,9- *Cyclagelosphaera deflandrei* (Manivit, 1966) Roth, 1973, sample 2, 10,11- *Cyclagelosphaera margerelii* Noël, 1965, sample 28, 12,13- *Cylindralithus serratus* Bramlette and Martini, 1964, sample 31, 14- *Diazomatolithus lehmanii* Noël, 1965, sample, 28, 15- *Discorhabdus ignotus* (Górka, 1957) Perch-Nielsen, 1968, sample, 28, 16- *Eiffelithus eximius* (Stover, 1966) Perch-Nielsen, 1968, sample, 34.

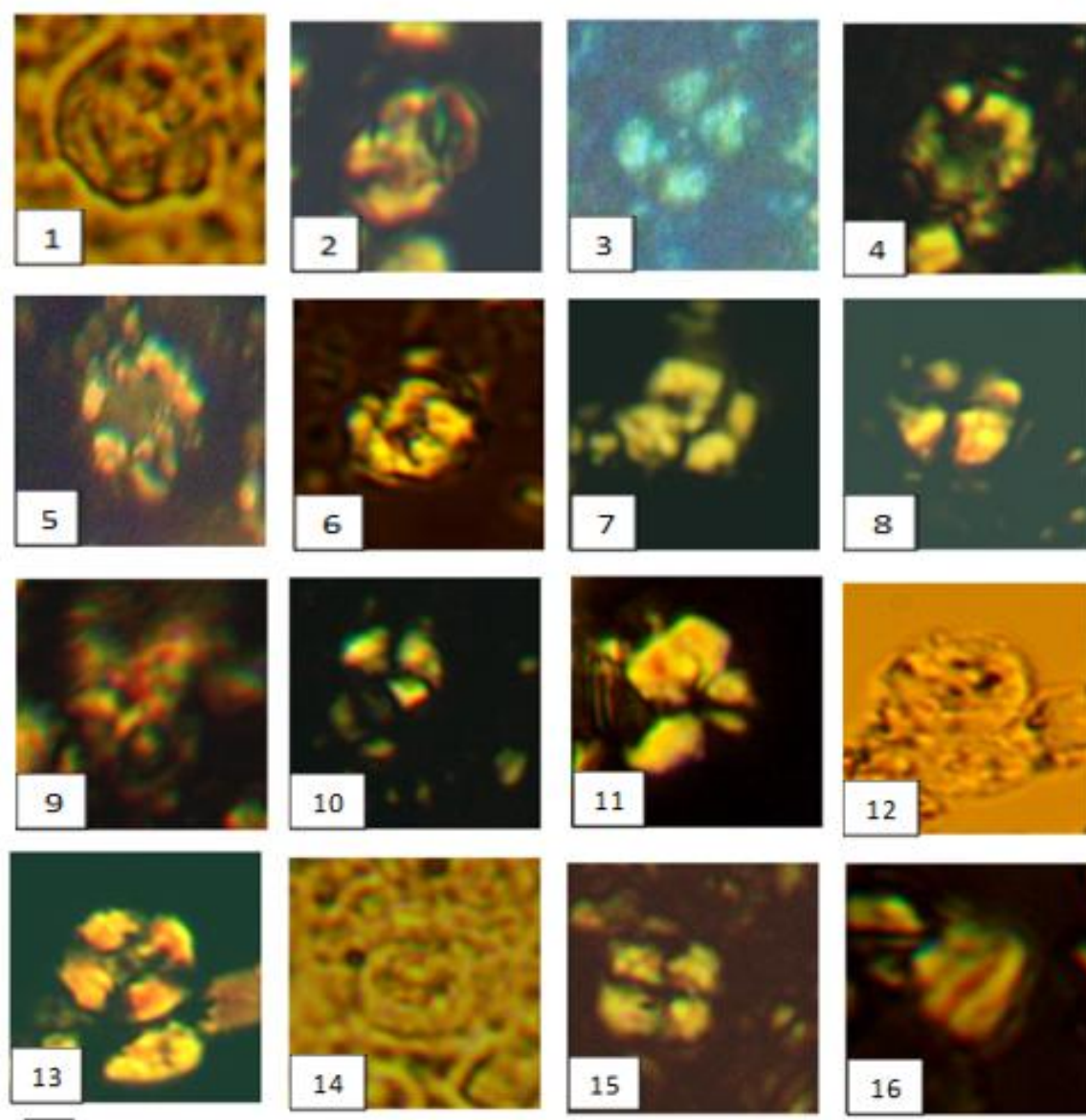


Plate 3. The Scale bar is 5µm 1- *Eiffellithus striatus* (Black, 1971) Applegate and Bergen, 1988, sample 2, 2- *Eiffellithus turriseiffelii* (Deflandre in Deflandre and Fert, 1954) Reinhardt, 1965, sample 39, 3- *Ellipsagelosphaera supergesta* Varol and Bowman 2019, sample 6, 4- *Eprolithus antiquus* Perch-Nielsen, 1979, sample 2, 5,6- *Eprolithus floralis* (Stradner, 1962) Stover, 1966, sample 23, 37, 7- *Flabellites oblongus* (Bukry, 1969) Crux in Crux et al., 1982, sample 36, 8- *Haqius circumradiatus* (Stover, 1966) Roth, 1978, sample 30, 9- *Hayesites albiensis* Manivit, 1971, sample 43, 10,11- *Hayesites irregularis* (Thierstein in Roth and Thierstein, 1972) Applegate et al. in Covington and Wise, 1987, sample 16,51, 12,13- *Microstaurus chiastius* (Worsley, 1971) Grün in Grün and Allemann 1975 emend. Bralower et al. 1989 sample 31, 14,15- *Helenea quadrata* (Worsley, 1971) Rutledge and Bown in Bown et al., 1998, sample 2, 16- *Lapideacassis glans* Black, 1971, sample 40.

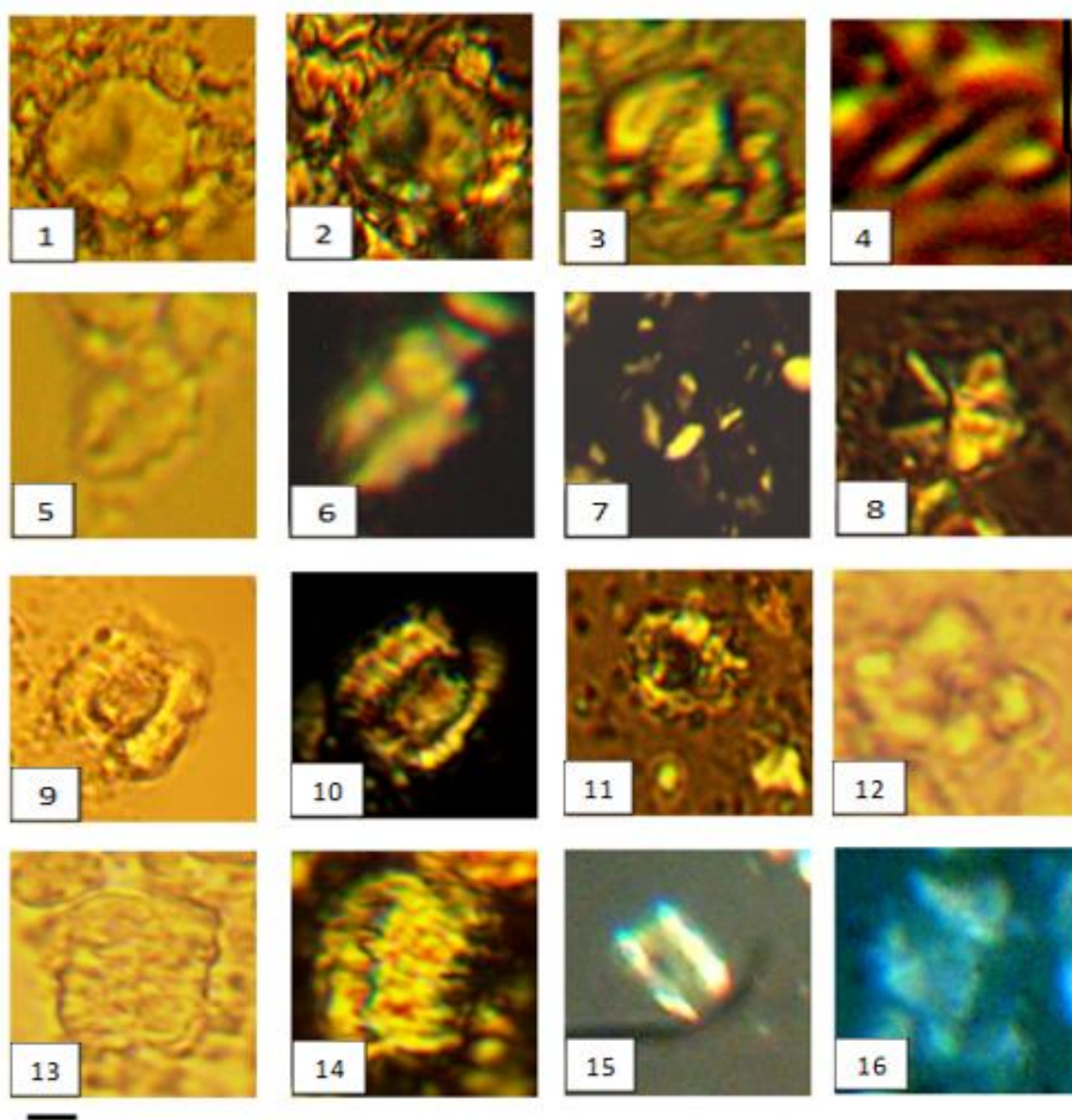


Plate 4. The Scale bar is 5µm 1,2- *Laguncula dorotheae* Black, 1971, sample 46, 3- *Lapideacassis tricornus* Wind and Wise in Wise and Wind, 1977, sample 50, 4- *Lithraphidites acutus* Verbeek and Manivit in Manivit et al., 1977, sample 50, 5,6- *Lithraphidites bollii* (Thierstein, 1971) Thierstein, 1973, sample 1, 7- *Manivitella pemmatoidea* (Deflandre in Manivit, 1965) Thierstein, 1971, sample 33, 8- *Micrantholithus hoschulzii* (Reinhardt, 1966) Thierstein, 1971, sample 33, 9,10- *Nannoconus bucheri* Brönnimann, 1955, sample 38, 11- *Nannoconus circularis* Deres and Achéritéguy, 1980, sample 16, 12- *Nannoconus cornuta* Deres and Achéritéguy 1980, sample 47, 13,14- *Nannoconus dislocatus* Perch-Nielsen, 1988, sample 37, 15- *Nannoconus elongatus* Brönnimann, 1955, sample 23, 16- *Micrantholithus obtusus* Stradner, 1963, sample 21.

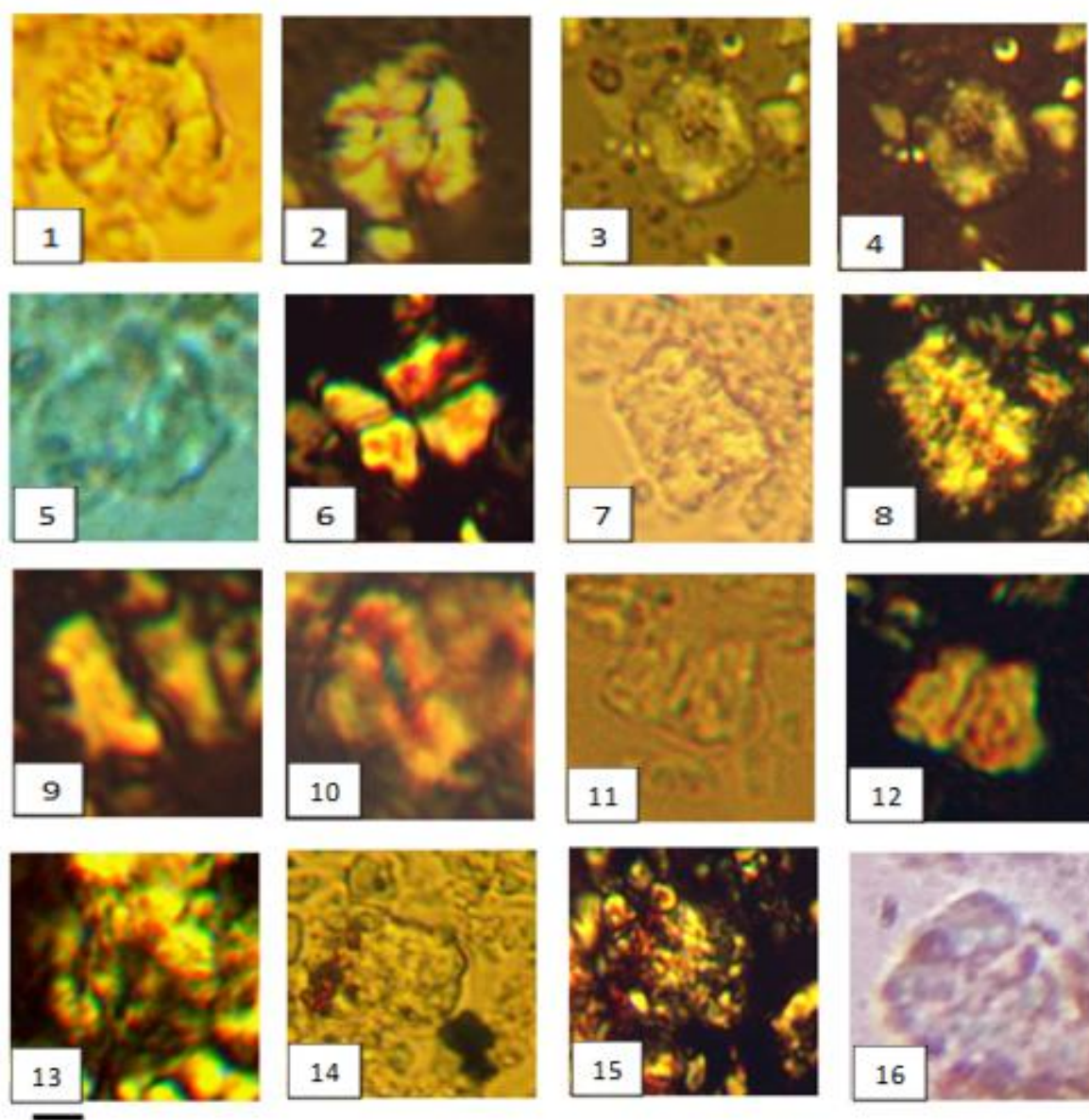


Plate 5. The Scale bar is 5µm 1,2- *Nannoconus fragilis* Deres and Achéritéguy, 1980, sample 38, 3,4- *Nannoconus globulus globulus* Brönnimann, 1955, sample 16, 5- *Nannoconus globulus minor* Bralower in Bralower et al., 1989, sample 13, 6- *Nannoconus inornatus* Rutledge and Bown, 1996, sample 47, 7,8- *Nannoconus kamptneri* Brönnimann, 1955, sample 32, 9- *Nannoconus minutus* Brönnimann, 1955, sample 29, 10- *Nannoconus multicaus* Deflandre and Deflandre-Rigaud, 1959, sample 29, 11,12- *Nannoconus steinmannii* Kamptner, 1931, sample 3, 13- *Nannoconus troelsenii* Alves, Lima and Shimabukuro 2017, sample 46, 14,15- *Nannoconus truittii* Brönnimann, 1955, sample 32, 16- *Nannoconus truittii frequens* DeresandAchéritéguy, 1980, sample 18.

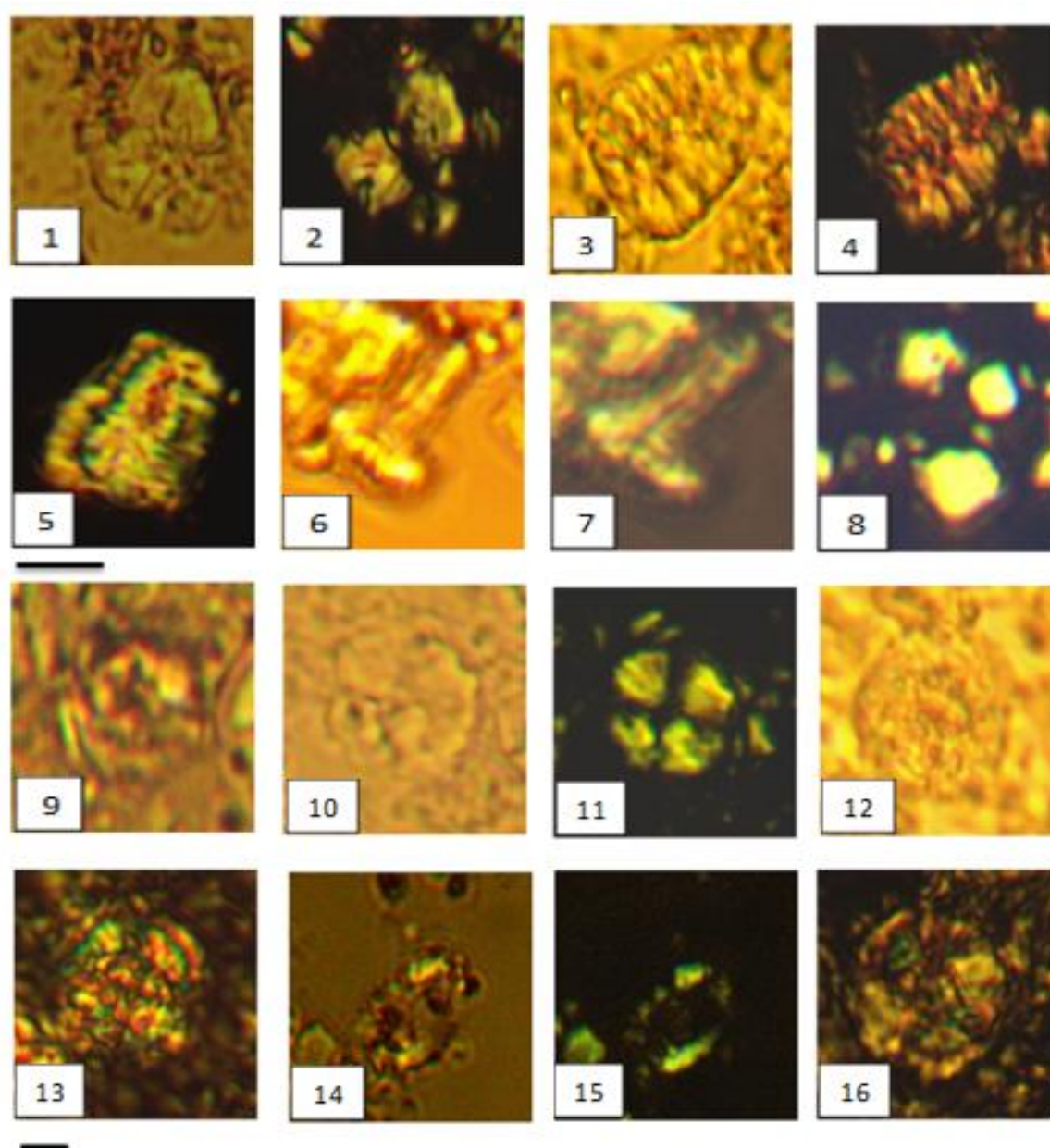


Plate 6. The Scale bar is 1-8 (7 μ m), 9-16 (5 μ m) 1,2- *Nannoconus truittii rectangularis* Deres Achéritéguy, 1980, sample 16, 3,4- *Nannoconus regularis* Deres and Acherit, sample 32, 5- *Nannoconus vocontiensis* Deres and Achéritéguy, 1980, sample 35, 6,7- *Owenia hillii* Crux, 1991, sample 40, 8- *Pickelhaube furtiva* (Roth, 1983) Applegate et al. in Covington and Wise, 1987, sample 48, 9- *Prediscosphaera columnata* (Stover, 1966) Perch-Nielsen, 1984, sample 28, 10,11- *Radiolithus hollandicus* Varol, 1992, sample 33, 12,13- *Radiolithus laingii* Varol, 1992, sample 33, 14,15- *Retecapsa crenulata* (Bramlette and Martini, 1964) Grün in Grün and Allemann, 1975, sample 13, 16- *Rhagodiscus amplius* Bown, 2005, sample 29.

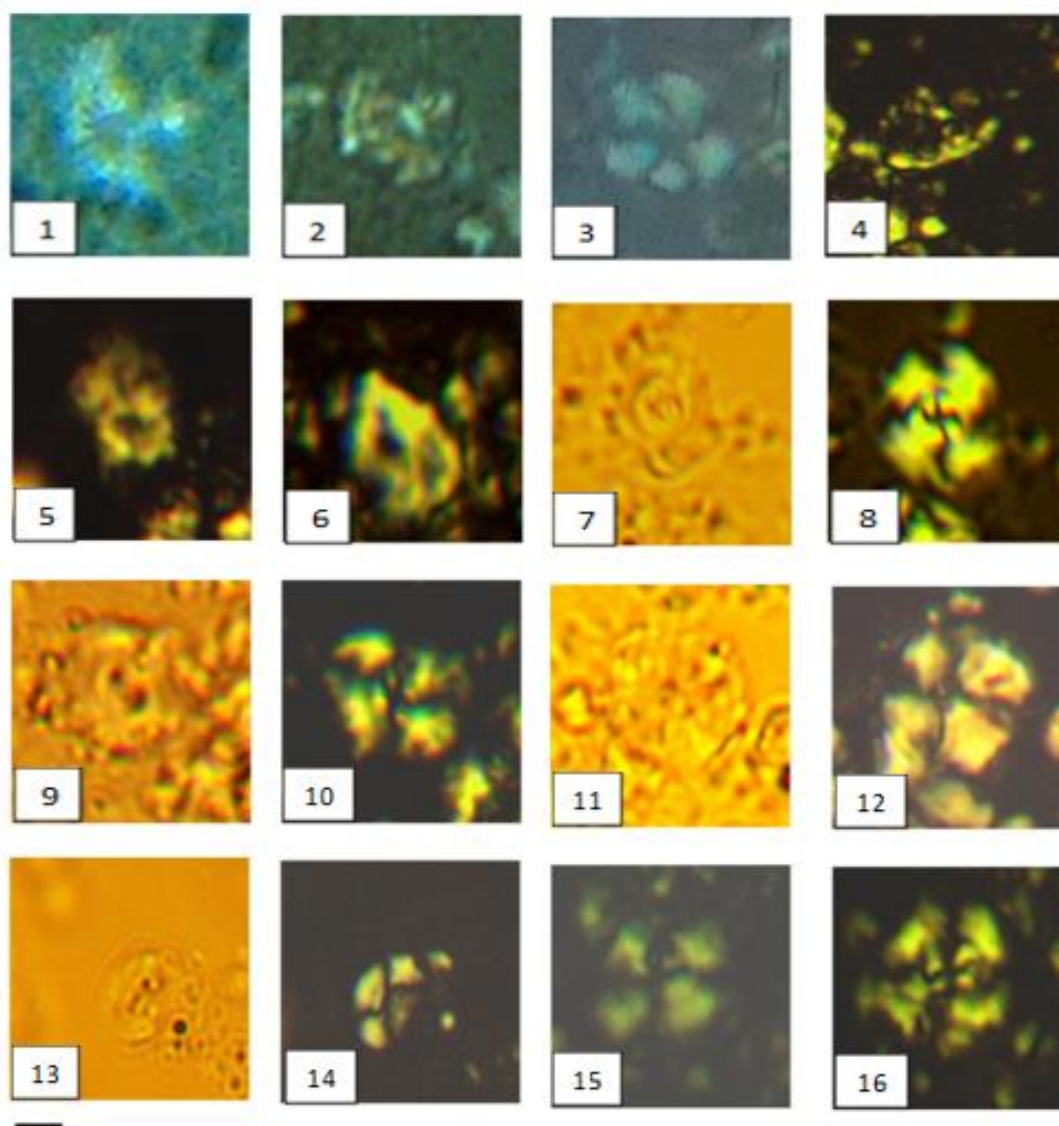


Plate 7. The Scale bar is 5µm 1- *Rhagodiscus asper* (Stradner, 1963) Reinhardt, 1967, sample 16, 2- *Rotelapillus crenulatus* (Stover, 1966) Perch-Nielsen, 1984, sample 18, 3- *Rucinolithus windleyae* Rutledge and Bown, 1996, sample 4, 4- *Speetonia colligata* Black, 1971, sample 5, 5- *Tegulolithus tessellatus* (Stradner in Stradner et al., 1968) Crux, 1986, sample 39, 6- *Tranolithus orionatus* (Reinhardt, 1966a) Reinhardt, 1966b, sample 34, 7,8- *Watznaueria barnesiae* (Black in Black and Barnes, 1959) Perch-Nielsen, 1968, sample 37, 9,10- *Watznaueria biporta* Bukry, 1969, sample 38, 11,12- *Watznaueria britannica* (Stradner, 1963) Reinhardt, 1964, sample 37, 13,14- *Watznaueria cythae* Worsley, 1971, sample 5, 15- *Watznaueria fos-sacincta* (Black, 1971) Bown in Bown and Cooper, 1989, sample 28, 16- *Watznaueria manivittiae* Bukry 1973, sample 31

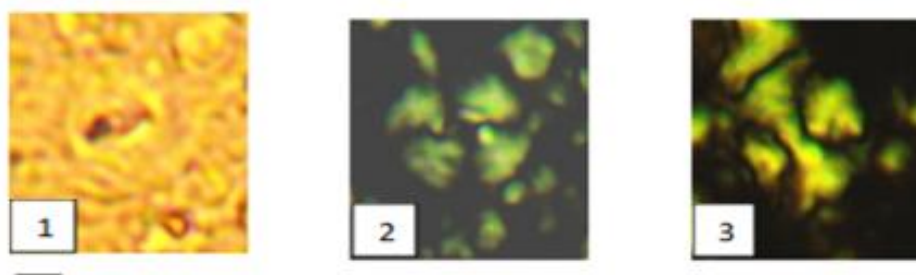


Plate 8. The Scale bar is 5µm 1,2- *Watznaueria ovata* Bukry, 1969, sample 38, 3- *Watznaueria supracretacea* (Reinhardt, 1965) Wise and Wind, 1977, sample 31.



الطباقية الحياتية لمتحجرات النانو الجيرية لتكوين سارمورد (الكريتاسي الأسفل - الأعلى)

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* الباحث المراسل.

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الملخص

تمت دراسة الطباقية الحياتية لمتحجرات النانو الجيرية لتكوين سارمورد (الكريتاسي الأسفل - الأعلى) في المقطع المكشوف في الجناح الجنوبي لطية بخمة، إقليم كردستان - شمال شرقي العراق. يتألف التكوين صخارياً من المارل، الحجر الجيري المارلي والحجر الجيري والمتمثلة بحوالي 52 نموذجاً. حيث لوحظ ان هذه الطبقات الصخرية كانت مفقورة لمتحجرات الفورامنيفر القاعية والطحالب الخضراء، وشوكيات الجلد، بالإضافة إلى بعض بقايا الكائنات الأخرى، تم تشخيص 83 نوعاً تعود إلى 37 جنساً من متحجرات النانو الجيرية حيث كانت الوفرة النسبية لها تتراوح ما بين المتوسطة إلى الجيدة ومن خلال التوزيع الطباقية لمتحجرات النانو الجيرية تم تحديد ستة انطقة طباقية حياتية واثنتان تحت نطاق. وهي من الاقدم الى الاحدث:

Speetonia colligate Interval Zone (Part) (CC4)

Lithraphidites bollii Interval Zone (CC5)

Micrantholithus hoschulzii Partial range Zone (CC6)

Chiastozygus litterarius Interval Zone (CC7)

Hayesites irregularis Interval Subzone (CC7a)

Rhagdiscus angustus Interval Subzone (CC7b)

Prediscosphaera columnata Interval Zone (CC8)

Eiffellthus turriseiffeli Interval Zone (CC9)

تمت مضاهاة هذه الانطقة مع مجموعة من الانطقة الطباقية العالمية والمحلية ومن خلال ذلك تم تحديد عمر التكوين الممتد من الهاتروفيان المبكر والى السينيوميان المبكر.

الكلمات المفتاحية:

الطباقية الحياتية، متحجرات النانو الجيرية، تكوين سارمورد، طية بخمة

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