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Nannobiostratigraphic Study of Dokan Formation (Cenomanian) in the Kosrat Anticline, Northeastern Iraq

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ABSTRACT

The Dokan Formation is distributed during the Cenomanian in northern and central Iraq. The research region is located in northeastern Iraq's Kosrat anticline, where the Dokan Formation is exposed at its southwestern flank. The formation is composed of marl, dolomitic limestone, and limestone, with interspersed chert nodules. The Qamchoqa Formation is documented to have an unconformable contact below the Dokan Formation, whereas the Kometan Formation is conformable at the top above the Dokan Formation. We have determined 46 species of calcareous nannofossils belonging to 28 genera:

Heterococcoliths: Chiastozygaceae (*Ahmuellerella*, *Chiastozygus*, *Neocrepidolithus*, *Placozygus*, *Reinhardtites*, *Staurolithites*, *Tranolithus*, *Zeugrhabdotus*), Eiffellithaceae (*Eiffellithus)*, Biscutaceae (*Biscutum)*, Prediscosphaeraceae (*Petrarhabdus*, *Prediscosphaera)*, Cretarhabdaceae (*Cretarhabdus*, *Retecapsa)*, Watznaueriaceae (*Cyclagelosphaera*, *Watznaueria)*, Arkhangelskiellaceae (*Arkhangelskiella*, *Broinsonia)*; Holococcoliths: Calyptrosphaeraceae (*Calculites*, *Octolithus)*; Nannoliths: Microrhabdulaceae (*Lithraphidites*, *Microrhabdulus)*, Polycyclolithaceae (*Eprolithus*, *Lithastrinus*, *Micula*, *Quadrum*, *Uniplanarius)*, Schizosphaerellaceae (*Ceratolithoides)*.

We identified two nannobiozones, *Eiffellithus turriseiffelii* Interval Biozone (CC9) and *Microrhabdulus decorates* Interval Biozone (CC10). By comparing these biozones with those of other calcareous nannofossil biozones from local sections and regional countries, we identify that these fossils are of Cenomanian age.

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دراسة الطباقية الحياتية لمتحجرات النانو الكلسية لتكوين دوكان (السينومانيان) في طية كوسرت المحدبة، شمال شرقي العراق

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الملخص

ينتشر تكوين دوكان (السينوماني) في شمالي ووسط العراق. تقع منطقة الدراسة في طية كوسرت المحدبة شمال شرقي العراق. ينكشف تكوين دوكان على الجانب الجنوبي الغربي من طية كوسرت المحدبة، حيث يتكون التكوين من المارل والحجر الجيري الدولومايتي والحجر الجيري، تتخللها عقد من الصوان. تكوين قمجوقة مسجل أسفل تكوين دوكان مع تماس غير متوافق، بينما في الأعلى يحده تكوين كوميتان بشكل متوافق. تم تحديد 46 نوعًا من متحجرات النانو الكلسية التي تنتمي إلى 28 جنساً هي:

Heterococcoliths: Chiastozygaceae(*Ahmuellerella*, *Chiastozygus*, *Neocrepidolithus*, *Placozygus*, *Reinhardtites*, *Staurolithites*, *Tranolithus*, *Zeugrhabdotus*), Eiffellithaceae (*Eiffellithus)*, Biscutaceae (Biscutum*)*, Prediscosphaeraceae (*Petrarhabdus*, *Prediscosphaera)*, Cretarhabdaceae (*Cretarhabdus*, *Retecapsa)*, Watznaueriaceae (*Cyclagelosphaera*, *Watznaueria)*, Arkhangelskiellaceae (*Arkhangelskiella*, *Broinsonia)*; Holococcoliths: Calyptrosphaeraceae (*Calculites*, *Octolithus)*;
Nannoliths: Microrhabdulaceae (*Lithraphidites*, *Microrhabdulus)*, Polycyclolithaceae (*Eprolithus*, *Lithastrinus*, *Micula*, *Quadrum*, *Uniplanarius)*, Schizosphaerellaceae (*Ceratolithoides)*.

تم تحديد اثنين من الانطقة الحياتية هما:

Eiffellithus turriseiffelii Interval biozone (CC9) and *Microrhabdulus decorates* Interval Biozone (CC10).

من خلال مقارنة هذه الانطقة الحياتية مع تلك الموجودة في الانطقة الحياتية للمناطق الأخرى من المقاطع المحلية والإقليمية حُدد عمر تكوين دوكان بالسينومانيان.

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Introduction

The type section of the Dokan Formation is located at the Dokan Dam, Sulaimaniya Governorate, northeast Iraq (lat. 36° N, long. 45° E), with an exposed thickness of approximately 3.75 meters. Dokan Formation generally comprises light grey or white, white-weathering oligosteginal limestones. Locally rubbly, with glauconitic coatings of constituent pebble-like messes. Locally worm-riddled (Bellen et al., 1959).

The research region is situated at the Kosrat anticline in northeastern Iraq (Fig. 1). The Dokan Formation is noticed at the southwestern edge of the Kosrat anticline. Assumable formation's thickness is approximately 11 meters. Dolomitic limestone and limestone make up the majority of the formation. There are scattered chert nodules throughout the formation at certain depths. Below the Dokan formation, the Qamchoqa formation seems to have an unconformable contact, whereas the Kometan Formation conformably borders it at the top (Fig. 2).

Tectonically, the Kosrat anticline represents one of the highly folded zone structures in northeastern Iraq. It extends north-west to south-east at a distance of about 85 km and a width of 5 km (exactly at longitude 44° 58′ 12″ east and latitude 35° 54′ 36″ north) west of Dokan lake.

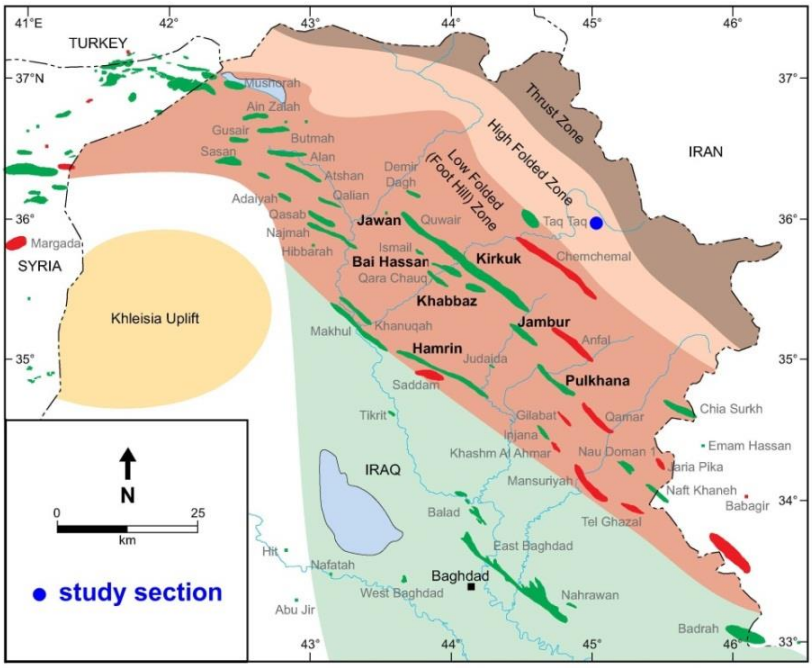

Fig. 1. Tectonic map indicating the research section's location (Al-Qayim, 2010).

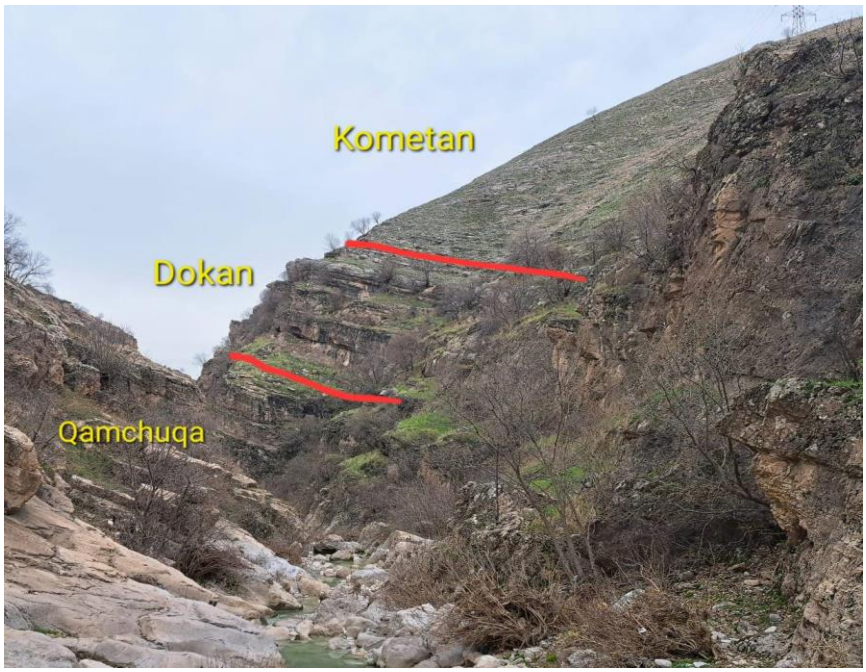

Fig. 2. Photo showing the formations in the study area.

One of the formations that was deposited in the upper AP8 tectonostratigraphic Megasequence is the Dokan Formation (Sharland *et al*., 2001). The micro-continents that had split off from the Arabian plate in the late Tithonian approached the intra-oceanic subduction zone trench in the Late Cenomanian–Early Turonian age. The beginning of the formation of N-S trending structures at this age in Saudi Arabia, Kuwait, and Iraq may have resulted from the diachronous collision of these micro-continents with the fore-arc region above the trench. The north-facing passive margin of the southern Neo-Tethys began to deform with the deposition of the Qalqula conglomerates in northern Iraq (Jassim and Goff, 2006).

The Dokan Formation was deposited after the initial ophiolite obduction into the Arabian Plate's formerly passive northeast coast, which resulted in fault renewal and uplift of the plate's northeast margin (Sharland et al., 2001). A foreland basin developed around the northern edge of the Arabian Plate as a result of multiple subsequent ophiolite obductions along the northern and northeastern plate margins. According to Jassim and Goff (2006), this was brought about by thrust sheets that were created as a result of compressional loading of the crust. The Dokan Formation originated in a foreland basin during the latter phases of Cretaceous Neo-Tethyan subduction (Numan, 2001). Next occurred the spreading and rifting of the Neo-Tethys, and the uplift of the Zagros fold belt (Figs. 3,4).

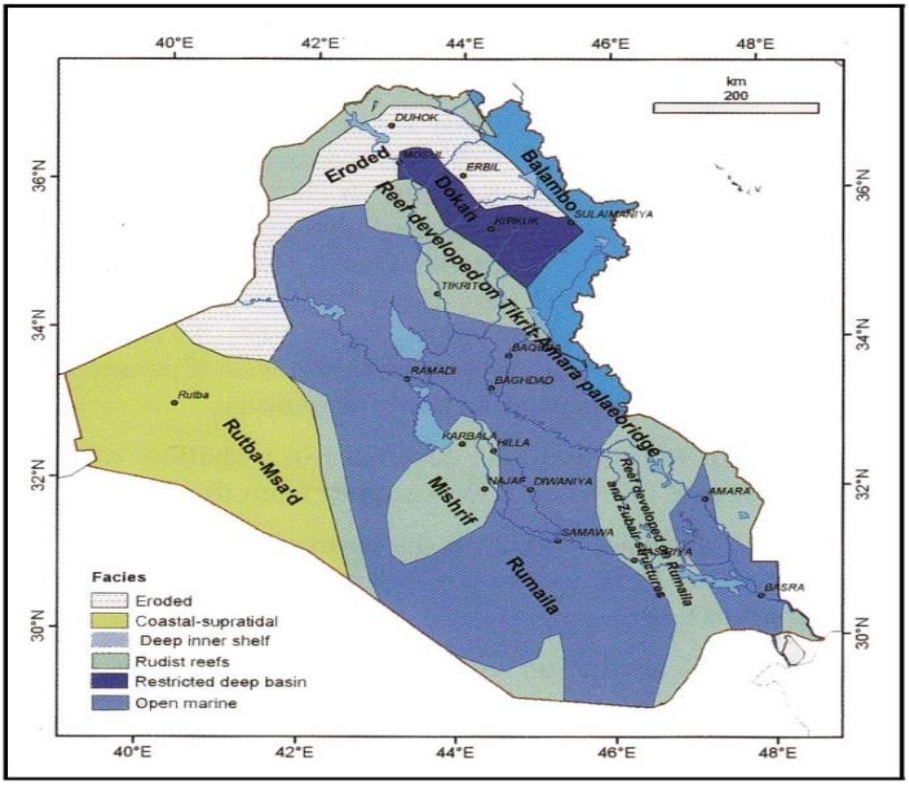

Fig. 3. Early Cenomanian rock units' paleogeographic distribution in Iraq (Jassim and Goff, 2006).

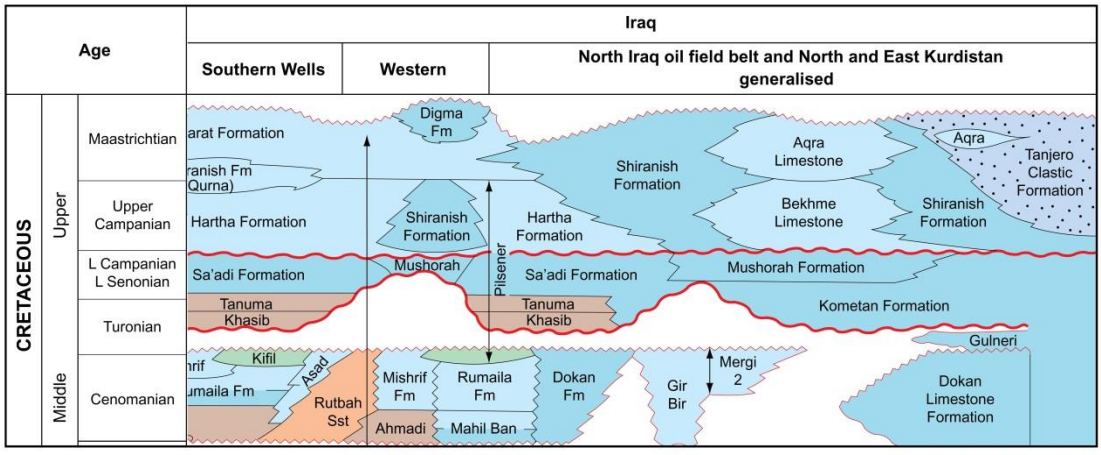

Fig. 4. Diagram illustrating the link between regional rock units (Haddad and Amin, 2007).

Materials and methods

All field phenomena in the outcrops were described as part of the field work, and the description concentrated on finding the thickness of the beds, examining the type of contact

surfaces between them, assessing their hardness, color, and other physical attributes, tracking the beds' side and vertical changes, and documenting any potential sedimentary structures.

From the Dokan Formation that was exposed, fifteen rock samples were collected. These materials are being used under a transmitted-light microscope to analyze calcareous nannofossils based on thin sections. The procedure (H) is used to remove the calcareous nannofossils (Armstrong and Brasier, 2005). There exists an examination-ready extraction technique for microfossils from rocks; palaeontologists often have preferred techniques for these steps. A small quantity of the disaggregated material is put in distilled water along with a drop of cellosize to function as a dispersion. This procedure allows for the production of slides of calcareous nannofossils. A heated hotplate is used to allow the cover slip to dry in order to enable permanent mounting.

Result and Discussion

Nannopaleontology

Nannopaleontologists employed a number of paleontological sources, e.g., Bown and Young (1997) and Perch-Nielsen (1985), to identify various species of calcareous nannofossils. The resources are housed at the Geology Department, University of Mosul in Mosul, Iraq (Figs. 5-7).

1 - Heterococcoliths

Family Chiastozygaceae Rood et al., 1973
Genus *Ahmuellerella* Reinhardt, 1964
Ahmuellerella sp.
Genus *Chiastozygus* Gartner, 1968
Chiastozygus amphipons (Bramlette and Martini, 1964) Gartner, 1968
Chiastozygus cf. *antiquus* (Bramlette and Martini, 1964) Gartner, 1968
Chiastozygus trabalis (Gorka, 1957) Burnett, 1997
Genus *Neocrepidolithus* Romein, 1979
Neocrepidolithus sp.
Genus *Placozygus* Hoffman, 1970
Placozygus spiralis (Bramlette and Martini, 1964) Hoffmann, 1970
Genus *Reinhardtites* Perch-Nielsen, 1968
Reinhardtites anthophorus (Deflandre, 1959) Perch-Nielsen, 1968
Reinhardtites levis Prins and Sissingh in Sissingh, 1977
Genus *Staurolithites* Caratini, 1963
Staurolithites integer (Bukry, 1969) Burnett, 1997
Genus *Tranolithus* Stover, 1966
Tranolithus orionatus (Reinhardt, 1966) Reinhardt, 1966
Genus *Zeugrhabdotus* Reinhardt, 1965
Zeugrhabdotus cf. *praesigmoides* Burnett, 1997
Zeugrhabdotus xenotus (Stover, 1966) Burnett *in* Gale et al., 1996
Family Eiffellithaceae Reinhardt, 1965
Genus *Eiffellithus* Reinhardt, 1965
Eiffellithus eximius (Stover, 1966) Perch-Nielsen, 1968
Eiffellithus paragogus Gartner, in Robaszynski et al, 1993
Eiffellithus parallelus Perch-Nielsen, 1973
Eiffellithus cf. *parvus* Watkins and Bergen, 2003
Eiffellithus turriseiffeli (Deflander and Fert, 1954) Reinhardt, 1965
Family Biscutaceae Black, 1971
Genus *Biscutum* Black in Black and Barnes, 1959
Biscutum sp.

Family Prediscosphaeraceae Rood et al., 1971
Genus *Petrarhabdus* Wind and Wise in Wise, 1983
Petrarhabdus copulates (Deflandre, 1959), Wind and Wise in Wise, 1983
Petrarhabdus kirenii Lees and Bown 2016
Genus *Prediscosphaera* Vekshina, 1959
Prediscosphaera ponticula (Bukry, 1969) Perch-Nielsen, 1984
Family Cretarhabdaceae Thierstein, 1973
Genus *Cretarhabdus* Bramlette and Martini, 1964
Cretarhabdus cf. *inaequalis* Crux, 1987
Genus *Retecapsa* Black, 1971
Retecapsa crenulata (Bramlette and Martini, 1964) Grün in Grün and Allemann, 1975
Retecapsa surirella (Deflandre and Fert, 1954) Grün in Grün and Allemann, 1975
Family Watznaueriaceae Rood et al., 1971
Genus *Cyclagelosphaera* Noel, 1965
Cyclagelosphaera margerelii Noel, 1965
Cyclagelosphaera reinhardtii (Perch-Nielsen, 1968) Romein, 1977
Cyclagelosphaera wiedmannii Reale and Monechi, 1994
Genus *Watznaueria* Reinhardt, 1964
Watznaueria barnesiae (Black in Black and Barnes, 1959) Perch-Nielsen, 1968
Watznaueria bayackii Worsley, 1971
Watznaueria biporta Bukry, 1969
Watznaueria cynthae Worsley, 1971
Watznaueria leesiae Young 2023
Family Arkhangelskiellaceae Bukry, 1969 emend Bown and Hampton, 1997 in Bown and Young, 1997
Genus *Arkhangelskiella* Vekshina, 1959
Arkhangelskiella cymbiformis Vekshina, 1959
Genus *Broinsonia* Bukry, 1969
Broinsonia enormis (Shumenko, 1968) Manivit, 1971
Broinsonia parca(Stradner, 1963) Bukry, 1969

2- Holococcoliths

Family Calyptrosphaeraceae Boudreaux and Hay, 1969
Genus *Calculites* Prins and Sissingh in Sissingh, 1977
Calculites obscurus (Deflandre, 1959) Sissingh, 1977
Calculites ovalis (Stradner, 1963) Prins and Sissingh in Sissingh, 1977
Calculites sp.
Genus *Octolithus* Romein, 1979
Octolithus *multiplus* (Perch-Nielsen, 1973) Romein, 1979

3- Nannoliths

Family Microrhabdulaceae Deflandre, 1963
Genus *Lithraphidites* Deflandre, 1963
Lithraphidites magnus (Covington and Wise, 1987) Aguado, in Aguado et al. 2022
Lithraphidites praequadratus Roth, 1978
Genus *Microrhabdulus* Deflandre, 1959
Microrhabdulus decoratus Deflandre, 1959
Microrhabdulus sp.
Family Polycyclolithaceae Forchheimer, 1972 emend Varol, 1992
Genus *Eprolithus* Stover, 1966
Eprolithus antiquus Perch-Nielsen, 1979
Genus *Lithastrinus* Stradner, 1962
Lithastrinus grillii Stradner, 1962
Lithastrinus quadricuspis Farhan, 1987

Genus *Micula* Vekshina, 1959
Micula cubiformis Forchheimer, 1972
Micula murus (Martini, 1961) Bukry, 1973
Micula staurophora (Gardet, 1955) Stradner, 1963
Genus *Quadrum* Prins and Perch-Nielsen *in* Manivit et al., 1977
Quadrum gartneri Prins and Perch-Nielsen *in* Manivit et al., 1977
Genus *Uniplanarius* Hattner and Wise, 1980
Uniplanarius sissinghii (Perch-Nielsen, 1986) Farhan 1987
Family Schizosphaerellaceae Deflandre, 1959
Genus *Ceratolithoides* Bramlette and Martini, 1964
Ceratolithoides aculeus (Stradner, 1961) Prins and Sissingh in Sissingh, 1977
Ceratolithoides dongenii Lees, 2007
Ceratolithoides prominens Burnett, 1997
Ceratolithoides sp.

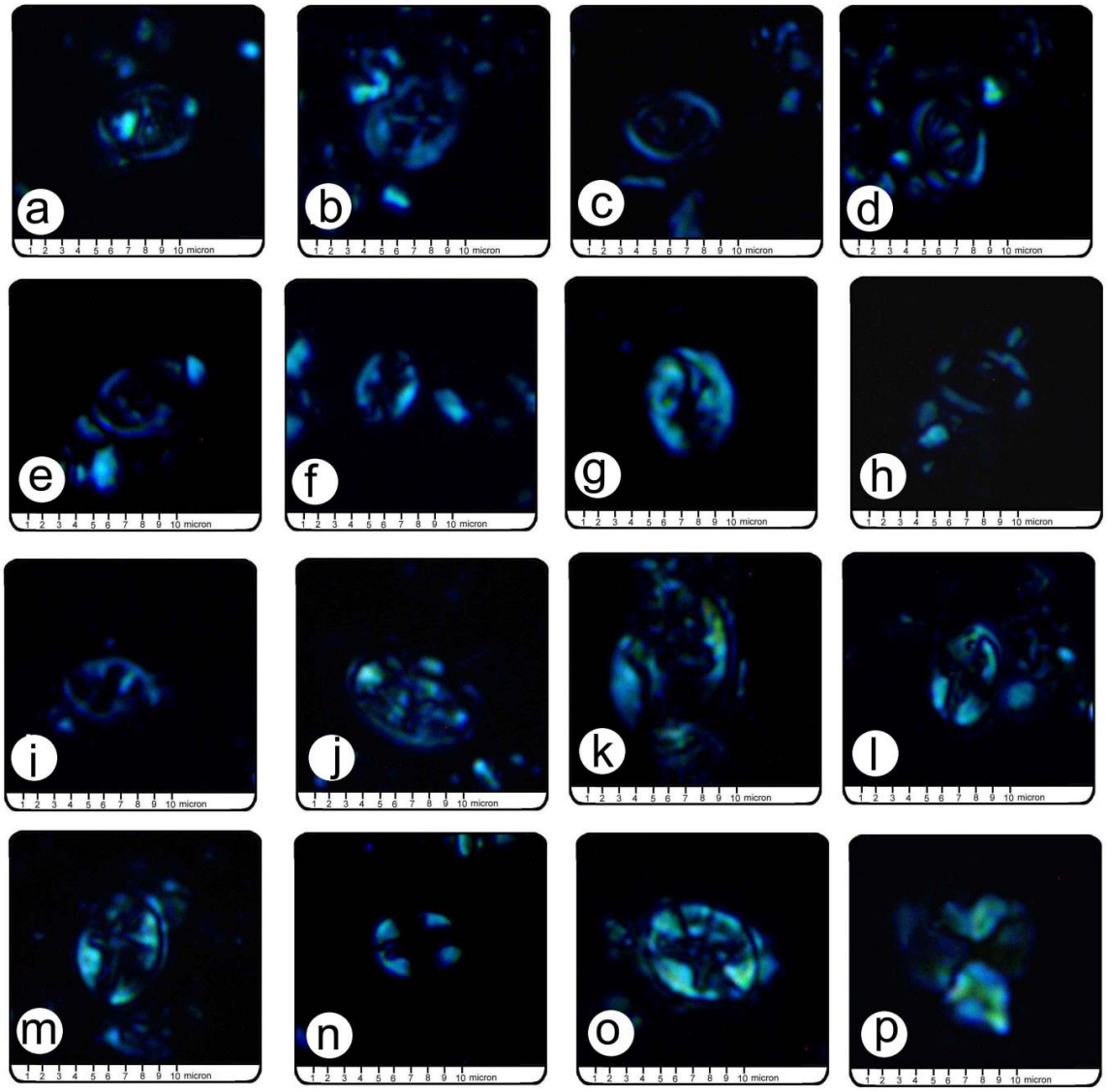

Fig. 5. Images illustrating polarized figures for the species of calcareous nannofossils.

(a) *Ahmuellerella* sp.; (b) *Chiastozygus amphipons*; (c) *Chiastozygus trabalis*; (d) *Neocrepidolithus* sp.; (e) *Placozygus spiralis;* (f) *Reinhardtites anthophorus;* (g) *Reinhardtites levis;* (h) *Staurolithites integer;* (i) *Tranolithus orionatus;* (j) *Zeugrhabdotus* cf. *praesigmoides*; (k) *Zeugrhabdotus xenotus;* (l) *Eiffellithus eximius;* (m) *Eiffellithus paragogus;* (n) *Eiffellithus parallelus;* (o) *Eiffellithus turriseiffeli*; (p) *Petrarhabdus copulates.*

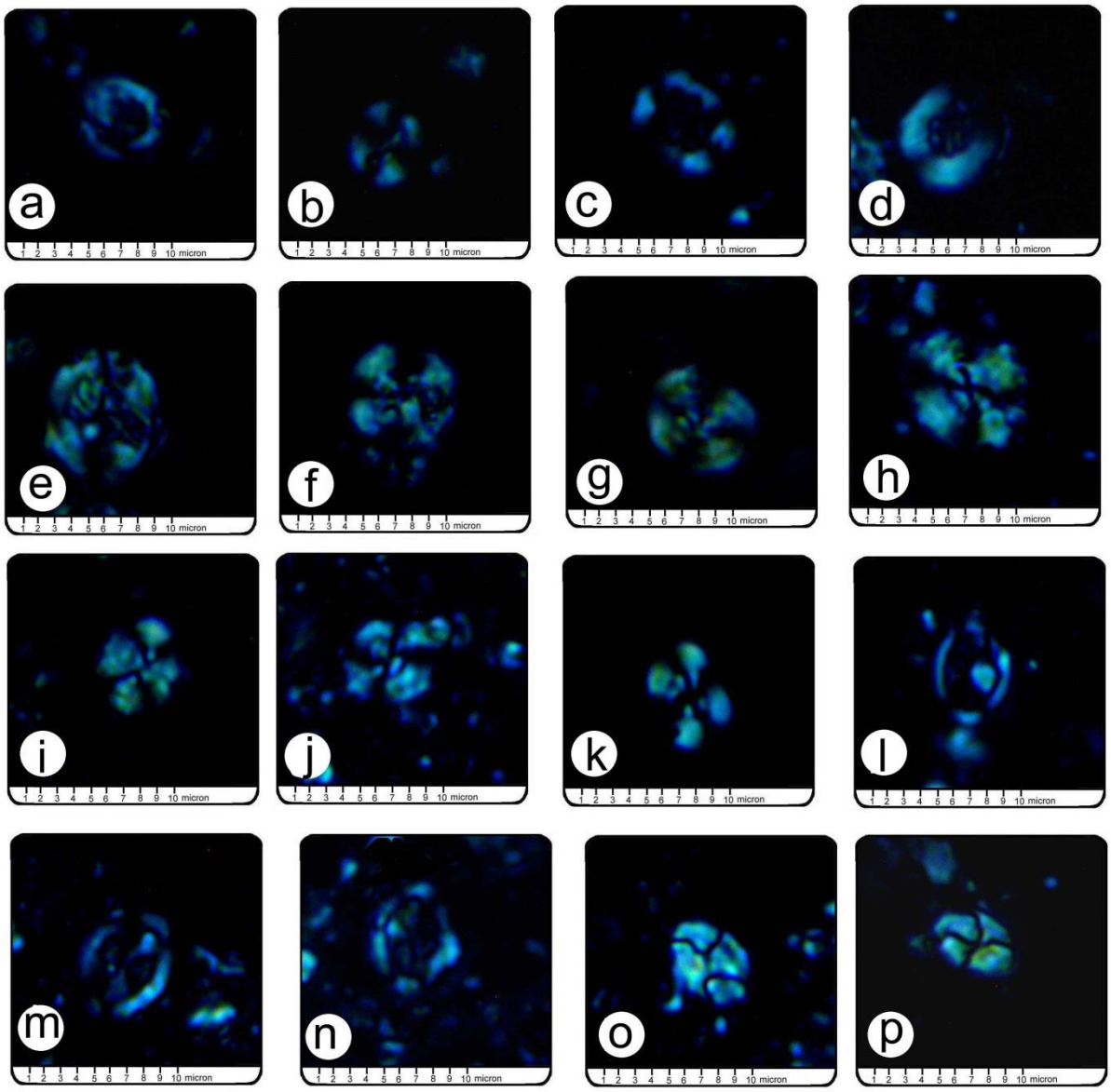

Fig. 6. Images illustrating polarized figures for the species of calcareous nannofossils.

(a) ***Prediscosphaera ponticula;*** **(b)** ***Cretarhabdus* cf. *inaequalis*****; (c)** ***Retecapsa crenulata;*** **(d)** ***Retecapsa surirella;*** **(e)** ***Cyclagelosphaera margerelii;*** **(f)** ***Cyclagelosphaera reinhardtii;*** **(g)** ***Cyclagelosphaera wiedmannii;*** **(h)** ***Watznaueria barnesiae;*** **(i)** ***Watznaueria bayackii;*** **(j)** ***Watznaueria cynthae;*** **(k)** ***Watznaueria leesiae;*** **(l)** ***Arkhangelskiella cymbiformis;*** **(m)** ***Broinsonia enormis;*** **(n)** ***Broinsonia parca;*** **(o)** ***Calculites obscurus;*** **(p)** ***Calculites ovalis.***

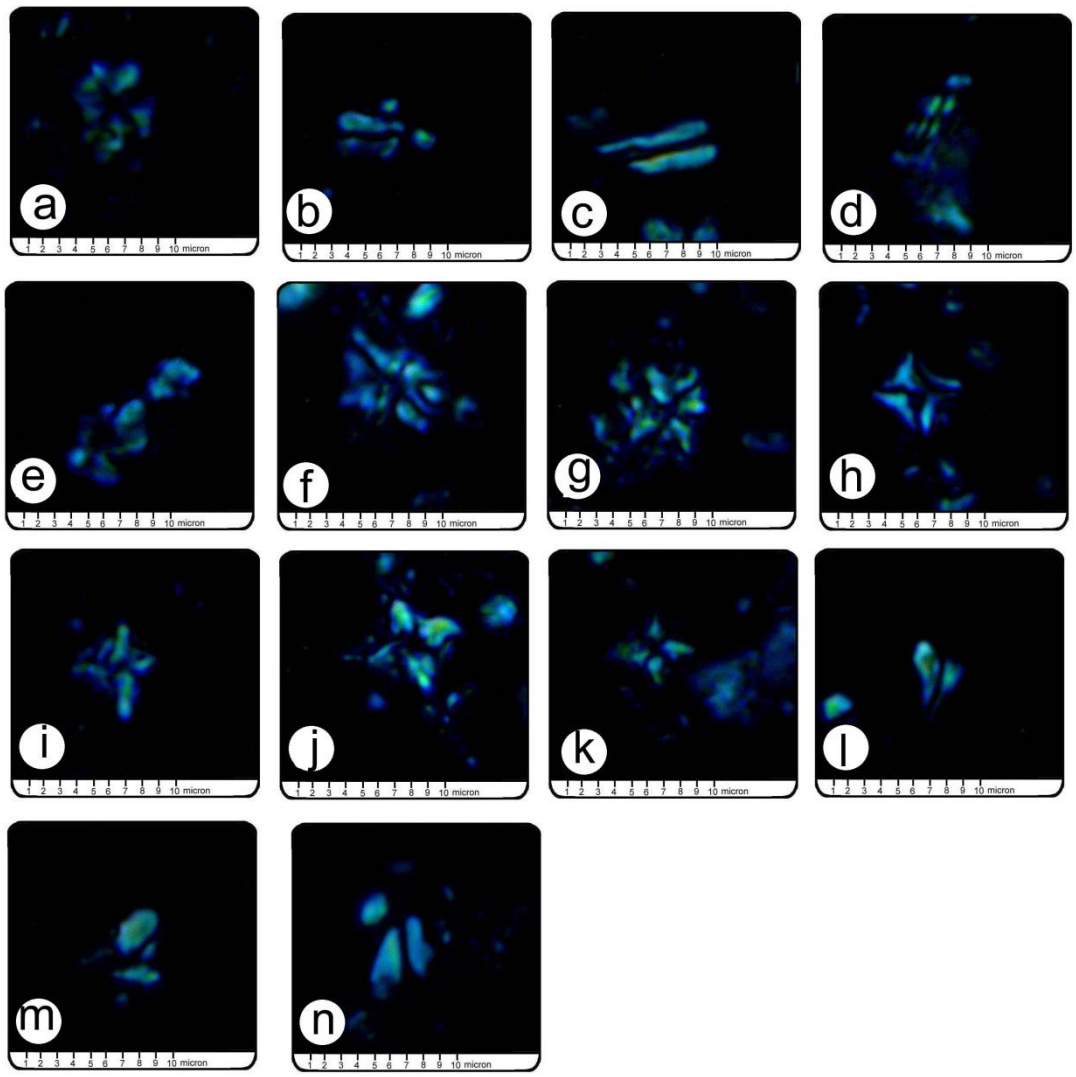

Fig. 7. Images illustrating polarized figures for the species of calcareous nannofossils.

(a) *Octolithus multiplus;* (b) *Lithraphidites magnus;* (c) *Lithraphidites praequadratus;* (d) *Microrhabdulus decorates*; (e) *Eprolithus antiquus;* (f) *Lithastrinus grillii;* (g) *Lithastrinus quadricuspis;* (h) *Micula cubiformis;* (i) *Micula murus;* (j) *Micula staurophora;* (k) *Uniplanarius sissinghii;* (l) *Ceratolithoides aculeus;* (m) *Ceratolithoides dongenii;* (n) *Ceratolithoides prominens.*

Nannobiostratigraphy

The following two biozones are established based on the stratigraphic distribution of the species that have been reported:

1- *Eiffellithus turriseiffelii* interval biozone (CC 9)

Definition: it is an interval range biozone of *Eiffellithus turriseiffelii* (Deflander and Fert, 1954).

Boundaries: this biozone is determined by the first appearance of *Eiffellithus turriseiffelii* (Deflander and Fert, 1954) and the first appearance of *Microrhabdulus decorates* (Deflandre, 1959).

Thickness: 5m.

Age: Late Albian- Early Cenomanian

Correlation and Discussion: The biozone (CC9) (*Eiffellithus turriseiffelii* Biozone) is connected by Sissingh (1977) and correlated to the lower region of the investigated UC 1 and 2 biozones by Burnett (1998), so that we may propose the Late Albian-Early Cenomanian (Gradstein et al., 2020) (Fig.8).

2- *Microrhabdulus decorates* Interval Biozone (CC10):

Definition: it is an interval range biozone of *Microrhabdulus decorates* (Deflandre, 1959)

Boundaries: this biozone is determined by the first appearance of Microrhabdulus *decorates* (Deflandre, 1959) and the first appearance of *Quadrum gartneri (*Manivit et al., 1977)

Thickness: 6.5 m.

Age: Late Cenomanian- Early Turonian

Correlation and Discussion: The biozone (CC10), which is decorated with *Microrhabdulus decorates* is connected with this biozone by Sissingh (1977) and correlated to lower part of UC 3, 4, 5 and 6 biozones which are studied by Burnett (1998); hence, the Late Cenomanian–Early Turonian is our suggestion (Gradstein et al.,2020) (Fig.8).

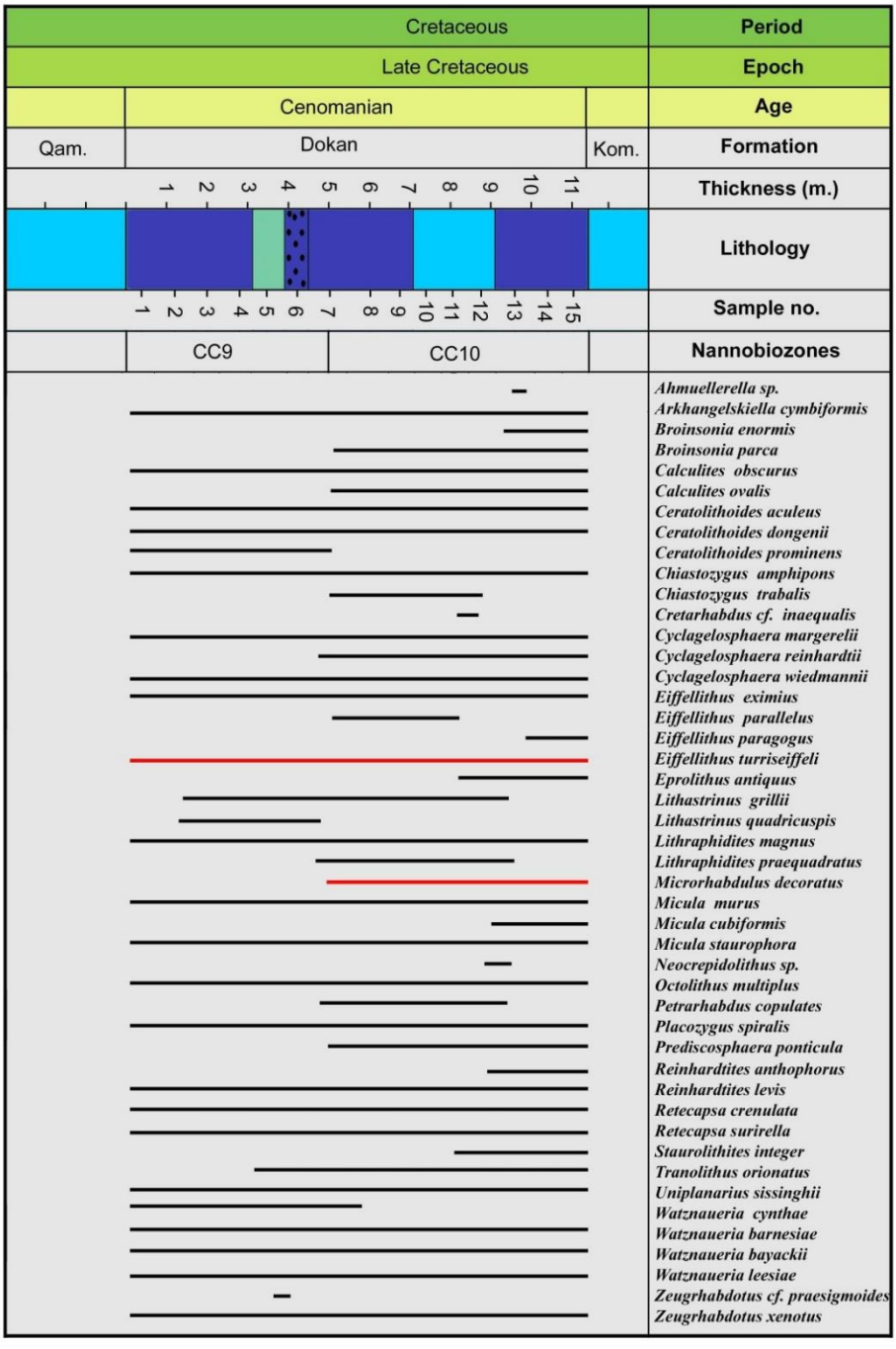

Fig. 8. Nannobiozones of Calcareous Nannofossils of study section Kosrat anticline, Northeastern Iraq.

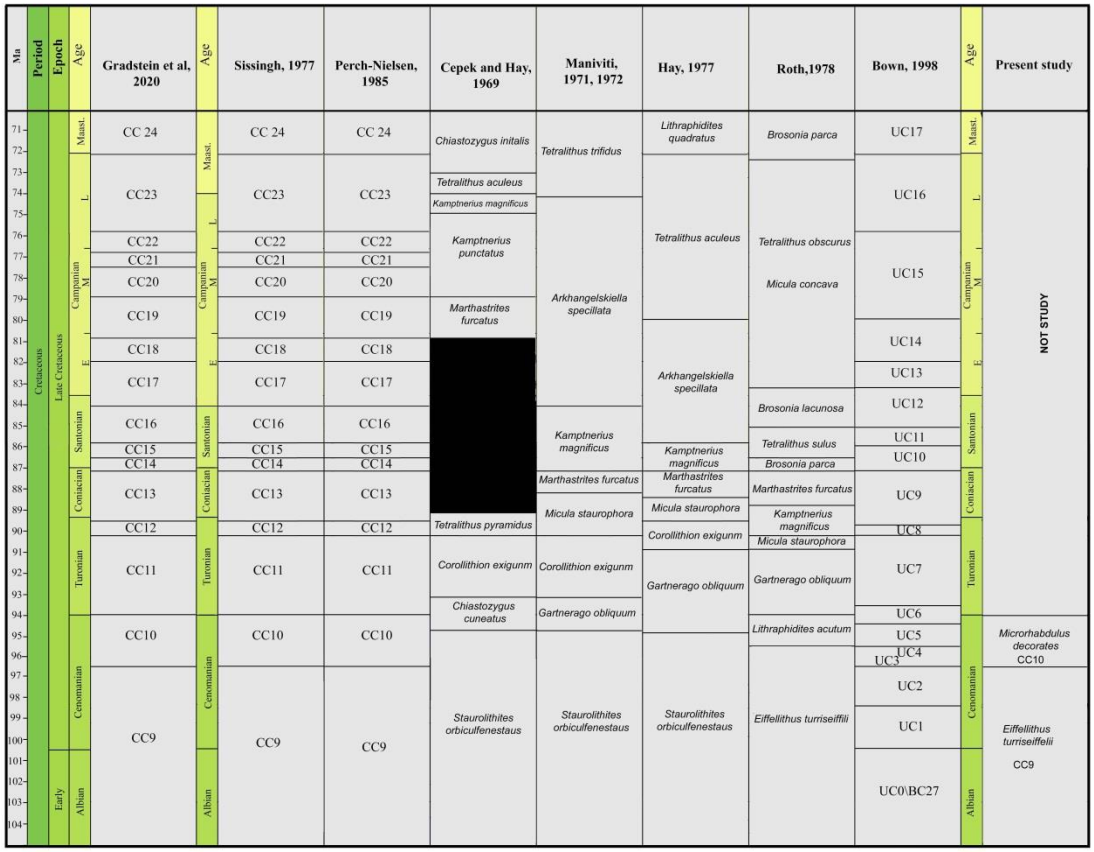

Fig. 9. Chart of Correlation for Calcareous Nannofossils in the Study Section's Biozones.

Conclusions

This study determined 46 species of calcareous nannofossils belonging to 28 genera. The Dokan Formation in northeastern Iraq's Kosrat anticline is dated to the Cenomanian age based on the stratigraphic ranges of the known calcareous fossil biozones, which are grouped as follows from oldest to youngest:

1- *Eiffellithus turriseiffelii* interval biozone (CC9)

2- *Microrhabdulus decorates* Interval Biozone (CC10)

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