IASJ المجلات الاكاديمية العراقية

Tikrit Journal of Pure Science

ISSN: 1813 – 1662 (Print) --- E-ISSN: 2415 – 1726 (Online)

Journal Homepage: http://tjps.tu.edu.iq/index.php/j

Calcareous nannofossils biostratigraphy and Paleoclimatology of the Bekhme Formation, Bekhere anticline, Dhouk area, Kurdistan region, Northern Iraq

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https://doi.org/10.25130/tjps.v28i2.1338

ARTICLE INFO.

Article history:

-Received: 16 / 6 / 2022

-Accepted: 13 / 10 / 2022

-Available online: 26 / 4 / 2023

Keywords: Bekhme Formation, Campanian, Nannofossils, Paleoclimate, Iraq.

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ABSTRACT

A Detailed Calcareous nannofossil study conducted on the Bekhme Formation that is cropped out at the Southern limb of the Bekhere anticline, eastern ward of the Dohuk city near Bajlur village, northern Iraq. The Bekhme Formation is composed of marly limestone, Organic limestone and fossiliferous limestone. The nannopaleontological classification of these calcareous nannofossils led us to determine thirty-four genus/species belonging to nine families. The nannobiostratigraphic analysis suggested three calcareous nannofossils biozones from oldest to youngest are: (1) *Quadrum sissinghii* Interval Zone; (2) *Quadrum trifidum* Interval Zone; (3) *Tranolithus phacelosus* Interval Zone. These biozones suggest that the studied section from the Bekhme Formation is the Middle to Late Campanian, and it refers to temperature fluctuations which considered as possible warm time period at subtropical areas.

1. Introduction

The Bekhme Formation (Late Campanian) was defined by Wetzel 1950 in [1], from the Bekhme area of the Greater Zab River in the High Folded Zone, northeast Iraq. The formation is recorded from several anticlines in the south and southwestern parts of the High Folded Zone in Iraq [2]. The formation thickness is about 315 m in its type locality section and is consisted of bituminous-secondary dolomites, limestones (Some globigerinal limestone intercalations with fossil detritus). In its upper part, reef-detrital limestones alternate with fore-reef shoal limestones that are enriched with foraminiferal faunas in the middle part, and comprising globigerinal and foraminiferal limestones with ferruginous globigerinal marls locally in the lower part [1]. The Bekhme Formation belongs to TMSAP9 (Tectonostratigraphic megasequence of Arabian Plate No.9).

The studied section of the Bekhme Formation is located at south- western limb of Bekhare anticline; eastern side of the Dohuk city that coordinates long.43° 10' 00"E., lat. 36° 52' 00"N., near Bajlur village (Fig.1). It is composed generally of marly limestone interspersed by four beds of tough limestone (Fig.2-d). The lower part of the formation is 35.5 meter thick, and consists of succession of gray-marly limestone beds (40-60 cm thick for each bed) interspersed by two beds of gray-hard massive limestone (May be dolomitic limestone 3,2.5 meters thick) respectively, while the upper part of the formation is 56.5 meters thick, which is consisted of succession of gray marly limestone beds (25-40 cm thick for each bed), intercalated with two gray-solid-limestone beds, the first is 40 cm thick that contains chert nodules (Fig.2-a), the second bed is 2.5 meters thick that representing a hardground surface contains chert nodules and boring trace fossils (Fig.2-c). The contact between the Bekhme Formation and the overlying Shiranish Formation determines by a solid tough limestone bed (30 cm thick) that represents hardground surface (Fig.2-b), then followed by yellowish gray to bluish marly limestone of the Shiranish Formation. The lower contact of formation is not exposed because the formation located at the

core of anticline. In some cases, the Bekhme Formation biozones were correlated with the Shiranish and Tanjero Formations in northern Iraq. [3],[4].

Many previous studies investigated the Bekhme Formation in Dohuk area ;[5], who recorded Four biozone of planktonic foraminifera through a biostratigraphic study of the Bekhme Formation of the section at the Southern limb of Bekhair anticline and determines the age of formation as the Late Campanian. He mentioned that the hardground surface contains boring trace fossils represents the unconformable boundary between the Bekhme Formation and the overlying Shiranish Formation. The study section is located in the High Folded Zone as a part of Unstable Shelf. Also, [6] studied a microfacies and sequence stratigraphy of the Bekhme Formation from a section at Southern limb of Bekhair anticline Northeast of the city Dohuk and recorded two Campanian foraminiferal biozones, they considered the Late Campanian age from the Bekhme Formation and determined the paleoenvironments of the formation at Middle shelf, Outer- shelf and Upper bathyal.

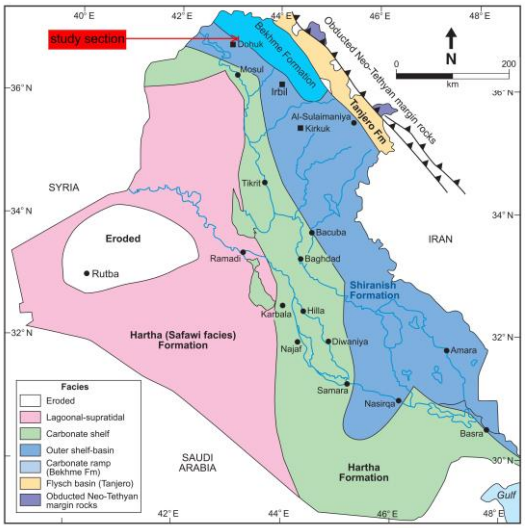

Fig. 1: Location map of the studied section (After [2].

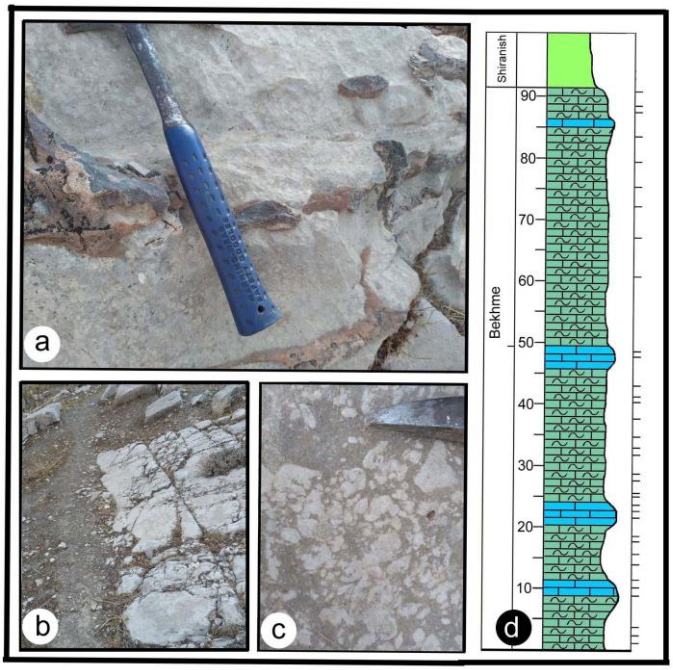

Fig. 2: a. Chert nodules from gray solid limestone beds, b. contact between the Bekhme Formation and the Shiranish Formation, c. tough ground surface, d. lithologic section column.

2. Materials and Methods

Materials

Data for this study was generated from Thirty-five samples of Bekhme Formation. Samples were collected at different interval at the different interval (40 cm-9m), which was obtained from Dohuk section consist mainly from Limestone.

Laboratory Analysis

(A) Nannofossil slides preparation making by using the method (H) [7], the procedure is as follows:

- About 5 grams of each rock sample is crushed to pass through a sieve of 45 μm and then soaked in filtered water. A small size drop is added to implement as a dispersant.
- A direct low heat source (hotplate) is used to lasting dry the slide and residue, taking into account during all stages of work, be careful and avoid contamination.
- Amorphous oleoresin called Canada balsam placed over an uncontaminated thin cover slip. Then it is flipped over the previously placed dry drop of crushed sample solution and left to dry and stick well, so the sample is then ready for examination under the transmitted microscope.

(B) Observation Techniques

The slides were examined for calcareous nannofossil content under light microscope in transmitted lights with cross-polarized and gypsum plate. Detailed investigation for the assemblages was made by Optika B-353POL microscope using x1000 magnification. Identification of species based on Perch-Nielsen and Young and Bown.

3. Results

The systematic classification of the calcareous nannofossils depending on many paleontological references [8] and [9] to identify forty species of calcareous nannofossils. The material and images are stored in the Department of Geology, College of Science, University of Mosul, Mosul, Iraq, (figs. 4,5,6,7).

The Nannopaleontology

I- Heterococcolith

Family Chistozygaceae Rood, Hay and Barnard, 1971

Genus *Ahmuellerella* Reinhardt, 1964

Ahmuellerella octoradriata (Górka,1957) Reinhardt, 1966

Genus *Chiastozygus* Gartner, 1968

Chiastozygus platyrhethum Hill, 1975

Genus *Gorkaea* Varol and Girgis, 1994

Gorkaea obliqueclausus (Varol) Varol and Girgis, 1994

Genus *Reinhardtites* Perch- Nielsen, 1968

Reinhardtitus anthophorus (Deflandre, 1959) Perch-Nielsen, 1968

Genus *Tranolithus* Stover, 1966

Tranolithus phacelosus Stover, 1966

Genus *Zeugrhabdotus* Reinhardt, 1965

Zeugrhabdotus embergeri (Noël, 1958) Perch-Nielsen, 1984

Family Eiffellithaceae Reinhardt, 1965

Genus *Eiffellithus* Reinhardt, 1965

Eiffellithus eximius (Stover, 1966) Perch-Nielsen, 1968

Family Rhagodiscaeae Hay, 1977

Genus *Rhagodiscus* Reihardit, 1967

Rhagodiscus splendens (Deflandre, 1953) Verbeek, 1977

Family Axopodorhabdaceae Wind and Wise in Wise and Wind, 1977

Genus *Axopodorhabdus* Wind and Wise in Wise and Wind, 1977

Axopodorhabdus sp.

Genus *Cribrocorona* Perch-Nielsen, 1973

Cribrocorona echinus (Bukry, 1975)Lees and Bown, 2005

Cribrocorona gallica (Stradner, 1963) Perch-Nielsen, 1973

Family Cretarhabdaceae Thierstein, 1973

Genus *Retecapsa* Black, 1971

Retecapsa angustiforata Black, 1971

Family Watznaueriaceae Rood et al. , 1971

Genus *Watznaueria* Reinhardt, 1974

Watznaueria barnesae (Black and Barnes, 1959) Perch-Nielsen, 1968

Watznaueria biporta Bukry, 1969

Family Arkhangelskiellaceae Bukry emend Bown and Hampton in Bown and Young, 1997

Genus *Arkhangelskiella* Vekshina, 1959

Arkhangelskiella cymbiformis Vekshina, 1959

Arkhangelskiella sp.

Genus *Broinsonia* Bukry, 1969

Broinsonia parca (Stradner, 1963)Bukry, 1969

II- Nannolith

Family Microrhabdulaceae Deflandre, 1963

Genus L*ithraphidites* Deflandre, 1963

Lithraphidites acutus Verbeek and Manivit in Manivit , 1977

Lithraphidites carniolensis Deflandre, 1963

Lithraphidites sp.

Genus *Microrhabdulus* Deflandre, 1959

Microrhadulus decuratus Deflandre, 1959

Microrhabdulus undosus Perch-Nielsen, 1973

Microrhadulus sp.

Family Polycyclolithaceae Forchheimer, 1972

Genus *Eprolithus* Stover, 1966

Eprolithus antiquus Perch-Nielsen, 1979

Eprolithus floralis (Stradner, 1962) Stover, 1966

Genus *Micula* Vekshina, 1959

Micula cubiformis Forchheimer, 1972

Micula decussata Vekshina, 1959

Micula praemurus (Bukry, 1973) Stradner and Steinmetz, 1984

Micula swastica Stradner and Steinmetz, 1984

Micula sp.

Genus *Quadrum* Manivit , 1977

Quadrum trifidum (Stradner In Stradner and Papp, 1961) Prins and Perch-Nielsen in Manivit , 1977

Quadrum sissinghii PercNielsen, 1984

Genus *Radiolithus* Stover, 1966

Radiolithus planus Stover, 1966

Genus *Ceratolithoides* Bramlette and Martini, 1964

Ceratolithoides aculeus (Stradner, 1961) Prins and Sissingh in Sissingh. ., 1977

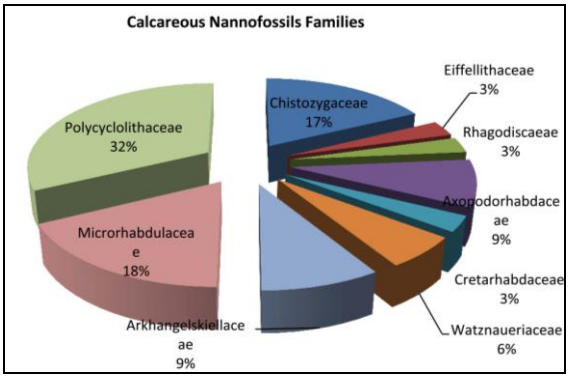

Fig. 3: Percentage of calcareous nannofossil families from Bekhme Formation.

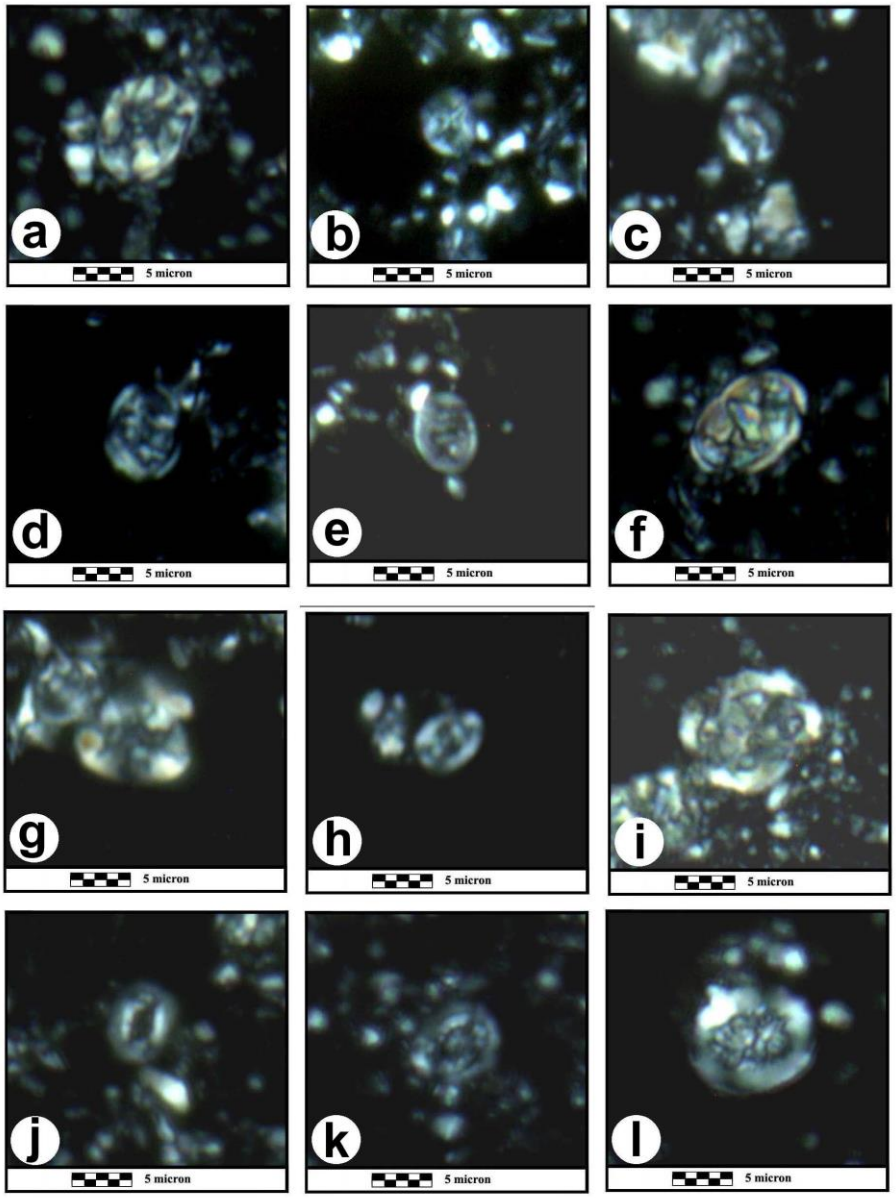

Fig.4: Polarized micrographs of calcareous nannofossil from the Bekhme Formation. (a) *Ahmuellerella octoradriata*; (b) *Chiastozygus platyrhethum*; (c) *Gorkaea obliqueclausus*; (d) *Reinhardtitus anthophorus*; (e) *Tranolithus phacelosus*; (f) *Zeugrhabdotus embergeri*; (g) *Eiffellithus eximius*; (h) *Rhagodiscus splendens*; (i) *Axopodorhabdus sp.*; (j) *Cribrocorona echinus*; (k) *Cribrocorona gallica*; (l) *Retecapsa angustiforata*.

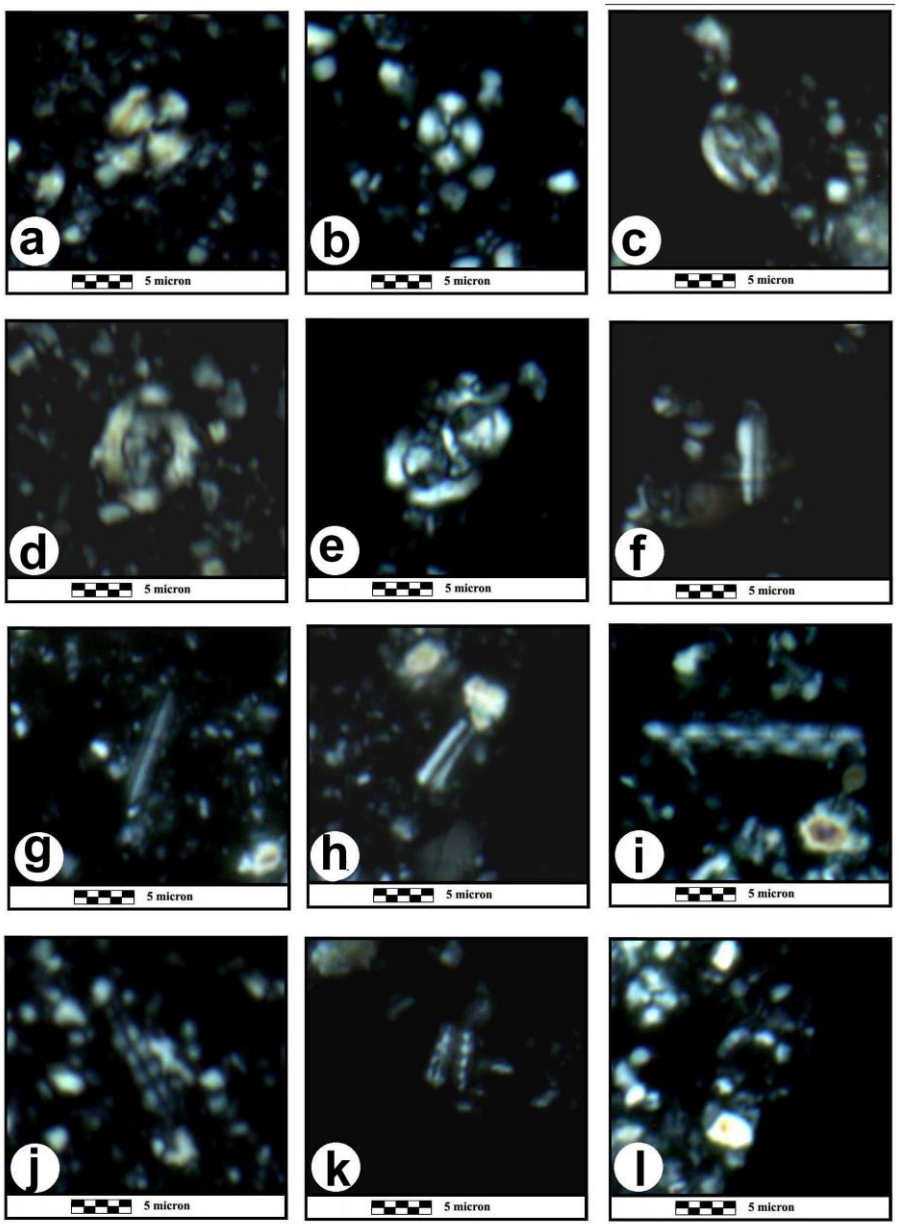

Fig. 5: polarized micrographs of calcareous nannofossil from the Bekhme Formation. (a) *Watznaueria barnesae*; (b) *Watznaueria biporta*; (c) *Arkhangelskiella cymbiformis*; (d) *Arkhangelskiella sp.*; (e) *Broinsonia parca*; (f) *Lithraphidites acutus*; (g) *Lithraphidites carniolensis*; (h) *Lithraphidites sp.*; (i) *Microrhadulus decuratus*; (j) *Microrhabdulus undosus*; (k) *Microrhadulus sp.*; (l) *Eprolithus antiquus*.

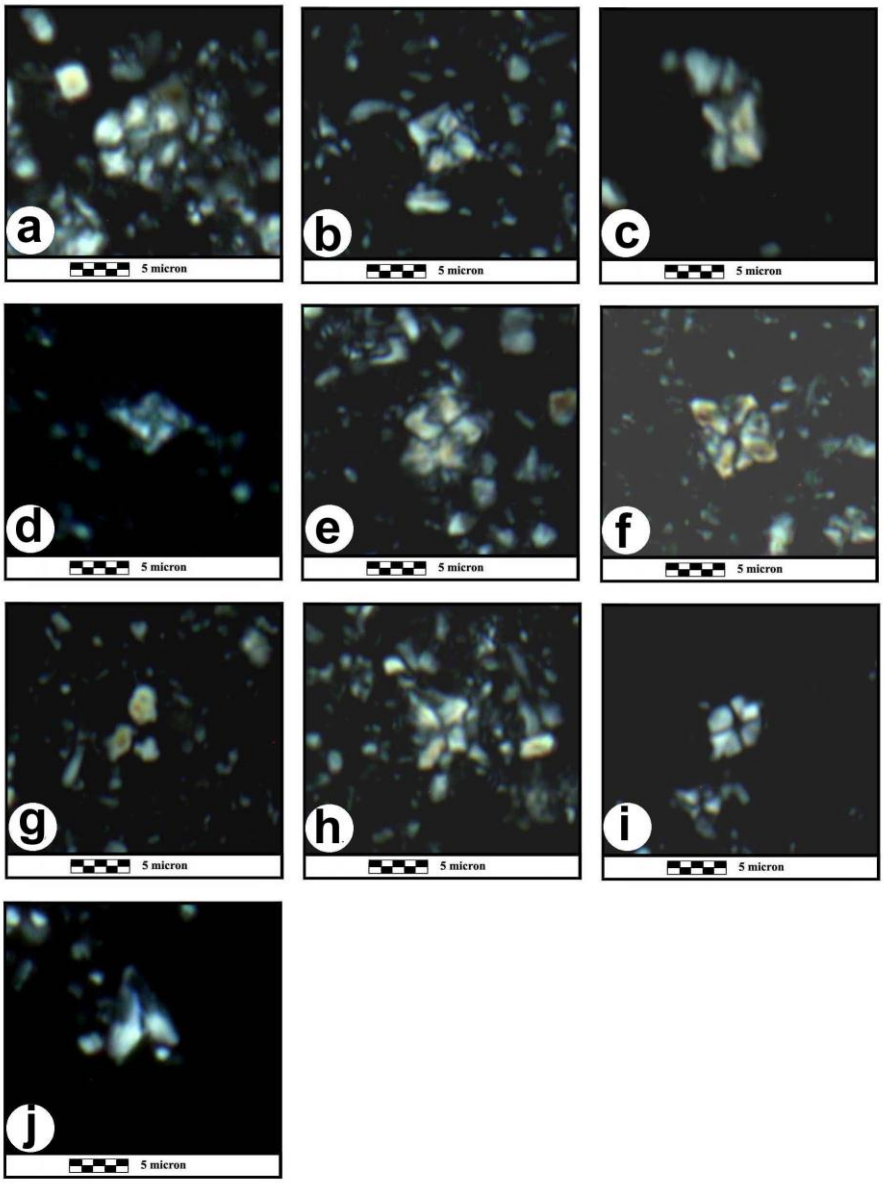

Fig. 6: polarized micrographs of calcareous nannofossil from the Bekhme Formation. (a) *Eprolithus floralis*; (b) *Micula cubiformis*; (c) *Micula decussata*; (d) *Micula praemurus*; (e) *Micula swastica*; (f) *Micula sp.*; (g) *Uniplanarius trifidum*; (h) *Uniplanarius sissinghii*; (i) *Radiolithus planus*; (j) *Ceratolithoides aculeus*.

4: Discussion

1- Calcareous nannofossils biostratigraphy:

• *Quadrum sissinghii* Interval Biozone

This biozone is an interval biozone for the species *Quadrum sissinghii*. The Lower boundary is determined by first appearance for the species *Quadrum sissinghii* and the upper boundary is determined by the first appearance the species *Quadrum trifidum.* The thickness of this biozone is lower part about 25 meter from the section. This biozone is correlated with CC21 (*Quadrum trifidum* Biozone), which studied by the [10] which aged of the middle Campanian, and correlated middle part of UC15 biozone which is studied by [11] and aged as the middle Campanian age [12], (Figs.7,8).

• *Quadrum trifidum* Interval Biozone

This biozone is an Interval biozone of the species *Quadrum trifidum*. The lower boundary is determined by first appearance of the species *Quadrum trifidum*, and the upper boundary is determined by the last appearance for the species *Reinhardtitus anthophorus*. The thickness of this biozone is 40 meter from the section. This biozone is correlated with CC22 (*Quadrum trifidum* biozone), which is studied by [10] and aged as the middle to late Campanian, and correlated upper part of UC15 biozone that is studied by [11] which aged middle to late Campanian age, and correlated with CC22 is studied by [13] aged late Campanian age, and correlated with CC22 is studied by [14] aged late Campanian age, and correlated with CC22 is studied by [15] aged late Campanian age, and correlated

with CC22 which is studied by [4] and aged as the late Campanian age, Therefore we suggest the late Campanian [12] (Figs.7,8).

• *Tranolithus phacelosus* Interval Biozone (CC 23)

This biozone is an Interval biozone for the species *Tranolithus phacelosus*. The Lower boundary of this biozone determined by last appearance of the species *Reinhardtitus anthophorus* and the last appearance of the species *Tranolithus phacelosus*. The thickness of this biozone is upper 27 meter from the section. This biozone is correlated with CC23 (*Tranolithus phacelosus* Biozone)which studied by [10] aged of the late Campanian, and correlated UC16, UC17 biozone, which is studied by [11] and aged as the late Campanian age, and correlated with CC23 is studied by [13] aged late Campanian age, and correlated with CC23, which is studied by [14] aged late Campanian age, and correlated with CC23, which is studied by [15] aged late Campanian age, and correlated with CC23, which is studied by [4] aged late Campanian age, Therefor we suggest the late Campanian [12] (Figs.7,8).

2-Paleoclimate

The study of calcareous nannofossils in the Bekhme Formation reveals a major events in the Campanian biodiversification. In this study, occurrence and the species richness of calcareous nannofossils in the Bekhme Formation show a warm marine environment dominant during the Campanian, It correlats with tropical and subtropical biozones[9].

The species showed important differences in number of individuals, and the increasing of the *Watznaueria* spp. populations shows the warmer condition in this section. The observing changes in the calcareous nannofossil assemblages of the Campanian in this Study, concentrating on the Campanian paleoclimate during the Late Campanian, and it refers to climate and temperature fluctuations that recorded by mainly associated with changes in calcareous nannoplankton, which has documented from different parts of the studied section. Changes in the ocean circulation in the Tethys are considered as possible warm time at subtropical areas (Fig.9).

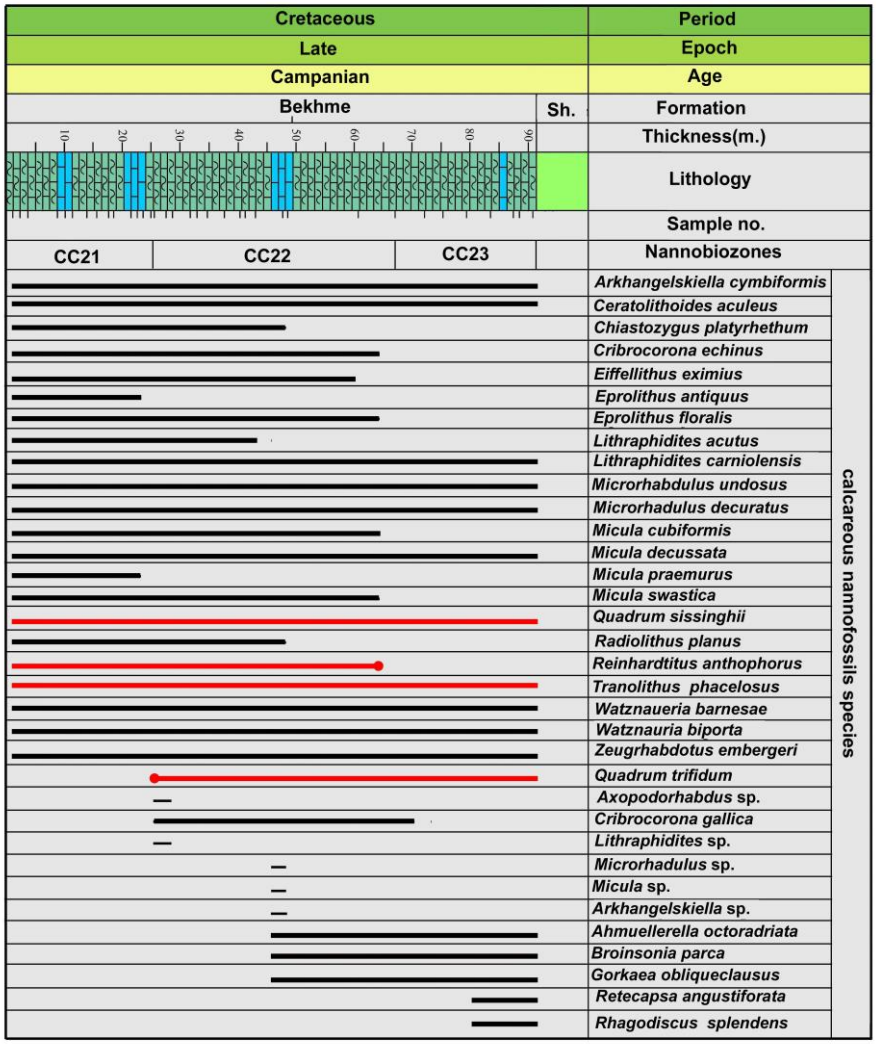

Fig. 7: Range chart of calcareous nannofossils for the Bekhme Formation, Northern Iraq.

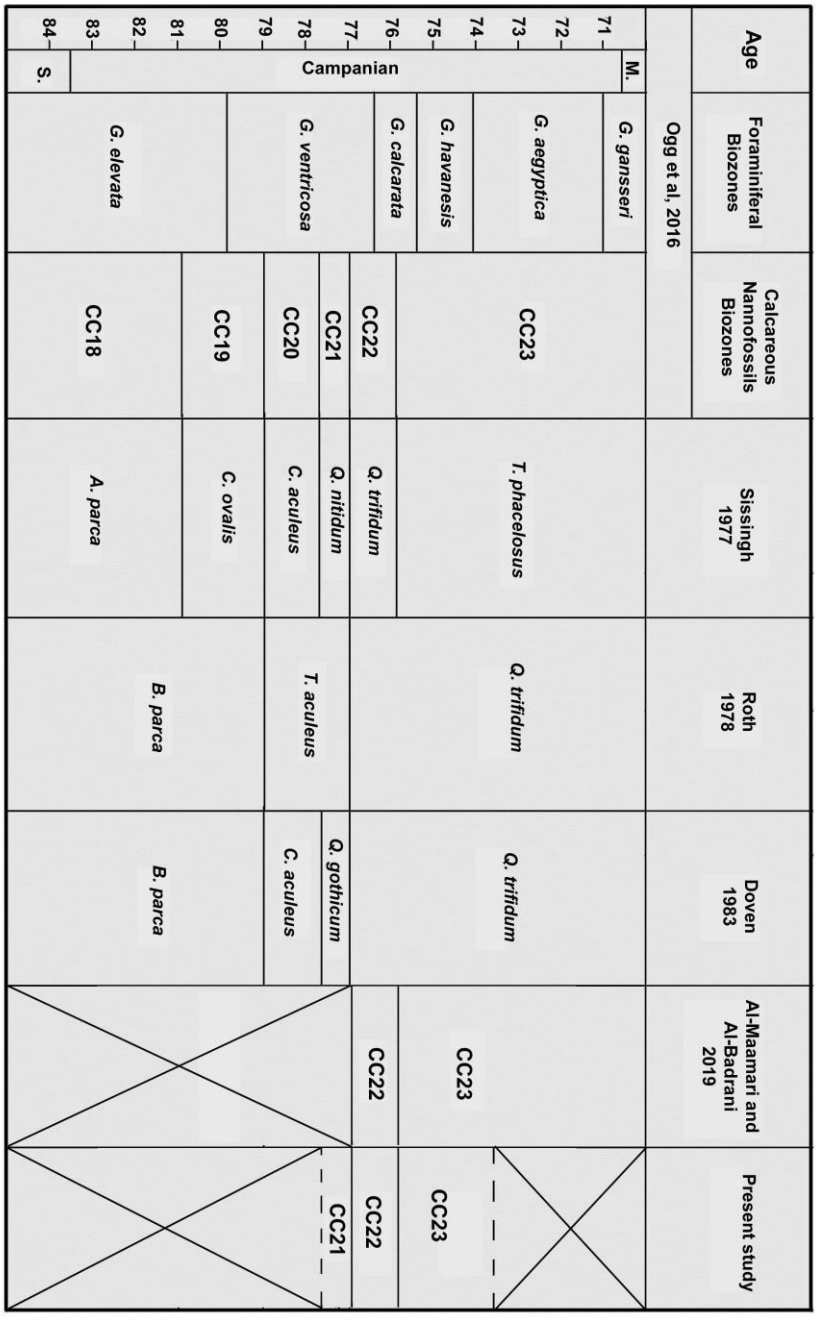

Fig. 8: Age correlation chart of calcareous nannofossils for the Bekhme Formation, Northern Iraq.

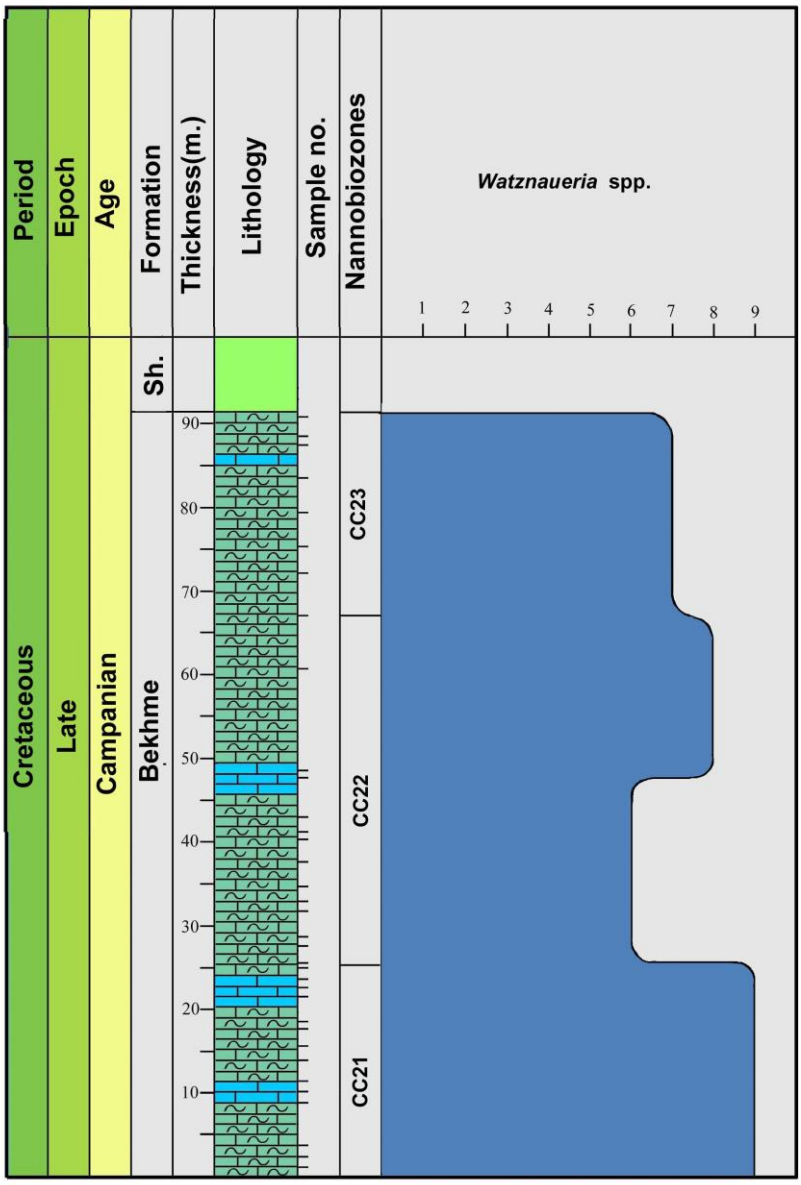

Fig. 9: *Watznaueria* percentage of calcareous nannofossils species from the studied section.

5. Conclusionm

From this study the followings are concluded :

1- (34) spcies of calacreous nanaofosssil recored from Bekhame formation , from Bekhaer anticline, Dhouk area, Kurdistan region, Northern Iraq.

2 – The species categorized into three biozones as follow:

- *Quadrum sissinghii* Interval Biozone (CC 21)
- *Quadrum trifidum* Interval Biozone (CC 22)
- *Tranolithus phacelosus* Interval Biozone (CC 23)

3 – The biozones corellted to other calcareous nannofossil biozones from both anothers sections and aged the Middle to Late Campanian.

4 – Paleoclimate and temperature fluctuations are considered as possible reasone for warming the envirnment at subtropical areas.

5-Acknowledgments

The authors are very grateful to the University of Mosul/College of Science for their provided facilities, which helped to improve the quality of this work.

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الطباقية الحياتية لمتحجرات النانو الكلسية لتكوين بخمة في طية بيخير المحدبة، محافظه دهوك او اقليم كردستان – شمالي العراق

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الملخص

تمت دراسة تفصيلية لمتحجرات النانو الكلسية لتكوين بخمة المنكشف في الجناح الجنوبي طية بخير المحدبة الى الشرق من مدينة دهوك وبالقرب من قرية باجلور, في محافظة دهوك، اقليم كردستان ، شمالي العراق. يتألف تكوين بخمة بصورة رئيسية من الحجر الجيري المارلي والحجر الجيري المتدلمت والحجر الجيري . ان دراسة متحجرات النانو الكلسية قادت الى تشخيص اربعة وثلاثون نوع \اجنس تعود الى تسعة عوائل.

تم تحديد ثلاثة انطقة حياتية بناءً على التجمعات المدروسة أعلاه وهي مرتبة من الاقدم الى الاحدث كالتالي:

(1) *Quadrum sissinghii* Interval Zone; (2) *Quadrum trifidum* Interval Zone; (3) *Tranolithus phacelosus* Interval Zone.

ان هذه الانطقة الحياتية تقترح بان عمر المقطع المدروس الكامبانيان الاوسط الى المتاخر، كذلك تشير الى التذبذبات بدرجات الحرارة ومن المحتمل دفئ المناخ في المناطق شبه الاستوائية.