Calcareous nannofossils biostratigraphy and Paleoclimatolology of the Bekhme Formation, Bekhere anticline, Dhouk area, Kurdistan region, Northern 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 Bekhre 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 nannopalaeontological 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 shool limestones that are enriched with foraminiferal faunas in the middle part, and comprising globigerinid and foraminiferal limestones with ferruginous globigerinid 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 interpersed 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 platyrrhethum Hill, 1975
Genus Gorkaea Varol and Girgis, 1994
Gorkaea obliquecaclusus (Varol) Varol and Girgis, 1994
Genus Reinhardtites Perch-Nielsen, 1968
Reinhardtitesanthophor us (Deflandre, 1959) Perch-Nielsen, 1968
Genus Tranolithus Stover, 1966
Tranolithus phaceolus Stover, 1966
Genus Zeugrhabdotus Reinhardt, 1965
Zeugrhabdotus embergeri (Noël, 1958) Perch-Nielsen, 1984
Family Eiffellithaceae Reinhardt, 1965
Family Rhagodiscaceae Hay, 1977
Genus Rhagodiscus Reinhardt, 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 Lithraphidites Deflandre, 1963
Lithraphidites acutus Verbeek and Manivit in Manivit, 1977
Lithraphidites carniolensis Deflandre, 1963
Lithraphidites sp.
Genus Microrhabdulus Deflandre, 1959
Microrhabdulus decuratus Deflandre, 1959
Microrhabdulus undosus Perch-Nielsen, 1973
Microrhabdulus 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 cabiformis 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.
4: Discussion

1- Calcareous nannofossils biostratigraphy:

- *Quadrum sissingii* Interval Biozone
  This biozone is an interval biozone for the species *Quadrum sissingii*. The Lower boundary is determined by first appearance for the species *Quadrum sissingii* and the upper boundary is determined by the last appearance for 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 [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 Reinhardtittus 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 correlates 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).

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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. Conclusion
From this study the followings are concluded:
1- (34) species of calcareous nanaofossil 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 corelled 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
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6. References


الطلابية الحياتية لمتحجرات النانو الكئابية لتكوين بخمة في طية بيخير المحدبة، محافظة دهوك أو

إقليم كردستان – شمال شمالي العراق

Namaeh Abdulhadi al-Husayni1، عمار أحمد البدراني

قسم علوم الأرض، كلية العلوم، جامعة دهوك، دهوك, العراق

قسم علوم الأرض، كلية العلوم، جامعة الموصل، الموصل, العراق

الملخص

تمت دراسة تفصيلية لمنشآت النانو الكئابية لتكوين بخمة المكتشفة في التجن درنة الجنوبي، طية بيخير المحدبة إلى الشرق من مدينة دهوك، وبالقرب من قناة بجاكار. في منشآت دهوك، الإقليم كردستان ، شمال شمالي العراق. يتألف تكوين بخمة بصورة رئيسية من الحجر العجري المائي والحجر الجيري المتشكل والحجر الحجري. ان دراسة منشآت النانو الكئابية قامت إلى تفاصيل الاتجاهات والأنواع التراكيبية تعود إلى تسعات عوائل.

تم تحديد ثلاثة اطارات، اثنتان تمثلان على التجن، التأثيرات المذروحة أعلاها وهي مرتبة من الأقدم إلى الأحدث كانها: (1) Quadrum sissinghii Interval Zone; (2) Quadrum trifidum Interval Zone; (3) Tranolithus phacelosus Interval Zone.

إن هذه الأطارات تقدر بان عمر المقطع المعنى المذروحة الكئابياتية الأوسط الى المناخ، كذلك تشير الى التغييرات بدرجات الحرارة ومن المحتمل دفع المناخ في المناطق شبه الاستوندية.