



Calcareous Nannofossils Biostratigraphy of Chia Gara Formation in Banik village, Northern Iraq

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Abstract:

Much of the Late Jurassic–Early Cretaceous Chia Gara Formation may be seen in northern Iraq. Black shale, thin to medium-bedded yellowish limestone, and thin-bedded brown argillaceous limestone make up the majority of its lithology. Late Jurassic to Early Cretaceous, is divided into four main calcareous nannofossil biozones based on the presence and range of key index species. These biozones, listed from youngest (top) to oldest (base), are as follows.

1. *Nannoconus bermudezii* Interval Range Biozone (CC0)

2. *Nannoconus steinmannii* Interval Range Biozone (CC1)

3. *Assipetra infracretacea* Interval Range Biozone (CC2)

4. *Calcicalathina oblongata* Interval Range Biozone (CC3)

• The age of the Chia Gara Formation was then determined by correlating these biozones with other zonal global biozonation systems (the Tithonian (Late Jurassic) to Valanginian (Early Cretaceous)).

Keywords: Chia Gara, calcareous nannofossils, Banik, Northern Iraq.

الطباقية الحياتية لمتحجرات النانو الكلسية لتكوين جياكارا في قرية بانيك شمالي العراق

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الخلاصة:

يظهر تكوين جياكارا ، الذي يمتد عمره من اواخر العصر الجوراسي الى اوائل العصر الكريتاسي في شمال العراق. التركيب الصخري للتكوين يتالف من الطفل الاسود اللون متعاقب مع الحدر الجيري الطيني رقيق الطبقات بالون البني، وحجر جيري اصفر رقيق الى متوسط السمك. يعد هذا المقطع من المقاطع المهمة لانه يمثل صخور مصدرية. بناءً على تحديد الانواع الدالة من متحجرات النانو الكلسية تم تحديد اربعة انطقه طباقية حياتية وهي من الاقدم في الاسفل الى الاحدث في الاعلى :

1. *Nannoconus bermudezii* Interval Range Biozone (CC0)
2. *Nannoconus steinmannii* Interval Range Biozone (CC1)
3. *Assipetra infracretacea* Interval Range Biozone (CC2)
4. *Calcicalathina oblongata* Interval Range Biozone (CC3)

ثم تم مضاهات الانطقة المحددة مع الانطقة الطباقية الحياتية العالمية وذلك لتحديد عمر تكوين جياكارا في منطقة بانيك والذي يتراوح بين التيثونيان (الجوراسي المتأخر) وحتى الفالانجانيان (الكريتاسي المبكر) .

الكلمات المفتاحية: جياكارا ، متحجرات النانو الكلسية، بانيك، شمال العراق

1. Introduction:

While the primary source rocks are often found in Jurassic and Lower Cretaceous strata[1-4], the majority of hydrocarbon reservoirs in Iraq are hosted in Cretaceous and Tertiary successions [5-6]. During the Mesozoic Era, carbonate, marl, and shale deposits accumulated in a large marine basin that covered the northern and northeastern part of Iraq. Oil-prone organic-rich successions may have been more likely to form during the Late Jurassic and Early Cretaceous due to the high regional heat gradient and worldwide marine transgression. Therefore, in order to comprehend the petroleum systems of the area, it is important to conduct thorough stratigraphic and geochemical research of Jurassic formations.

One of the most significant Upper Jurassic–Lower Cretaceous source-rock intervals in northern Iraq is the Chia Gara Formation. This formation originated at Chia Gara Anticline, which extends from the Middle Tithonian to the Berriasian, is located in the High Folded Zone, south of Amadiya. [7]. The formation is mostly composed of thin-bedded ammonite-bearing limestone and shale, with yellow marly limestone and shale rising to a thickness of around 232 meters at the type section [7].

According to numerous earlier geological and geochemical studies, the Chia Gara Formation is a highly efficient gas-prone source rock that has been validated for the production of hydrocarbons [32-1-8-26-27-2-18]. In addition, a close genetic relationship between hydrocarbons, oil seeps, and organic materials preserved in the Chia Gara Formation was revealed by oil–source correlation and biomarker analysis [25-3-17]. However, prior research has mostly been restricted to certain regions or a limited number of tectonic domains. Therefore, the purpose of this work is to determine the petrographic features of carbonate facies and the petroleum source rock characteristics in some northern Iraqi tectonic zones.

A reference section of the Chia Gara escarpment at a single representative section near Banik Village (42°58'2.6"E, 37°13'33.4"N), It is located in northern Iraq, some 25 kilometers northeast of Zakho City. , was used for this study (Fig. 1). The research area is situated in the Foreland Basin's High Folded Zone, where tectonic deformation and erosion have produced a large outcrop of Jurassic and Cretaceous successions along the axes and sides of regional anticlines.

However, prior research has mostly been restricted to certain regions or a limited number of tectonic domains. Therefore, the purpose of this work is to determine the petrographic features of carbonate facies and the petroleum source rock qualities of the Chia Gara Formation in certain northern Iraqi tectonic zones. A reference section of the Chia Gara Formation escarpment at a single representative section near Banik Village (42°58'2.6"E, 37°13'33.4"N), which is about 25 km northeast of Zakho City, northern Iraq, was used for this study (Fig. 1). The research area is situated in the Foreland Basin's High Folded Zone, where tectonic deformation and erosion have produced a large outcrop of Jurassic and Cretaceous successions along the axes and sides of regional anticlines. [28-4]

The Chia Gara Formation was deposited during the Late Jurassic–Early Cretaceous

in a relatively deep outer-shelf environment linked to the extensional history and emergence of the Neo-Tethys Ocean near the Arabian Plate border. [31]. According to biostratigraphic evidence, the formation on the upper boundary has been dated from the Berriasian to the Middle Tithonian [7]. The upper boundary is progressively becoming closer to the Valanginian stage. The formation beds are a component of Resuming ocean-floor spreading in the southern Neo-Tethys is linked to the Arabian Plate Megasequence AP8 (Late Tithonian–Turonian), which was formed in a major intra-shelf basin. [41]. According to Jassim and Buday (2006), The deep outer-shelf marine depositional environment of the Chia Gara Formation was ideal for the accumulation of organic-rich muds, further improving source rock quality in shale-dominated intervals **Fig.1**.

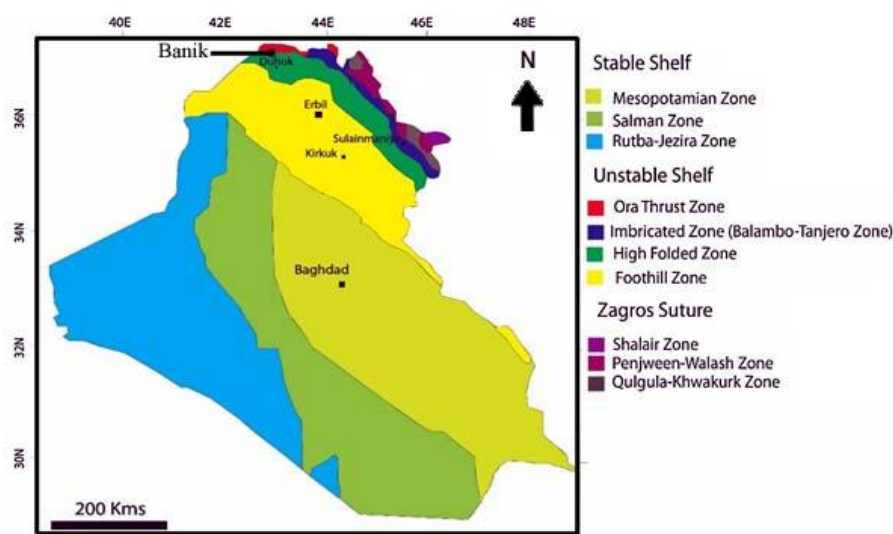


Fig.1: The tectonic map and locations of the research regions (derived from Numan (2000), [22])

- Figure 2 depicts the Arabian Plate's Late Tithonian–Early Berriasian paleogeographic setting. The basin architecture at this time is characterized by a facies distribution that was largely uniform across the Jurassic–Cretaceous transition. Despite such complexity in the geologic architecture of the Gercus formations, the variations in thickness between the outcrop and subsurface wells, such as near the Tigris, are not great. The formation is primarily composed of black shale, thin to medium-bedded yellowish limestone, and thin-bedded brown argillaceous limestone.
- The lower part is dominated by organic-rich shale interbedded with argillaceous limestone, reflecting favorable conditions for organic matter preservation.

accumulation during deposition [16] (Fig. 2)..

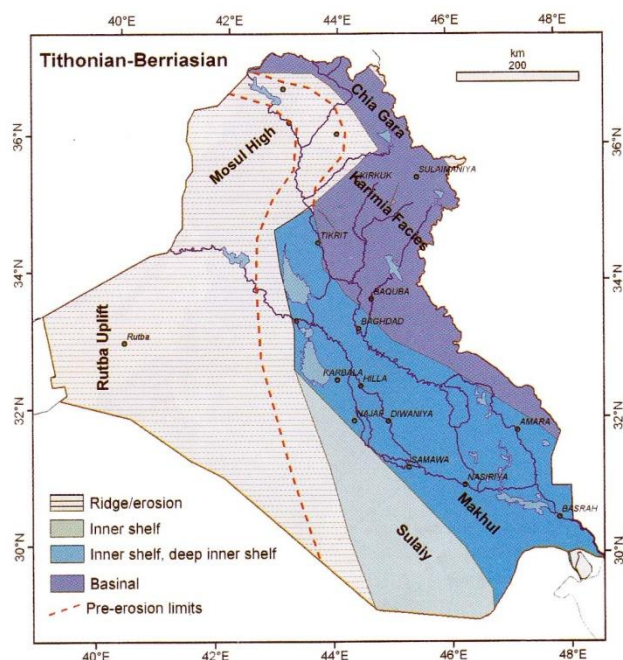


Fig. 2 Iraq's Late Tithonian–Early Berriasian Paleogeography [22].

Bellen et al. (1958) determined that the Chia Gara Formation was deposited between the Middle Tithonian and Berriasian, based on biostratigraphic data. (1959). It is substantially developed in the northern region of Iraq's unstable shelf, laterally grading into the Foothill Zone's Makhul and Karimia Mudstone formations. In contrast, equivalent deposits of the stable and southwestern unstable shelves are represented by the Tithonian-age Sulaiy Formation [11].

From Zakho to the Sirwan Gorge, this record is rather extensive throughout the Kurdistan Region of northern and northeastern Iraq, representing the entire geographical range of the Chia Gara Formation as a regional observation. It is found in many of the underground areas and is typically gated out in the High Folded and Imbricate tectonic zones. Compared to basin morphology, thickness variations across the basin indicate variations in depositional setting and basin evolution, and isopach data indicate that the main depositional centre in the Late Jurassic was located between the Tigris River-northern Mosul—Kirkuk region.

The studied section of Chia Gara Formation has a largely homogenous lithology and consists of predominately shale interbedded with very thinly bedded argillaceous limestone. The succession is about (50) m thick at exposure. The basal interval is defined by organic-rich

shale interbedded with argillaceous limestone, which reflects favorable conditions for organic-matter preservation (the proportion of brittle shale decreases, while limestone and argillaceous limestone increase; the top part consists mainly of marl and marly limestone. Both ammonite fossils are found throughout the carbonate beds but are better preserved in limestone layers and carbonate concretions.

2. Material and methods:

A total of (125) rock samples were selected from the Chia Gara Formation, northern Iraq for calcareous nannofossil examining. Preparation of thin sections for examination by transmitted-light microscope (Method H of Armstrong & Brasier 2005) The calcareous nannofossils were taxonomically identified from the prepared thin sections based on their diagnostic morphological features.

3. Results:

Under the optical microscope, a heterococcolith and nannolith assemblage with numerous uncertain systematic affiliation taxa (Incertae sedis) of calcareous nannofossils was found. The taxa that we identified are described in summary form below **Fig.3**.

1. Family Chiastozygaceae Rood et al., 1973

Genus Zeugrhabdotus Reinhardt, 1965

Zeugrhabdotus embergeri (Noël, 1959) Perch-Nielsen, 1984

2. Family Cretarhabdaceae Thierstein, 1973

Genus Cruciellipsis Thierstein, 1971

Cruciellipsis cuvillieri (Manivit, 1966) Thierstein, 1971

3. Family Rhagodiscaceae Hay, 1977

Genus Calcicalathina Thierstein, 1971

Calcicalathina oblongata (Worsley, 1971) Thierstein, 1971

4. Family Watznaueriaceae Rood et al., 1971

Genus Cyclagelosphaera Noël, 1965

Cyclagelosphaera margerelii Noël, 1965

Genus Diazomatolithus Noël, 1965

Diazomatolithus lehmanii Noël, 1965

Genus Watznaueria Reinhardt, 1964

Watznaueria manivitiae Bukry 1973

1. Nannoliths

1. Family Microrhabdulaceae Deflandre, 1963

Genus *Lithraphidites* Deflandre, 1963

Lithraphidites carniolensis Deflandre, 1963

2. Family Nannoconaceae Deflandre, 1959

Genus *Nannoconus* Kamptner, 1931

Nannoconus bermudezii Brönnimann, 1955

Nannoconus kamptneri Brönnimann, 1955

Nannoconus steinmannii minor Deres & Achéritéguy, 1980

Nannoconus steinmannii steinmannii Kamptner, 1931

3. Family Tubodiscaceae Bown & Rutledge, 1997 in Bown & Young, 1997

Genus *Tubodiscus* Thierstein, 1973

Tubodiscus verenae Thierstein, 1973

2. Incertae sedis nannoliths:

Genus *Assipetra* Roth, 1973

Assipetra infracretacea (Thierstein, 1973) Roth, 1973

Genus *Hexalithus* Gardet, 1955

Hexalithus geometricus Casellato 2010

Hexalithus noeliae Loeblich & Tappan, 1966

Genus *Polycostella* Thierstein, 1971

Polycostella senaria Thierstein, 1971

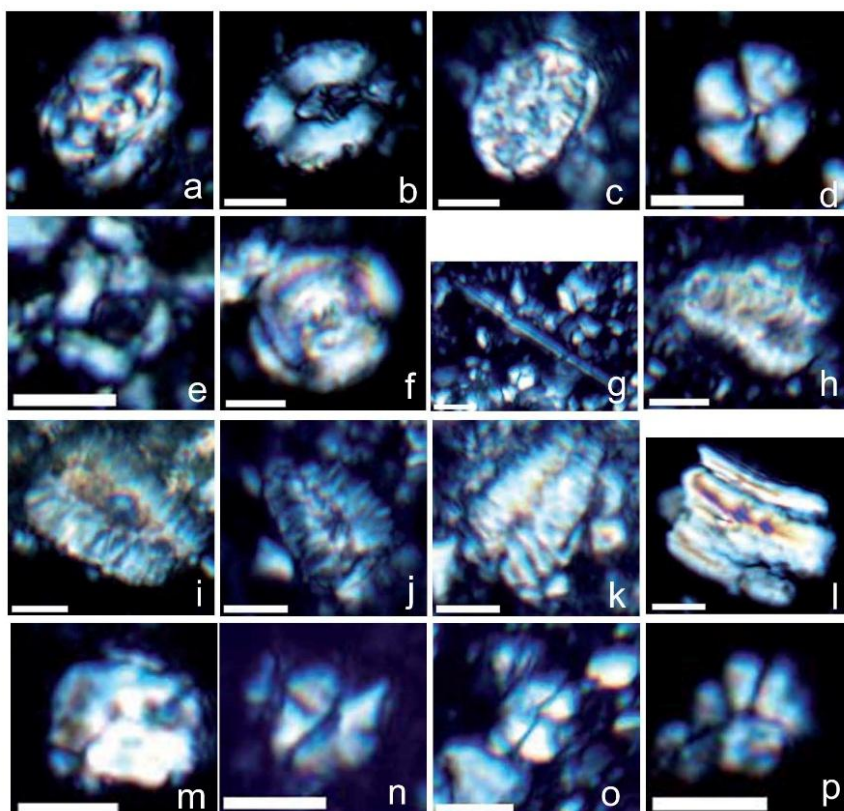


Fig.3 (a) Polarized micrographs of calcareous nannofossil from the Chia Gara Formation *Zeughrabdotus embergeri*; (b) *Cruciellipsis cuvillieri*; (c) *Calcicalathina oblongata*; (d) *Cyclagelosphaera margerelii*; (e) *Diazomatolithus lehmanii*; (f) *Watznaueria manivitiae*; (g) *Lithraphidites carniolensis*; (h) *Nannoconus bermudezii*;

(i) *Nannoconus kamptneri*; (j) *Nannoconus steinmannii minor*; (k) *Nannoconus steinmannii steinmannii*; (l) *Tubodiscus verenaе*; (m) *Assipetra infracretacea*; (n) *Hexalithus geometricus*; (o) *Hexalithus noeliae*; (p) *Polycostella senaria*.

4. Discussion

1. *Nannoconus bermudezii* Interval Range zone (CC0)

Definition: Interval biozone for the species *Nannoconus bermudezii* Brönnimann, 1955.

Boundaries: from FO of *Nannoconus bermudezii* Brönnimann, 1955 to the FO *Nannoconus steinmannii* Kamptner, 1931.

Thickness: 17 m.

Discussion: There is a correlation between this biozone and the CC1 (*Nannoconus steinmannii* Interval Zone) by Sissigh (1977) and correlated with NC1(*Nannoconus coloni* Interval Zone) biozone which is studied by Roth (1978) with CC1 biozone which is studied by Perch-Nielsen, (1979a)(1983) therefore we suggested the Berriasian [20] **Fig.4** , **Fig. 5**.

2. *Nannoconus steinmannii* Interval Range zone (CC1)

Definition: Interval biozone for the species *Nannoconus steinmannii* Kamptner, 1931.

Boundaries: from FO of *Nannoconus steinmannii* Kamptner, 1931 to FO *Assipetra infracretacea* [45-39].

Thickness: 12m.

Discussion: This biozone is correlated with the biozone (CC1) (*Nannoconus steinmannii* Interval Zone) by Sissigh (1977) and correlated with NC1 (*Nannoconus coloni* Interval Zone) biozone which is studied by Roth (1978) with CC1 biozone which is studied by Perch-Nielsen, (1979a)(1983) therefore we suggested the Berriasian [20] **Fig.4** , **Fig. 5**.

3. *Assipetra infracretacea* Interval Range zone (CC2)

Definition: Interval biozone for the species *Assipetra infracretacea* [45-38].

Boundaries: FO *Assipetra infracretacea* [45-39] to FO

Calcicalathina oblongata [46-44].

Thickness: 8m.

Discussion: We proposed the Berrasian to Valanginian to [20] because this biozone is correlated with the biozone (CC2) (*Stradneria crenulata* Interval Zone) by Sissigh (1977) and correlated with the NC2 (*Retecapsa angustiforata*) biozone, which is studied by Roth (1978) with CC2 biozones, which is studied by Perch-Nielsen (1979a) **Fig.4** , **Fig. 5**.

4. Interval Range zone (CC3) of *Calcicalathina oblongata*

Definition: *Calcicalathina oblongata* interval biozone (Worsley, 1971; Thierstein, 1971).

Limitations: FO *Cretarhabdus loriei* Gartner, 1968 to FO *Calcicalathina oblongata* (Worsley, 1971) Thierstein, 1971.

Thickness: 10m.

Discussion: We proposed the Valanginian (Gradstein et al., 2020) because this biozone is correlated with the biozone (CC3) (*Calcicalathina oblongata* Interval Zone) by Sissigh (1977) and correlated with the NC3 (*Tubodiscus verenae*) biozone that is studied by Roth (1978) with CC3 biozones that are studied by Perch-Nielsen (1979a) (1983) **Fig.4.**, **Fig. 5**.

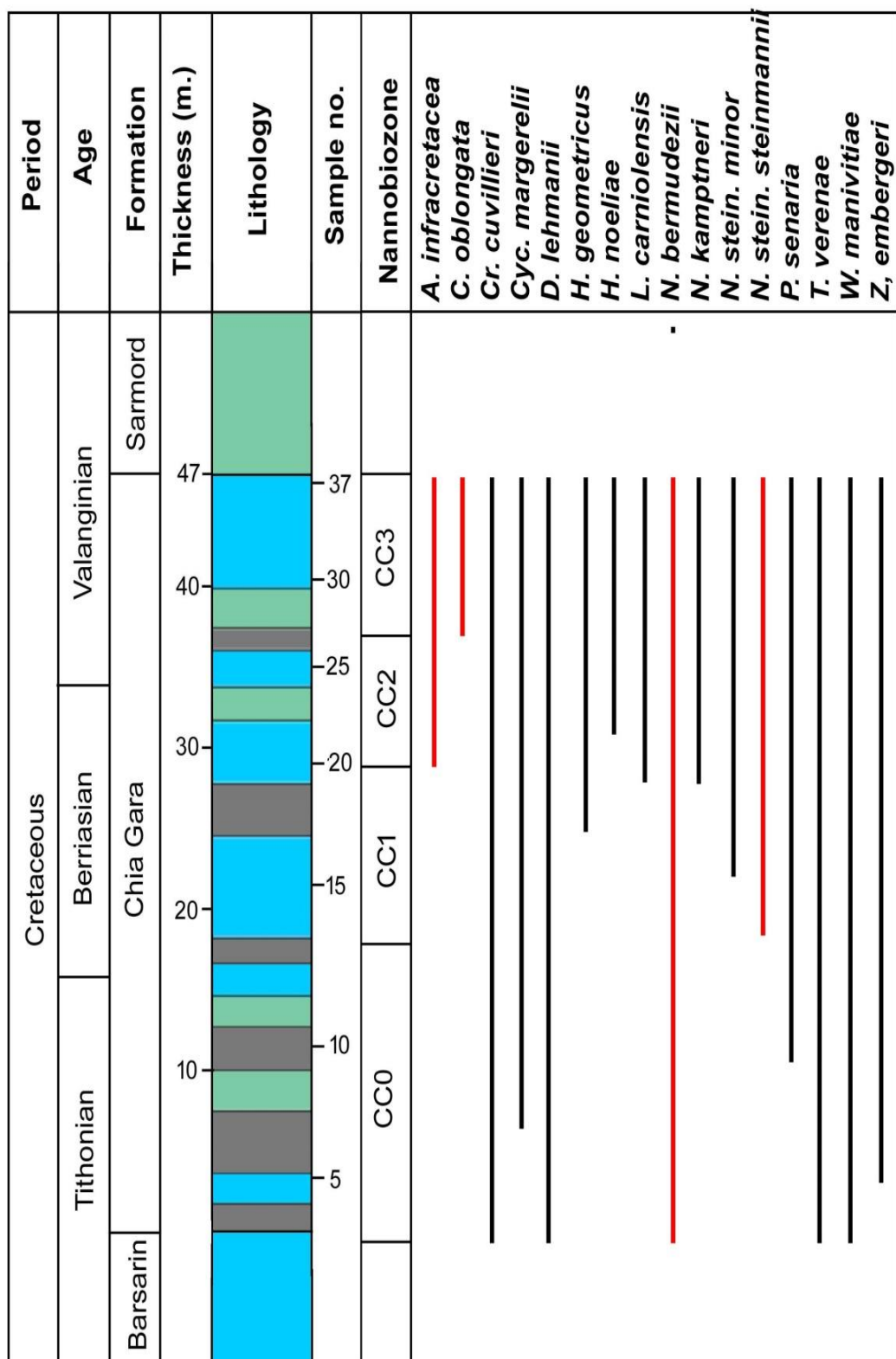


Fig.4 The Clacereous Nannofossils for (Banik) section

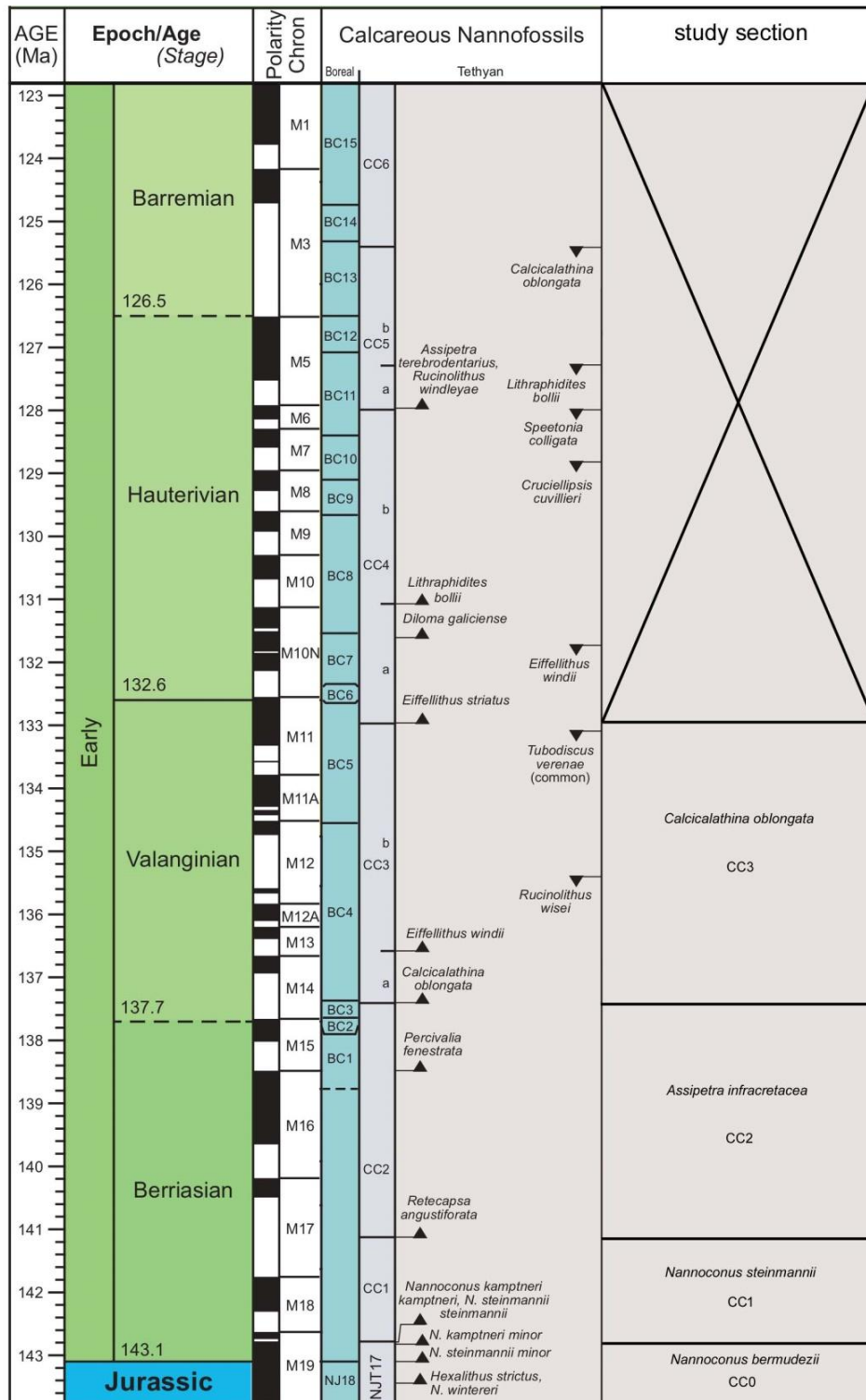


Fig. 5 Correlation chart for Calcareous Nannofossils for lower Cretaceous

5. Conclusions

Four biozones were identified based on the identification taxa and index species of

Calcareous nannofossils, with the younger ones at the top and the older ones at the bottom.:

1. *Nannoconus bermudezii* Interval Range Biozone (CC0)
2. *Nannoconus steinmannii* Interval Range Biozone (CC1)
3. *Assipetra infracretacea* Interval Range Biozone (CC2)
4. *Calcicalathina oblongata* Interval Range Biozone (CC3)

Then these biozones were correlated with other zonal global biozonation schemes of the Chia Gara Formation is determining that the age of the Formation in (Tithonian to Valanginian). **Fig. 5.**

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