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Lithofacies and Age Determination Study of Fatha Formation in Mushak, Salah Al-Din Government, Northern Iraq

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ABSTRACT

A Fatha Formation (Middle Miocene) exposure section was studied in the Mushak area, Baiji, Northern Iraq. A section 35m thick consists of sequences of limestones, green marls, red claystone, and gypsum. These sequences are repeated within the section and have a thickness of 35 m. As for the stratigraphic boundaries, the lower contact is unconformity with the Pila Spi Formation, while the upper boundary is conformity with the Injana Formation. The Paleontological study of limestone rocks was carried out by examining thin sections of 15 samples. Three microfacies appear: Bioclastic Lime Packstone, Peloidal Lime Wackestone, and Lime Mudstone Microfacies, which are subtidal to restricted lagoon and open marine. The recorded calcareous nannofossil assemblages include one biozone, which is from the lower to the upper part of the section: *Sphenolithus heteromorphus* Interval Biozone (CN4). Following the standard biozonation, this biozone concludes the age of the Middle Miocene (Langhian).

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دراسة السحنات الصخارية وتحديد العمر لتكوين الفتحة في مسحك، محافظة صلاح الدين، شمالي العراق

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الملخص

تمت دراسة مقطع سطحي من تكوين الفتحة (الميوسين الأوسط) في منطقة مسحك، بيجي، شمالي العراق .يتكون التكوين من تتابعات من صخور الحجر الجيري وصخورالمارل الأخضر وصخور الحجر الطيني الأحمر وصخورالجبس . تتكرر هذه التتابعات داخل المقطع ويبلغ سمكها 35 مترًا . أما بالنسبة للحدود الطباقية فإن الحد السفلي غير متوافق لتكوين بلاسبي، أما الحد العلوي فهو متوافق مع تكوين إنجانة. أجريت الدراسة المستحاثية لصخور الحجر الجيري من خلال فحص مقطع رقيق مكون من (15) عينة . شخصت حوالي ثلاث سحنات دقيقة: سحنة الحجر الجيري العضوي، وسحنة الحجر الجيري، وسحنة حجر الطين الجيري الدقيقة التي ترسبت في بيئات الترسيب تحت المد والجزر البحرية المحدودة والمفتوحة . تشتمل تجمعات متحجرات النانو الكلسية المسجلة على الانطقة الحياتية بنطاق حياتي واحد فقط تقع من الجزء السفلي إلى الجزء العلوي من المقطع: *Sphenolithus heteromorphus* Interval Biozone (CN4). حدد هذا النطاق الحياتي عمر المايوسين الأوسط (لانجيان) .

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Introduction

The current study includes the lithostratigraphy and the microfacies analysis of the Fatha Formation with a thickness of 35 m located at north of Salah al-Din in the Baiji area, on the Tigris River and Jabal Makhoul within line (43° 24′ 08″ E, 35° 10′ 59″ N) and thickness 35m. One of the most widely distributed formations in the region is the Middle Miocene Fatha Formation in Iraq (Al-Juboury et al., 2001; Jassim and Goff, 2006).

Fatha Formation (Middle Miocene) was included within the Fars Group, which was described from Iran by Pilgrim (1908) in Bellen et al. (1959), which is exposed in Iran and consists of several sedimentary cycles. Each cycle consists of green and red shale, limestone, gypsum, anhydrite, and salt rock. The formation's name was modified to the Fatha Formation in Iraq by and the type section of the formation was chosen on the northeastern limb of an Makhul anticline. It consists of irregular cycles of greenish-gray marl, reddish brown marl, limestone, and anhydrite (AL-Rawi et al., 1993). (Al-Jubouri, 1999) studied the formation in the south of Mosul between Hammam Al-Alil and the Al-Fatha area. The study included a field description of the four sections, in addition to a petrographic study of limestone and marly limestone, for the depositional environment. Results of Juouri (1999) indicated that those formations were a Lagoon and one of the primary delta environments. (Al-Lahibi,1994) studied the same formation in the fold of Sheikh Ibrahim and Butma Al-Sharqiah, mineral formation and the supremacy of calcite metal the mineral calcite and the limited presence of dolomite, as well as he identified seven microfacies and showed that the environment for deposition of the formation marine is shallow to semi-confined with high salinity.

(Kharoufa, 2008) studied the same formation based on Ostracoda assemblages in selected areas of northern Iraq and showed that the formation has a depositional environment of the shallow basin affected by the tectonic movements that occurred during the middle Miocene, which led to the formation of a shallow marine environment to an isolated lagoon environment. (Fig.1)

The current study has a main goal; first is to determine Lithofacies and sedimentary structures of the Fatha Formation sequences and their contact boundaries, second is to discover microfacies and depositional environment, and establish an appropriate environmental model for the study area.

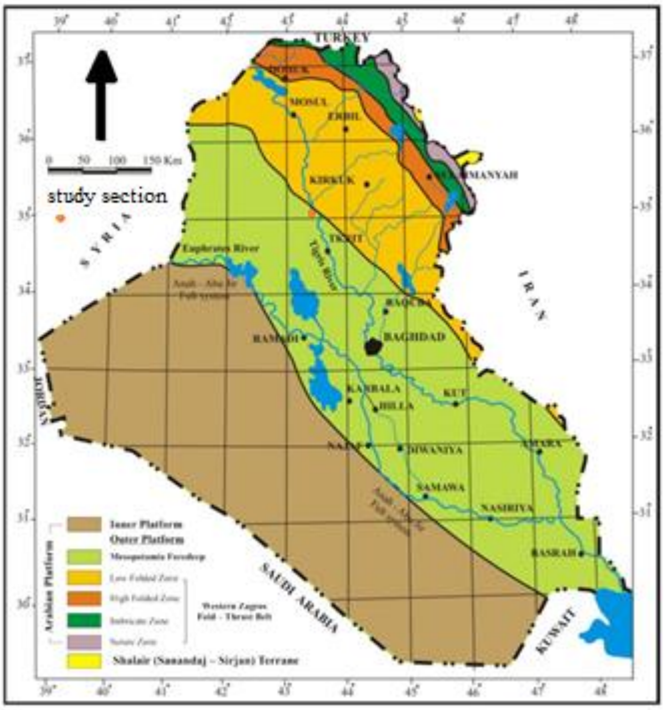

Fig. 1. Tectonic map showing the Location of the study area (Fouad, 2015)

Methodology

Materials:

The methodology includes outcrop sampling for 15 samples of the Fatha Formation from beds lower to upper sequences distances of 0.5 to 2m.

Laboratory Analysis:

(A) Preparing calcareous Nannofossil Slides by Using the Method (H) (Armstrong and Brasier, 2005). A clear number of individuals that showed special characteristics, species, and genera were selected, and images were captured using a modern, high-resolution ONY-cyber shot 3x imaging device.

(B) Observation Techniques

With a cross-polarized and gypsum plate, the slides were inspected under a light microscope to check for the presence of calcareous nannofossils. Extensive investigations were conducted on the collections with the use of x1000 magnification. The many authors' published catalogues (Deflandre and Ferth, 1954) from libraries and the internet were used to identify the species.

Results and discussions

1 - Lithofacies

The outcrop of the Fatha Formation in the studied section consists of alternations of different sedimentary cycles of limestone, red claystone, green marl, and gypsum, and these sequences are repeated with a thickness of 35m. The thickness of the limestone layers increases gradually towards the top of the sequences, with layers of red clay, green marl, and brown marl limestone alternating with red clay layers in the middle of the formation, which ends with the gypsum layers. Hard well bedded gray, brown and yellow limestone is well recognized, which included iron oxide nodules distributed in the layer, laminae of red soft clays with thickness of 1m followed by layers of 0.5m thick marls, lenticular in shape, of a light grey color, followed by relatively massive 9m marly limestone layers affected by many fractures and different joint sets, sometimes interspersed in shape of lenses and flakes of marly clay and whose colors are limited to red, green, and light grey, Brown iron oxide nodules are found in different parts of the layer. The repetition and thickness of the marly limestone and limestone layers gradually increase towards the top formation. The top is a gypsum layer, which generally consists of nodular, coalesced gypsum that gradually transforms to solid gypsum (Fig. 2, A, B). The lower contact is unconformity with the Pila Spi Formation, while the upper boundary is conformably rest below the Injana Formation. Due to the loss of the early Miocene and Oligocene, it is inferred that the appearance of the Intraformational breccia and the boring organism, which is submarine sedimentary evidence of the unconformity surface (Fig.3), represents the stratigraphic section of the study area.

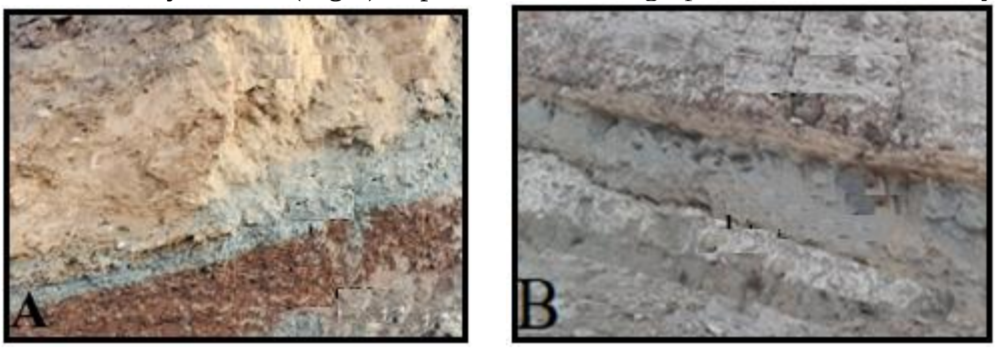

Fig. 2. The Lithofacies of Fatha Formation (A) Sequences Claystone red soft, Marl green soft, and limestone hard, (B) Sequences massive Limestone rich in dissolution and massive Gypsum.

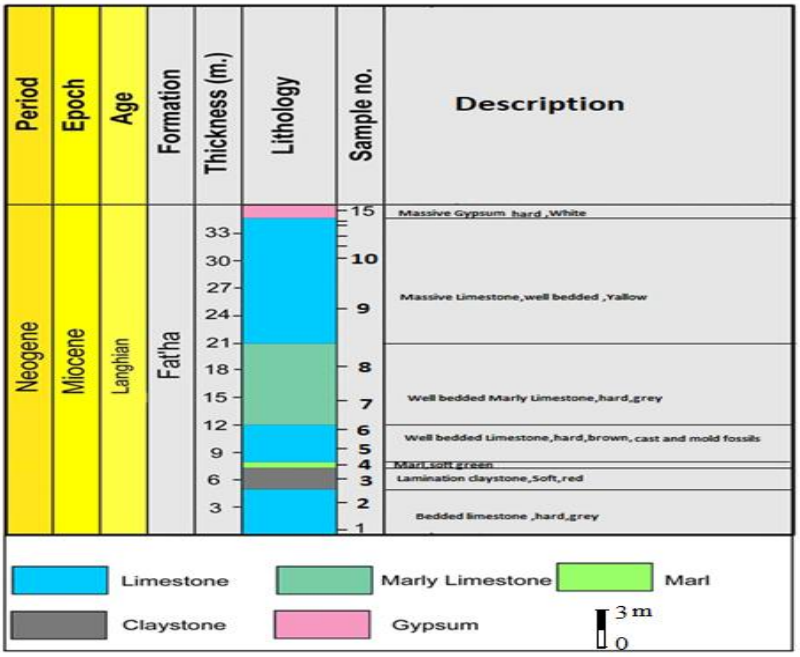

Fig. 3. The stratigraphic sequences of the Fatha Formation in the study area.

2 – Microfacies analysis and depositional environment

The carbonates generally form about 75% of the total Fatha sediments in the section. These units have thicknesses ranging from 1 to 20.0 m, with each bed's thickness rising with succession. In the examined limestone section, there are highly fossiliferous strata with frequent, mostly recrystallized shell pieces. The facies of the formation were divided into three microfacies: (1) Bioclastic Lime Packstone, (2) Peloidal Lime Wackestone, and (3) Lime Mudstone Microfacies. Several compositions are distinguished according to the type and abundance of bioclasts present (Fig.4. A, B, C). Bioclasts include gastropods, rotalids, miliolids, pelecypods, bryozoans, echinoids, ostracods, and calcareous algae, and authigenic quartz (Fig.4. D, E, F). Pellets were common and varied from ovoid to sub-rounded. The common bladed and spar calcite cement may be of phreatic or meteoric origin (Tucker, 1990). The bioclastic packstone was deposited on the edge of a shoal in a platform environment, whereas those sediments were deposited in a shallow marine setting (Al-Hashimi and Amer, 1985). Bioclastic mollusks Microfacies of Limestone: Fine-grained, micritic limestone with trace proportions of silt- and sand-sized grains, mostly quartz, characterizes this microfacies. It mostly affects the upper portion of the lower member. Among the frequent bioclasts found are bryozoans, gastropods, ostracods, and benthic foraminifera. There are microfacies of peloidal limestone wackestone that have few fossil remnants. These pellets are typically ovoid, micritized, and occasionally dolomitized and porous with sparry calcite envelopes. These pelmicrites' scanning electron images reveal the sparry calcite sheath around the micritic carbonates. These sediments were deposited at intermediate depths and low tide in calm, shallow-water marine environments.

Limestone microfacies: This fine-grained microfacies contains uncommon fossil ghosts. Gypsum is used to fill in some of the spaces that arise. With sporadic remnants of calcispheres, foraminifera, and ostracods, the lime muds are often peloidal. Planktonic foraminifera are conspicuously absent from the low-diversity benthic foraminifera collection seen in the limestone strata. Cryptalgal laminites, stromatolites, a variety of ichnofauna (including burrowers like Planolites and Skolithos), and scavengers like ostracods and pelecypods are found inside the limestones. Lagunal environments are where the limestone deposits were deposited. In addition to the low diversity of foraminifera, she included Quinqueloculina and Triloculina as supporting evidence. She confirmed that other beds were deposited in relatively shallow, tropical or subtropical marine settings, based on identifying marine fossil assemblages. Marly Limestone brown, well bedded, and too hard

The carbonate-rich claystones are found in 2 m-thick layers. The sediments are frequently fractured and laminated to heavily bedded surfaces. They are rich in fossils, such as those of gastropods, pelecypods, and oysters. The soft claystones are either red or yellow. While the contact with limestone strata is gradational, that of this basal limestone with the adjacent marl beds is often erratic and erosional.

Subtidal depositional settings are limited to open-marine habitats. The oysters were interpreted by Ma'ala et al. (1989) as animals that lived in a lagoon with brackish water. Open-marine conditions are indicated by the grey to yellowish marls. The overlying claystone's deposition was most likely caused by a shift in the area of active sedimentation or a fresh, relative rise in sea level.

The sedimentary facies of the Fatha Formation differ from one place to another depending on its location in the sedimentary basin. In general, the facies of the middle of the basin are characterized by being composed of a thick succession of evaporites, carbonates, and clays, while the facies of the edge of the basin are less thick and are dominated by clastics. The ideal cycle for the formation of the hole consists of green marl at the bottom, which represents marine progress. When there is little or no detrital material in normal marine water, carbonate rocks are formed. When the water becomes hypersaline due to increased evaporation, evaporite precipitate, and the cycle ends with red clay deposits, which represent a continental environment and marine retreat (Fig. 4) and (Fig.5).

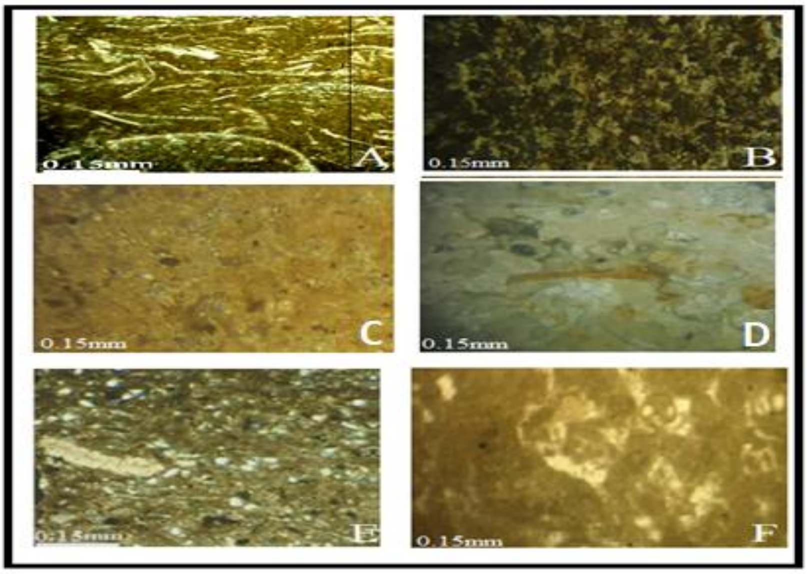

Fig. 4. The Lithofacies of Fatha Formation (A) Bioclastic pelecypods Lime Packstone Microfacies. (B) Peloidal Lime Wackestone microfacies dark subrounded. (C) Lime Mudstone microfacies with pyrite in the matrix. (D)Algae mats show the appearance of colonies. (E) Authigenic quartz silt-sized grains. (F) Miliolids benthonic within micrite.

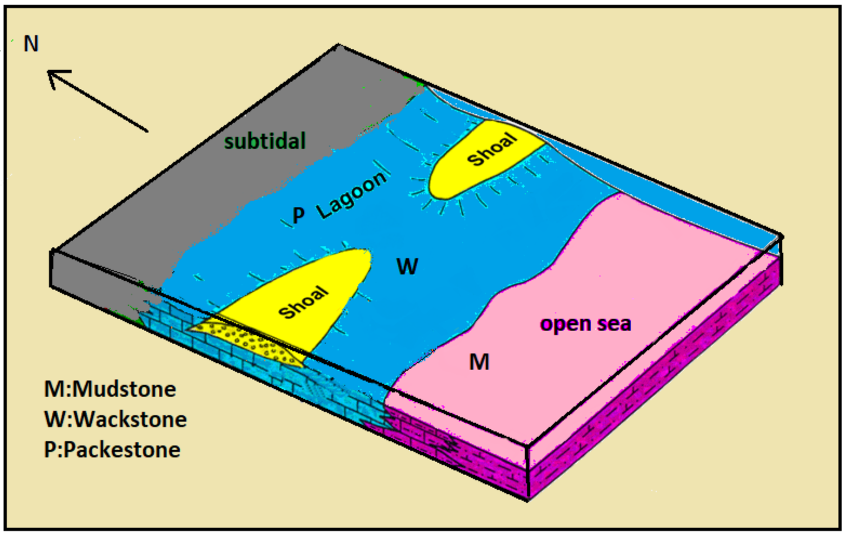

Fig. 5. Depositional model of the Fatha Formation in the study area

3- Nannofossils Biozones

It distinguished many nannofossil biozones (Fig.6). The systematic classification of the calcareous nannofossils, depending on many paleontological references to identify twelve species of calcareous nannofossils. The material and images are stored in the Department of Geology, College of Science, University of Mosul, Mosul, Iraq.

Family Helicosphaeraceae

Genus Helicosphaera

Helicosphaera euphratis

Helicosphaera sp.

Family Coccolithaceae

Genus Coccolithus

Coccolithus pelagicus

Genus *Ericsonia*

Ericsonia formosa

Ericsonia sp.

Genus *Cruciplacolithus*

Cruciplacolithus sp.

Family Noelaerhabdaceae

Genus Cyclicargolithus

Cyclicargolithus floridanus

Cyclicargolithus bukryi

Cyclicargolithus abisectus

Family Discoasteraceae

Genus Discoaster

Discoaster nobilis

Family Sphenolithaceae

Genus Sphenolithus

Sphenolithus conicus

Sphenolithus heteromorphus

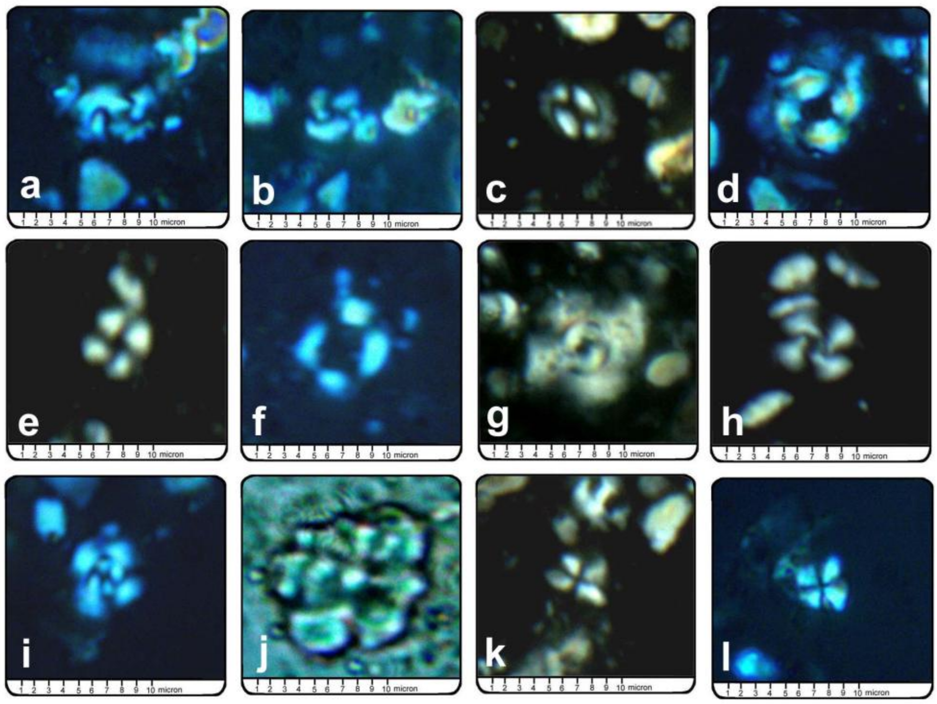

Figure 6: Light photos of significant calcareous nannofossil taxa from Fatha Formation (a) Helicosphaera euphratis; (b) Helicosphaera sp.; (c)Coccolithus pelagicus; (d)Ericsonia formosa; (e) Ericsonia sp.; (f) Cruciplacolithus sp.; (g) Cyclicargolithus abisectus; (h) Cyclicargolithus bukryi; (i) Cyclicargolithus floridanus; (j) Discoaster nobilis; (k) Sphenolithus conicus; (l) Sphenolithus heteromorphus.

4 –Age determination

Depending on the recorded nannofossil species and their biostratigraphic range, as shown in the current study. One main biozone has been recorded, and one interval biozone is identified (Figs 6 and 7). This is the Sphenolithus heteromorphus Interval Biozone (CN4), which is defined as an interval biozone determined by the last occurrence of the Helicosphaera ampliaperta to the last occurrence of the Sphenolithus heteromorphus. This biozone roughly agrees with the biozone CN4 by Okada and Buky (1980), and with biozone NN5 by Martini (1971), and with biozone CNM7 by Backman et al. (2012), and with biozone Diascoaster signum by Al-Shareefi et al. (2022); therefore, it concludes the age of this biozone is Middle Miocene (Langhian) based on Gradstein et al. (2020).

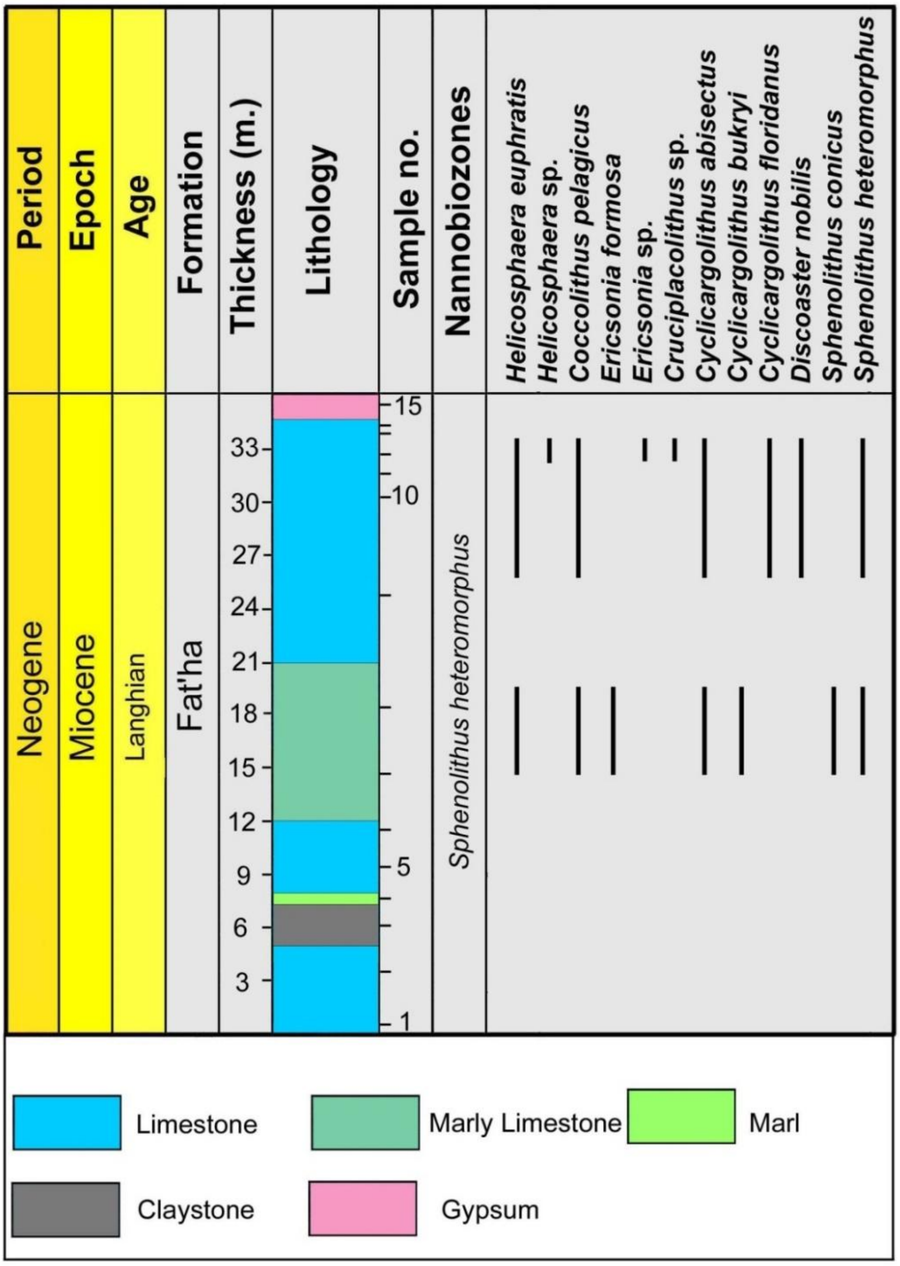

Fig.7. A range chart shows the extension of the recorded calcareous nannofossils within the Fatha Formation, Mushak section of Baiji area.

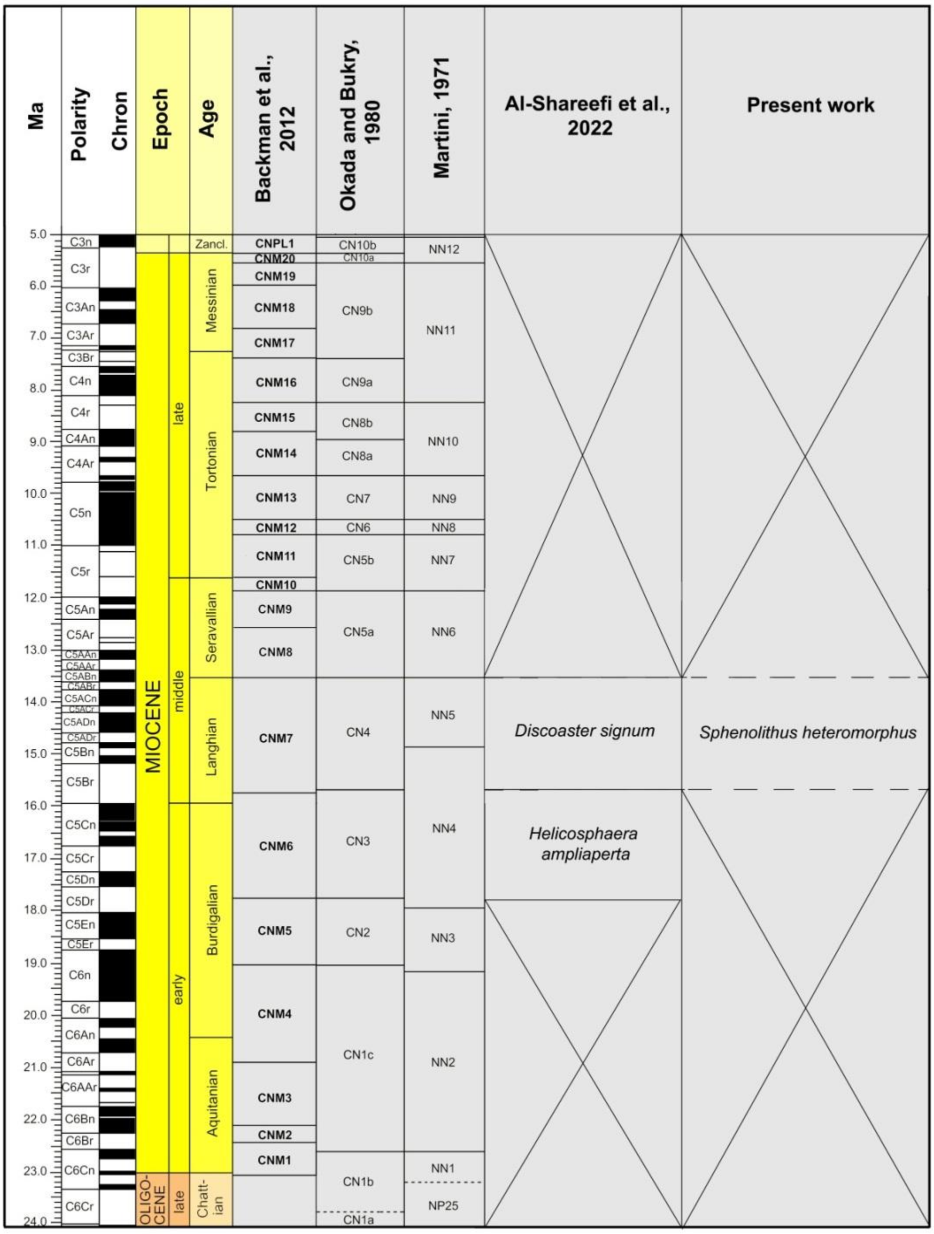

Fig. 8. Correlation chart for calcareous nannofossils of the study section.

Conclusions

1 - The Fatha Formation from the studied Mushak section in the Baji area shows a different lithology, consisting of sequences of limestone, green marl, red claystone, and gypsum. These sequences are repeated within the section and have a thickness of 35m.

2- The lower contact is unconformity with the Pila Spi Formation, while the upper boundary is conformity with the Injana Formation

3- Three microfacies: Bioclastic Lime Packstone, Peloidal Lime Wackestone, and Lime Mudstone Microfacies

4-The deposition for formation of subtidal, restricted, and open-marine environments

5- One biozones of Calcareous nannofossils where recorded, it is Sphenolithus heteromorphus Interval Biozone (CN4), this biozones are correlated with other calcareous nannofossils biozones from both local and regional sections that lead to conclude the age of the Middle Miocene (Laghian to Sarvallian) and Barren zone of the nannofossil extend from sample no. 3 to sample No. 15.

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