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CALCAREOUS NANNOFOSSILS FROM THE EOCENE SEQUENCE OF THE NAOPURDAN GROUP, BETWAT LOCALITY, SULAIMANIYAH, KURDISTAN REGION, IRAQ

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ABSTRACT

Ten samples were collected from the Eocene sequence of the Naopurdan Group at the Betwat locality within the Thrust Zone of the Sulaimaniyah area, Kurdistan/ Iraq. The samples covered 120 meters of a succession represented by marlstone/ shale, siltstone and sandstone with limestone interlayers and slightly metamorphosed shale/ slate. This succession unconformably underlies a serpentinite rock bed, which is derived from the Mawat ophiolite complex. A biostratigraphic study is carried out for the first time for the calcareous nannofossils present in this sequence and emphasized the age of Middle Eocene. The nannofossil assemblage identified in this study comprises important species that highlights the NP15 and NP16 Zones of the Lutetian stage of the Middle Eocene in the Naopurdan Group. The *Sphenolithus* spp. included *Sphenolithus furcatolithoides*, *S. cuniculus*, *S. spiniger*, *S. predistentus*, *S. orphanknollensis*, *S. kempii*, *S. Runus*, *S. perpendicularis*, *S. richteri*, and *S. moriformis*. The *Reticulofenestra* spp. included *Reticulofenestra erbae*, *R. westerholdii*, *R. bisecta*, *R. reticulata*, *R. minuta*, and *R. dictyoda*. The *Toweius* spp. included *Toweius gammation* and *T. callosus*, together with species like *Blackites spinosus*, *Blackites tenuis* and *Cyclicargolithus floridanus*.

متحجرات النانو الكلسية من تتابع الإيوسين لمجموعة ناوبردان، مقطع بيتوات، السليمانية، اقليم كردستان، العراق

سوران عثمان عبد الله خراجيانى

المستخلص

غطت عشر نماذج صخرية مقطعا كاملا من عصر الإيوسين من موقع بيتوات الواقع داخل نطاق الطيات المندفعة في منطقة السليمانية، كردستان/ العراق وشمل 120 مترا من مارل/ طفل، وحجر رمل وغرين وطبقات جيرية متداخلة مع صخور قليلة التحول تعود الى مجموعة ناوبردان. يقع هذا التتابع تحت صخور سيربنتينيات تعود الى معقد ماوات بشكل غيرتوافقي. تمت دراسة الطباقية الأحيائية للمتحجرات النانو الكلسية لأول مرة في هذا التتابع، وأكدت النتائج العصر الإيوسيني الأوسط. أظهرت نتائج هذه الدراسة وجود عدد من أجناس وأنواع من المتحجرات النانو الكلسية التي تشير الى وجود النطاقين NP15 و NP16 من عصر الإيوسين الأوسط (اللوتيتان) في عينات مجموعة ناوبردان و هي:

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Sphenolithus spp.; *Sphenolithus furcatolithoides, S. cuniculus, S. spiniger, S. predistentus, S. orphanknollensis, S. kempii, S. Runus, S. perpendicularis, S. richteri,* and *S. moriformis*. *Reticulofenestra* spp.; *Reticulofenestra erbae, R. westerholdii, R. bisecta, R. reticulata, R. minuta,* and *R. dictyoda, Toweius gammation, Toweius callosus, Blackites spinosus, Blackites tenuis* and *Cyclicargolithus floridanus*.

INTRODUCTION

The Naopurdan Group of northeast Iraq has not been studied in detail despite of its huge thickness, which reaches more than 2000 meters. Many authors used planktonic foraminiferas to date this group. Bolton (1958) determined the age as Paleocene – Oligocene or possible Miocene. According to Polnikov and Nikolajev (1962); in Jassim and Goff (2006) the age should be Eocene and Oligocene. These suggestions, however, were not substantiated by any detail paleontological investigations. Fossil contents such as *Nummulites atacicus* and *Nummulites aturicus* indicate Early Eocene; *Alveolina oblonga* to the Early – Middle Eocene; *Globorotalia* (*Morozovella*) *lehneri* to the Middle Eocene; and *Porticulasphaera mexicana* to the Middle – earliest Late Eocene. However, Al-Qayim *et al*. (2014) studied the biostratigraphy using planktonic foraminiferal zonation and benthonic foraminiferal assemblages from the shale of the group; they claimed that the age of the group at the Thrust Zone is Lower Eocene (Ypresian).

This study examines the sequence at Betwat section using calcareous nannofossils. The Betwat section was selected to re-assess the age of the sequence, which is 120 m thick. The section is located at 25 Km northeast of the Sulaimaniyah city, and 10 Km northwest of the Chwarta town. It lies inside Betwat Village at coordinants intersection 35° 46' 49" N and 45° 29' 27" E) (Figs.1 and 2).

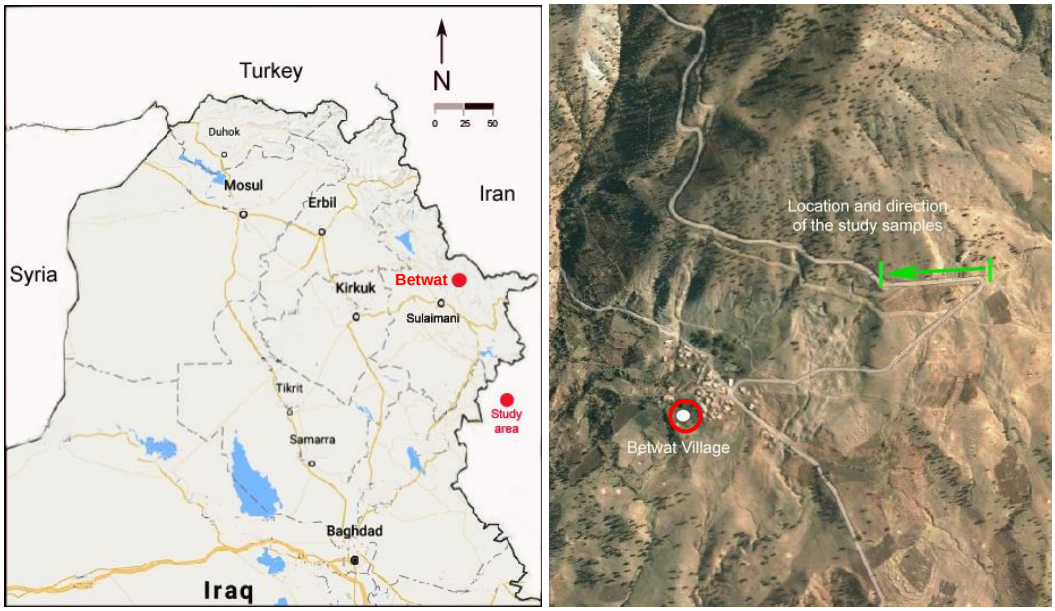

Fig.1**:** Geographic location of the Betwat locality, Sulaimaniyah, Kurdistan, Iraq, with Satellite image (Google Earth)

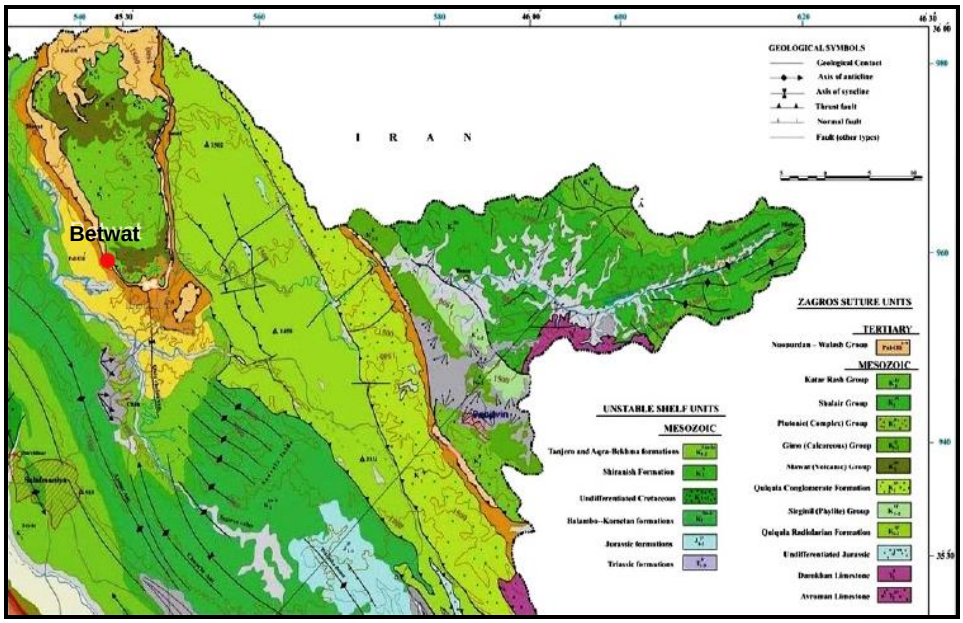

Fig.2: Geological map of the Sulaimaniyah area, showing the study area (after Ma'ala, 2008)

GEOLOGICAL SETTING

Tectonically, the Naopurdan Group and the study area are located within the Thrust Zone; a zone where the stratigraphic succession is severely deformed due to the tectonic processes. Consequently, the position of some stratigraphic successions was dislocated and caused the interpretations and age determination complicated and even not possible sometimes. Heron and Lees (1943) referred to the name Naopurdan as the Lower Division of the Nappe Zone (or the Shaly Rock Group). The name Naopurdan Shaly Group was first used by Bolton (1958) to describe the lowermost tectonic unit of the Thrust Zone of Iraq.

LITHOSTRATIGRAPHY OF THE BETWAT SECTION

The stratigraphic succession at the Betwat locality is topped by metamorphosed rocks (slate and serpentinite) of the Mawat ophiolite complex. The succession is gently dipping to the northwest at 32 – 35°. The overall-measured thickness is 120 m from which the sampling campaign was executed. The lithostratigraphic sequence from bottom to top consists of light-green to olive marlstone and red shale dominants, siltstone, sandstone, light-olive marly limestone interlayers and a brown limestone bed. This clastic sequence is succeeded by slightly metamorphosed shale/ slate and a serpentinite rocks that were derived from Mawat ophiolite complex which is unconformably topping them (Fig.3). The sequence is underlined by a 250 m thick bed of conglomerate. This conglomerate represents the lower unit of the Naopurdan Group.

The type locality at Naopurdan Village in the Rawanduz Valley contains lavas and pyroclastics; elsewhere volcanic rocks are rare. Buday (1980) divided the group into two subgroups: the Naopurdan-Type Subgroup, which comprises intercalated sedimentary and volcanic units and the Sidekan-Type Subgroup that composed only of sedimentary rocks. Mirza *et al*. (2016) studied the petrology of the nummulitic limestone of the Naopurdan Group. Ali *et al*. (2017) reported that the conglomerates of Walash and Naopurdan clastic rocks were mainly derived from local erosion of the Walash and Naopurdan sub-alkaline basalt/ basaltic andesite.

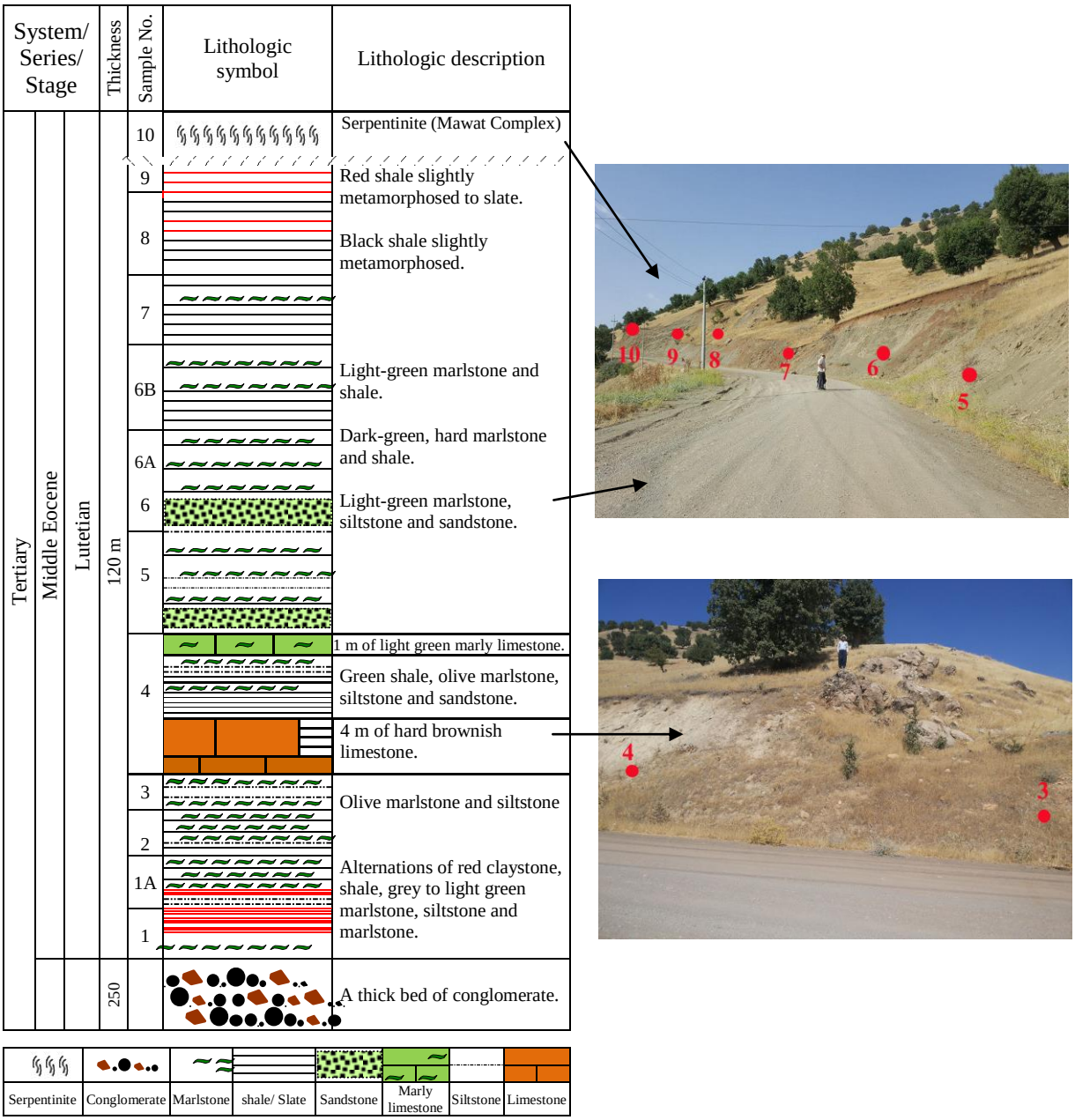

Fig.3: Lithostratigraphic column of the Naopurdan Group, Betwat section, Sulaimaniyah area, Kurdistan, Iraq

MATERIAL AND METHODS

The calcareous nannofossils were studied in smear-slides, using transmitted-light microscopy in plain-polarized and cross-polarized at magnification powers 400 and 630, and a 5µm scale bar is provided on each micrograph. For preparation and making the smear slides, the outer surface of the hand specimens is cleaned off, and then a fine powder of the rock sample is scraped off onto a slide cover slip. The cover slip then is moistened with distilled water and spread across the cover slip with a suitable stick such as a wooden toothpick. The cover slip is placed on a hot plate to dry. Once dry the cover slip is inverted and glued to a glass slide using a suitable adhesive such as Cyanoacrylate.

CALCAREOUS NANNOFOSSILS AND BIOSTRATIGRAPHIC ZONATION

The study of calcareous nannofossils is based on the investigation of the smear-slides under polarized microscopy to examine and identify calcareous nannofossils genera/ species for the first time as illustrated in Fig.4 (4.1 – 4.25) and Fig.5 (5.1 – 5.25). Some important genera/ species were determined in the present study, which are markers of the Middle Eocene age. Among those genera, *Sphenolithus*, *Reticulofenestra*, and *Toweius* were found. They are described according to their classification, age and distribution within the stratigraphic column of the Betwat locality. The zones of Martini (1971), and Bown and Dunkley (2012) were used for the biostratigraphic zonation. Furthermore, the International Nannoplankton Association (INA) home page (2018) was used to describe the genus/ species of the nannofossils.

- **Family SPHENOLITHACEAE (**Deflandre, 1952)

Sphenoliths are the abundant and well preserved components in the samples of the Naopurdan Group from the study area. Sphenolithaceae are conical discoasteralids with a concave base, consisting of a mass of elements radiating from a common origin. They appeared from Paleocene to Pliocene. They show maximum radiation during Eocene and Oligocene.

– *Sphenolithus radians* Group: Species of this group belong to the Eocene to the Early Oligocene with compound spines that are visible, but dim at 0° and brightest when at 45° to the polarizing directions. They have four quadrants (base) and are square or tapering. Some species of this group are found in the samples of the Betwat section and were described as follows:

- ***Sphenolithus spiniger*** (Bukry, 1971)**:** Small to medium sized with short spine, narrow triangular shape. Lower quadrants are largest and the compound spine is dark at 0°. First occurrence: Ypresian, NP14 Zone. Last occurrence: Priabonian, NP17 Zone (Fig.4.10).

- ***Sphenolithus orphanknollensis* (**Perch-Nielsen, 1971)**:** It is a *Sphenolith* with small, narrow, tapering spine. First occurrence: Ypresian, NP13 Zone. Last occurrence: Lutetian, NP15 Zone (Figs.4.14, 4.21; and 5.21).

- ***Sphenolithus runus*** (Bown and Dunkley, 2012)**:** It is spinose, dart-shaped *Sphenolith* with a low base comprising a single cycle of triangular quadrants when viewed at 0°. The relatively tall, tapering spine is in extinction at 0° and bright at 45°. The quadrants are appeared larger, and are extended distally, at 45°. First occurrence: Lutetian, NP16 Zone. Last occurrence: Bartonian, NP16 Zone (Figs.4.6 and 4.23).

- ***Sphenolithus richteri*** (Bown and Dunkley, 2012)**:** Small narrow *Sphenolith* with square base, comprising equidimensional quadrants, and tapering monocrystalline spine that is dark at 0° and bright at 45°. First occurrence: Lutetian, NP16 Zone. Last occurrence: Bartonian, NP16 Zone (Fig.4.24).

– *Sphenolithus furcatolithoides* Group: They are small Middle Eocene *sphenoliths* with duocrystalline spines that are dark in the 45° position. The species of this group found here are:

- ***Sphenolithus furcatolithoides*** (Locker, 1967)**:** Spines diverge just above the base and are near-parallel in the lower part. First occurrence: Lutetian, NP15 Zone. Last occurrence: Bartonian, NP16 Zone (Figs.4.18, 5.6, 5.11 and 5.15).

- ***Sphenolithus cuniculus*** (Bown, 2005)**:** A *Sphenolith* of medium to large, short lower quadrants and long upper quadrants that bifurcate (forms with low basal quadrants ('feet') and ~90° bifurcations). First occurrence: Lutetian, NP15 Zone. Last occurrence: Bartonian, NP16 Zone (Fig.5.25).

- ***Sphenolithus kempii*** (Bown and Dunkley, 2012)**:** Three or four long spines and square base. At 0°, the two outer spines are bright, the middle spine is dark and the base is bright. At 45°, the middle spine is bright, the two outer spines are dark and the base is darker and crossed by X-shaped extinction lines. First occurrence: Bartonian, NP15 Zone. Last occurrence: Bartonian, NP15 Zone (Fig.5.17).

- ***Sphenolithus perpendicularis*** (Shamrock, 2010)**:** *Sphenolith* with a small to medium-sized square base, bearing two tapering, apical spines that diverge by around 90° just above the basal cycles. First occurrence: Lutetian, NP15 Zone. Last occurrence: Lutetian, NP15 Zone (Figs.4.19 and 5.10).

- ***Sphenolithus predistentus*** (Bramlette and Wilcoxon, 1967)**:** Small to medium sized with tall, narrow bifurcating spine and very short, flat, lower quadrants. First occurrence: Lutetian, NP16 zone. Last occurrence: Chattian, NP24 zone (Figs.4.3, 4.6 and 4.9).

- ***Sphenolithus moriformis*** (Brönnimann and Stradner, 1960; Bramlette and Wilcoxon, 1967)**:** Beehive shaped *Sphenolith*, apical elements not in extinction in vertical position and no spine, upper and lower parts of similar size. First occurrence: Selandian, NP5 Zone. Last occurrence: Tortonian, NN10 Zone (Figs.4.13, 5.8 and 5.22).

– **Genus *Reticulofenestra* Hay, (**Mohler and Wade, 1966**):** Coccoliths with bridge no slits.

- ***Reticulofenestra dictyoda*** (Deflandre in Deflandre and Fert, 1954; Stradner in Stradner and Edwards, 1968)**:** It is small to very large size, elliptical reticulofenestrids with open central area. First occurrence: Ypresian, NP13 Zone. Last occurrence: Early Miocene, NN2 Zone (Figs.5.3, 5.6 and 5.9).

- ***Reticulofenestra minuta*** (Roth, 1970)**:** They are *coccoliths* of very small size, elliptical with open central area. First occurrence: Ypresian, Np13 Zone. Last occurrence: Piacenzian, NN4 Zone (Figs.4.20, 5.1, 5.12 and 5.20).

- ***Reticulofenestra bisecta*** (Roth, 1970)**:** Medium to large *reticulofenestrids* coccoliths with a solid central plug. First occurrence: Ypresian, Np13 Zone. Last occurrence: Aquitanian, NN1 Zone (Figs.4.11, 4.15 and 4.19).

- ***Reticulofenestra westerholdii*** (Bown and Dunkley, 2012)**:** Medium-sized *Reticulofenestra* (5 – 8 μm), they are circular reticulofenestrids with open central area (similar in width to, or slightly narrower than, the rim width), but no perceptible net. First occurrence: Lutetian, NP16 Zone. Last occurrence: Priabonian, NP19-20 Zone (Figs.4.1 and 4.25).

- ***Reticulofenestra erbae*** (Fornaciari *et al.*, 2010)**:** Medium to large, circular *reticulofenestrids* with narrow closed central area crossed by a distinctive, robust, visible net. First occurrence: Bartonian, NP16-17 Zone. Last occurrence: Priabonian, NP19-20 Zone (Fig.4.7).

– **Genus *Toweius (***Hay and Mohler, 1967**):** The genus is typically medium, elliptical to circular placoliths with central areas that are typically spanned by a proximal net and/ or distal conjunct nets or bars.

- ***Toweius gammation*** (Bramlette and Sullivan, 1961; Romein, 1979)**:** Medium-sized, circular; central area with bright central plug crossed by strongly curving swastika-like extinction lines. Shield elements are usually conspicuous in LM. First occurrence: Ypresian, NP11 Zone. Last occurrence: Lutetian, NP14-15 Zone (Figs.4.4, 4.17, 5.17 and 5.24).

- ***Toweius callosus*** (Perch-Nielsen, 1971)**:** It is medium to large, elliptical to sub-circular *Toweius*, Central area spanned by a fine-proximal net that is not typically discernible in LM. First occurrence: Thanetian, NP9 Zone. Last occurrence: Lutetian, NP15 Zone (Fig.4.22).

▪ **Family RHABDOSPHAERACEAE (**Haeckel, 1894)

– **Genus *Blackites*** (Hay and Towe, 1962)

- ***Blackites spinosus*** (Deflandre and Fert, 1954; Hay and Towe, 1962)**:** *Rhabdolith* with a tall, narrow, styliform spine that tapers gradually to a point and the outer surface is smooth. The width of the spine is around half that of the coccolith but considerable taller. The rim is relatively broad and distinctly convex. First occurrence: Lutetian, NP14 Zone. Last occurrence: Rupelian NP23 Zone (Figs.4.5 and 4.8).

- ***Blackites tenuis*** (Bramlette and Sullivan, 1961; Sherwood, 1974)**:** *Rhabdolith* with a tall, narrow, styliform spine that is narrow at its base broadens slightly and then tapers to a point, but is never as broad as the coccolith rim. The rim is relatively narrow with a bright inner cycle. First occurrence: Lutetian, NP15 Zone. Last occurrence: Rupelian NP23 Zone (Fig.4.16).

- ***Pseudotriquetrorhabdulus inversus*** (Bukry and Bramlette, 1969; Wise *in* Wise and Constans, 1976)**:** They are tapers at ends, ragged appearance and narrow axial canal. First occurrence: Lutetian, NP15 Zone. Last occurrence: Rupelian NP23 Zone (Fig.5.23).

- ***Coccolithus formosus*** (Kamptner, 1963; Wise, 1973)**:** Large circular *Coccolithus* with narrow central area. First occurrence: Lutetian, NP12 Zone. Last occurrence: Rupelian NP21 Zone (Fig.5.20).

- ***Cyclicargolithus floridanus*** (Roth and Hay, in Hay *et al*., 1967, Bukry, 1971)**:** Coccoliths circular to sub-circular with small central-area, <11 µm in width. First occurrence: Lutetian, NP15 Zone. Last occurrence: Serravallian NN6 Zone (Figs.4.12 and 5.2).

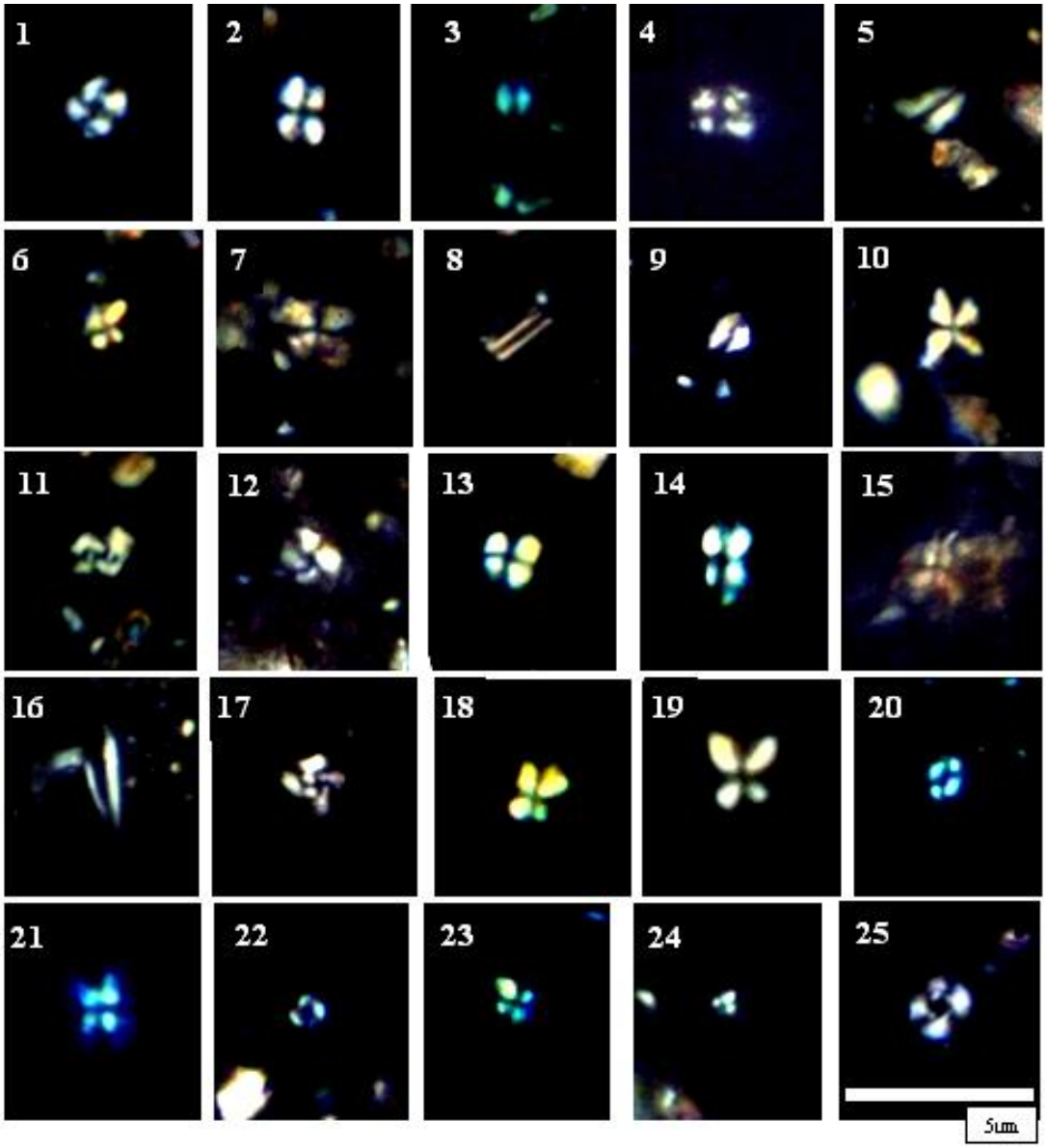

Fig.4: Some genus/ species of calcareous nannofossils identified in the Middle Eocene strata of the Naopurdan Group, Betwat locality

1) *Reticulofenestra westerholdii*, WZ7, 40X. **2)** *Sphenolithus spiniger*, WZ7, 40X. **3)** *Sphenolithus predistentus*, WZ7, 40X. **4)** *Toweius gammation*, WZ5, 40X. **5)** *Blackites spinosus*, WZ6B, 40X. **6)** *Sphenolithus Runus*, WZ6, 40X. **7)** *Reticulofenestra erbae*, WZ6A, 40X. **8)** *Blackites spinosus*, WZ6, 40X. **9)** *Sphenolithus predistentus*, WZ6A, 40X. **10)** *Sphenolithus spiniger*, WZ6, 40X. **11)** *Reticulofenestra bisecta*, WZ6, 40X. **12)** *Cyclicargolithus floridanus*, WZ6, 40X. **13)** *Sphenolithus moriformis*, WZ6, 40X. **14)** *Sphenolithus orphanknollensis*, WZ6, 40X. **15)** *Sphenolithus* sp., WZ5, 40X. **16)** *Blackites tenuis*, WZ5, 40X. **17)** *Toweius gammation*, WZ5, 40X. **18)** *Sphenolithus furcatolithoides*, WZ5, 40X. **19)** *Sphenolithus perpendicularis*, WZ5, 40X. **20)** *Reticulofenestra minuta*, WZ5, 40X. **21)** *Sphenolithus orphanknollensis*, WZ5, 40X. **22)** *Toweius callosus*, WZ5, 40X. **23)** *Sphenolithus runus*, WZ5, 40X. **24)** *Sphenolithus richteri*, WZ5, 40X. **25)** *Reticulofenestra westerholdii*, WZ5, 40X.

Note: the white bar represents five micrometers.

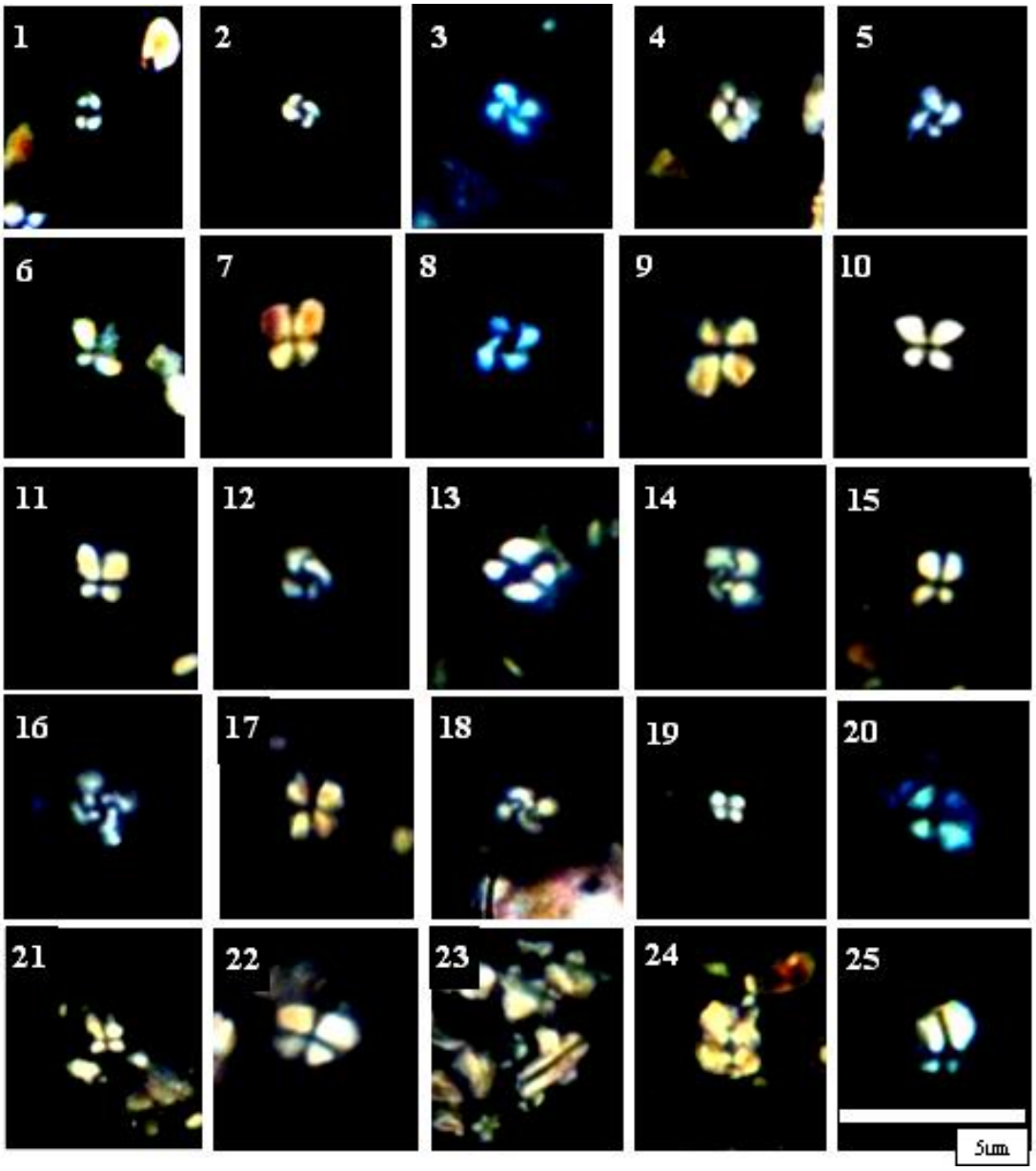

Fig.5: Some genus/ species of calcareous nannofossils identified in the Middle Eocene strata of the Naopurdan Group, Betwat locality

1) *Reticulofenestra minuta*, WZ4, 40X. **2)** *Cyclicargolithus floridanus*, WZ4, 40X. **3)** *Reticulofenestra dictyoda*, WZ4, 40X. **4)** *Toweius pertusus*, WZ4, 40X. **5)** *Reticulofenestra dictyoda*, WZ2, 40X. **6)** *Sphenolithus furcatolithoides*, WZ2, 40X. **7)** *Sphenolithus moriformis*, WZ1A, 40X. **8)** *Reticulofenestra dictyoda*, WZ1A, 40X. **9)** *Sphenolithus spiniger*, WZ1A, 40X. **10)** *Sphenolithus perpendicularis*, WZ1A, 40X. **11)** *Sphenolithus furcatolithoides*, WZ1A, 40X. **12)** *Reticulofenestra minuta*, WZ1A, 40X. **13)** *Toweius pertusus*, WZ1A, 40X. **14)** *Reticulofenestra bisecta***,** WZ1A, 40X. **15)** *Sphenolithus furcatolithoides*, WZ1, 40X. **16)** *Toweius gammation*, WZ1A, 40X. **17)** *Sphenolithus kempii*, WZ1A, 40X. **18)** *Reticulofenestra bisecta*, WZ1A, 40X. **19)** *Reticulofenestra minuta* WZ1A, 40X. **20)** *Coccolithus formosus*, WZ1, 40X. **21)** *Sphenolithus orphanknollensis*, WZ1, 40X. **22)** *Sphenolithus moriformis*, WZ1, 40X. **23)** *Pseudotriquetrorhabdulus inversus*, WZ1, 40X. **24)** *Toweius gammation*, WZ1, 40X. **25)** *Sphenolithus cuniculus*, WZ1, 40X.

DISCUSSION

As shown above in Figs.4, 5 and 6, the two important marker species, indicative of the Np15 Zone, are *Sphenolithus kempii* and *Sphenolithus perpendicularis* {*Sphenolithus perpendicularis* which show unique morphology and are moderately abundant over their notably short stratigraphic range (Shamrock, 2010)}. Their distribution within the studied sequence emphasizes the Middle Eocene age. They were found in Samples 1A to 5.

The other marker species is *Sphenolithus orphanknollensis*, which appeared in Samples 1 to 6A. It is first appearance is at the NP13 Zone, which is indicative of the Ypresian and its last appearance is at the Np15 Zone of the Lutetian. *Sphenolithus spiniger*, which appeared in a short period after *Sphenolithus orphanknollensis* at the NP14 Zone and disappeared at NP17 Zone, was found in samples 1A to 7.

Sphenolithus furcatolithoides and *Sphenolithus cuniculus* first appeared at the NP15 Zone of the Lutetian, and disappeared at the NP16 Zone. *Sphenolithus furcatolithoides* was identified in samples 1 – 7 and *Sphenolithus cuniculus* was identified in samples 1A – 5.

The partial range zone of the above species put samples 1 to 5 in the NP15 Zone of the Lutetian of the Middle Eocene (Fig.6). This zone is characteristic of the successive marlstone, shale, siltstone, sandstone and limestone in the lithostratigraphic column (Figure 3). Therefore, this part of the Naopurdan Group lies within the NP15 Zone of the Lutetian.

The occurrence of the species *Sphenolithus runus* and *Sphenolithus richteri* was recorded at the NP16 Zone of the Lutetian; each has a short range so that their first and last occurrences were located within the NP16 Zone only. In the studied section, their first appearance was recorded in samples 5 and 6. They confirm the Lutetian age of the Middle Eocene. *Sphenolithus predistentus* is another important marker species of NP16 Zone. Its first occurrence was recorded in samples 6 – 7. *Reticulofenestra westerholdii* and *Reticulofenestra erbae* also first appeared at NP16 Zone, and they were recognized at in samples 6A to 7. These five important species indicate the presence of NP16 Zone in samples 5 – 7 (Fig.6). This zone is characteristic of the marlstone and shale shown in the lithostratigraphic column (Figure 3).

Reticulofenestra dictyoda, *Reticulofenestra minuta* and *Reticulofenestra bisecta* (appeared at the Ypresian, NP13 Zone to Miocene, NN4). They are accompanied by *Blackites spinosus* and *Blackites tenuis* (appeared in the Ypresian, NP13 Zone to Rupelian, NP24 Zone). They passed through NP15 and NP16 zones in the studied samples and confirm the presence of NP15 and NP16 zones. *Toweius* spp. such as *Toweius callosus* and *Toweius spinosus* (appeared at the Late Paleocene – Early Eocene respectively and were extinct at the end of the NP14 Zone or within the NP15 Zone), but here we see radiation of this species to the beginning of the NP16 Zone. Those five species were labeled in red-dashed lines in the biostratigraphic zonation chart (Figure 6).

The results of the biostratigraphic zonation for calcareous nannofossil of this study demonstrate the presence of biozones NP15 and NP16 of the Middle Eocene/ Lutetian age (based on the biozones of Martini, 1971). This study is correlated to the foraminiferal zone of Lutetian age of Berggren *et al*., (1995) where the biozone of the calcareous nannofossil coincides with the planktonic-foraminiferal zone *Gb. Kugleri/ M. aragonensis CRZ* to *M. lehneri PRZ* (P11-P12) as shown in Fig.7.

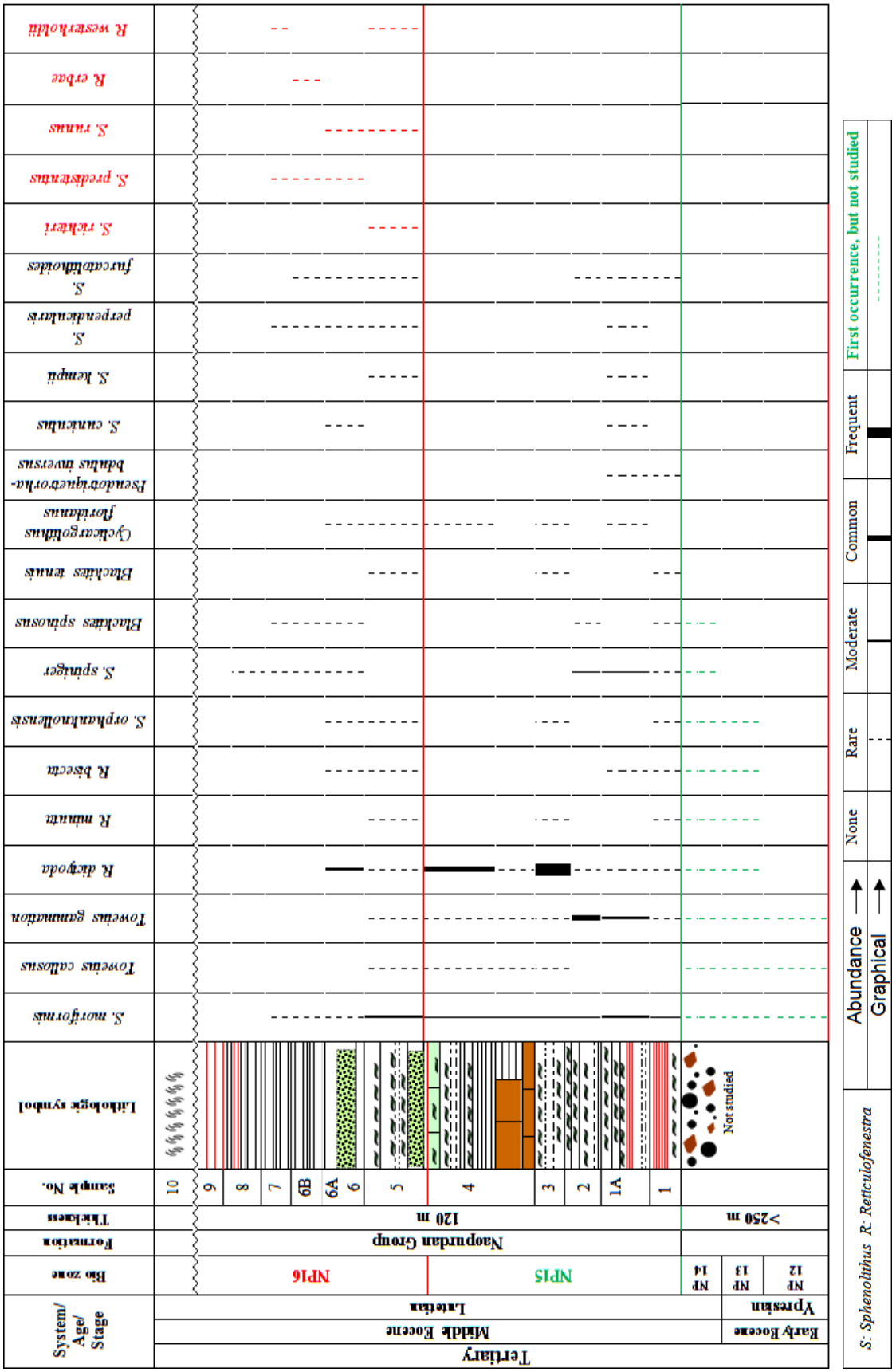

Fig.6: Calcareous nannofossil zonation chart of the section Betwat, Sulaimaniyah area

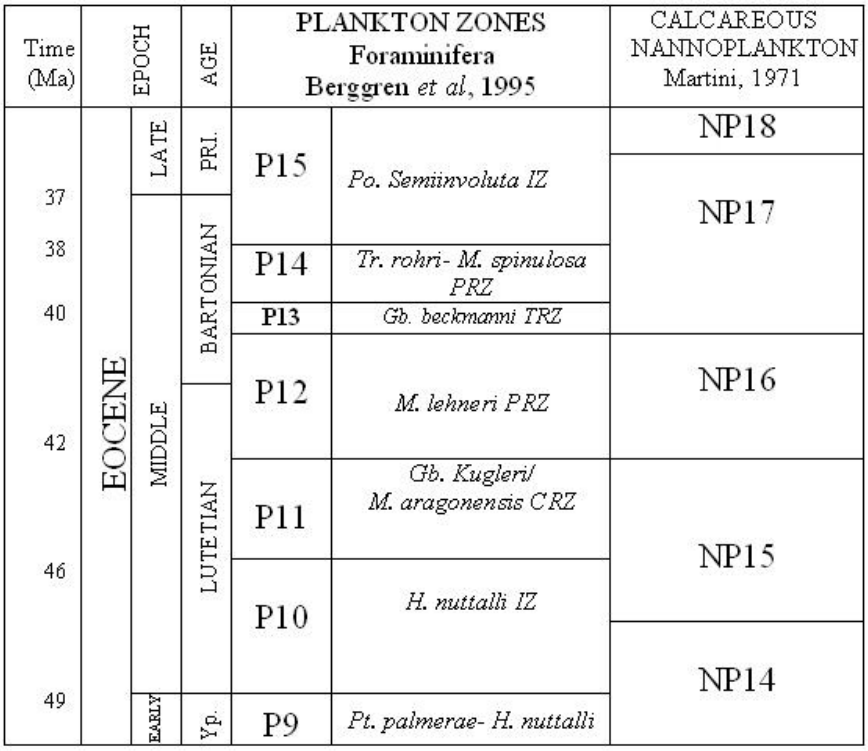

Fig.7: Eocene time scale/ Zones of planktonic foraminifera and nannoplankton (from Berggren *et al*., 1995, P.140). It shows the calcareous biozones NP15-NP16 and its equivalent planktonic- foraminiferal biozones P11-P12

The lithostratigraphic study and the calcareous nannofossil assemblages recognized in this study show that the deposition in the basin of the Naopurdan Group was gradational between the fine clastics. The studied unit can be correlated with the unnamed shale unit, limestone and volcanic rocks of Eocene age in Iran. The group can also be correlated with some parts of the Urse Formation of the Hakkari Complex in southeast Turkey, which is of Middle Eocene age and composed of shale, silty shale, metamorphosed limestone, and partly metamorphosed sandstone and shale (Jassim and Goff, 2006).

CONCLUSION

The results of the biostratigraphic analysis of calcareous nannofossil assemblages across the studied Eocene sequence of the Naopurdan Group in the Thrust Zone at Betwat locality, documents the presence of biozones NP15 and NP16 that represent the Lutetian stage of the Middle Eocene.

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