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LARGE BENTHIC FORAMINIFERAL ASSEMBLAGES FROM THE NAOPURDAN LIMESTONE (EOCENE); PALEOENVIRONMENTAL RECONSTRUCTION, KURDISTAN REGION, NORTH-EASTERN IRAQ

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Abstract

The Naopurdan Limestone unit was investigated for the first time in the Dawzhan section, Sulaimaniyah, Kurdistan Region, NE Iraq, with a focus on large benthic foraminifera. Well-preserved species of benthic foraminifera were identified as belonging to the genera *Alveolina*, *Nummulites*, *Lokhartia*, *Operculina*, *Assilina*, *Rotalia*, *Disclocyclina*, *Glomalvelina*, and *Orbitolites*. Among these, *Alveolina* stood out as the most diverse genus, encompassing fifteen species such as *Alveolina archiaci*, *A. solilda*, *A.subovata*, *A. palermitana*, *A. oblonga*, *A.*cf. *munieri*, *A. leupoldi*, *A. laxa*, *A. ilierdensis*, *A.* aff. *haymanensis*, *A. globoas*, *A. globula*, *A. elliptica*, *A. decipiens*, *A. cosigena*, and *A.* sp. A comparison of these recognized microfossils with previously reported assemblages from Iraq and other Tethyan sub-basins indicates that the deposition took place during the Eocene and corresponds to Shallow Benthic Foraminiferal Zones (SBZ 5-18). The abundance and diversity of the larger benthic foraminifera suggest that the Naopurdan Limestone Unit was formed under transgressive conditions.

Keywords: Eocene; Naopurdan Limestone Unit; Benthic Foraminifera; Dawzhan; Kurdistan Region, NE-Iraq.

1. Introduction

According to Hamza, (2023), the Naopurdan Group now known as the Naopurdan Formation is exposed in various localities in northeastern Iraq. Serra-Kiel et al., (1998) have recorded twenty Shallow Water Benthic Foraminiferal Biozones (SBZ1-20) for the Paleocene-Eocene, which include the major groups of benthic foraminifera (Alveolinids, Nummulitids, and Orthophragminids) of the Tethys. Among them, the genus *Nummulites* has high diversity at the species level with many evolutionary lineages (Hadi et al., 2019d). Large Benthic Foraminifera (LBF) exhibit an environmentally sensitive depth distribution, reproductive strategy, and morphology. Individuals residing in deeper waters typically possess a more flattened test shape

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to facilitate light penetration, whereas those in shallower waters tend to have sturdier test shapes and thicker test walls (Cotton, 2012). In the mountainous area of northeastern Iraq, a lithostratigraphic unit known as the Naopurdan Group is present in many locations. This group consists of various types of lithology, with a focus on carbonates in our study (Buday, 1980). The carbonates within the Naopurdan Limestone Unit contain a wide variety of larger and smaller foraminifera. This unit is widespread in northeastern Iraq and is considered part of the Iraqi Zagros Suture Zone (IZSZ), which includes numerous nappes, ophiolite complexes, and Paleogene sedimentary rocks (Van Bellen et al., 1959; Buday, 1980). The Naopurdan Group is further divided into two subgroups: the Naopurdan-Type Subgroup and the Sidekan-Type Subgroup. It was deposited during the Paleogene period as noted by Jassim and Goff (2006). Studies by Sharbazheri et al., (2009), and Ghafor et al., (2024), focused on the Eocene rocks in North and Northeastern Iraq, specifically examining planktic and benthic foraminifera and categorizing the Eocene sediments into various biozones. Ghafor and Baziany (2009), identified three groups of larger foraminifera (Alveolinidae, Soritidae, and Nummulitidae) in the Red Bed Series, which are likely part of the Walash−Naopurdan group. Mirza et al., (2016) conducted a study on Naopurdan limestone from Northeastern Iraq, determining that it is of Middle Eocene age. Ali et al., (2017) reported the Eocene to Oligocene age of the Walash and Naopurdan groups in Northeastern Iraq. The Early Eocene rocks in Sinjar, Shaqlawa, and Dhouk areas were extensively studied by Al-Fattah et al., (2018, 2020), who utilized planktic and benthic foraminifera for age determination. Calcareous nannofossils were employed by Kharajiany (2018) to investigate the Eocene/Naopurdan age at the Betwata section in NE Iraq. Ahmad et al., (2022) conducted a study on the condensed section within the Naopurdan Group and confirmed the Lutetian age of the succession. Ghafor & Al-Qayim (2014, 2021) examined the Middle-Late Lutetian to Early Bartonian age of the Damlouk Member, in the Ratga Formation, Western Desert, Iraq, focusing on planktic foraminifera. Additionally, Al-Qayim & Ghafor (2022) assigned the Middle-Late Lutetian to Early Bartonian age to the lower part of the Damlouk Member, in the Western Desert, Iraq, based on benthic foraminifera. The most recent contributions on the Eocene Naopurdan were published by Ghafor & Muhammad (2022), Karim et al., (2022), and finally, Al-Taee et al., (2024a,b) studied the Eocene benthic foraminifera from the Sinjar area. The Dawzhan section was studied for the first time (Figure 1) and is located within the Imbricate-Thrust Zone. According to Buday (1980 and 1987), it represents a partial area where the Iranian and Arabian plates collided during the Eocene (Numan, 1997; Karim, 2005). Heron & Lees, 1943 (in Bellen et al., 1959), clarified that the name Naopurdan is a part of the Early Division of the Nappe Zone and is underlain by Cretaceous rocks and the Red Bed Series (Al-Mehaidi, 1975; Numan, 1997; Surdashy, 1997; Karim, 2005) show that the area is of Late Cretaceous and Eocene ages and is a part of the continental sides of the Iranian and Arabian plates, The main objectives of this article are to identify the foraminiferal assemblages, provide a systematic description of the benthic foraminifera and conduct a paleoenvironmental reconstruction.

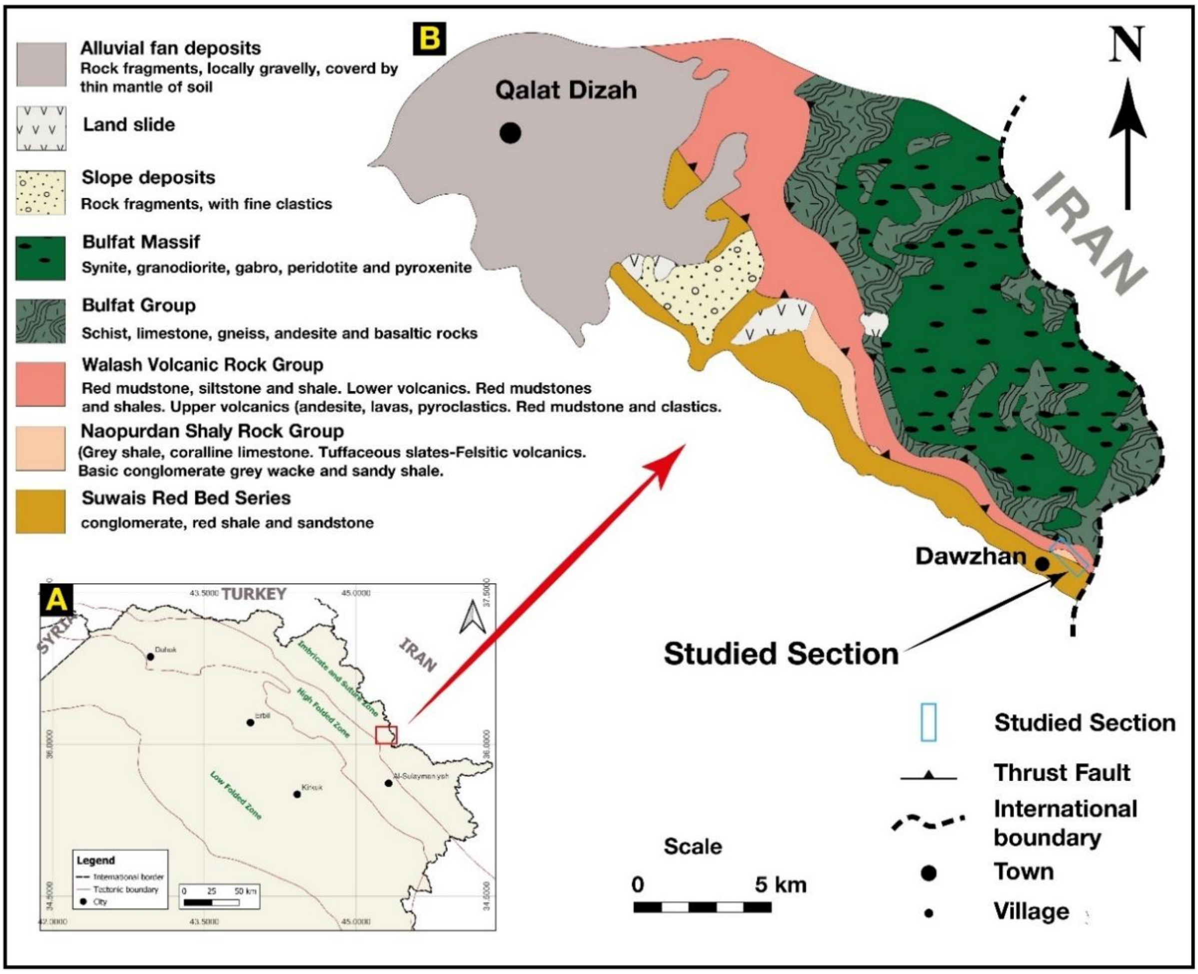

Figure 1: Map of the current study site: (A) Tectonic map of Iraq (Al-Kadhimi et al. 1996) and B) Studied area.

2. Materials and methods

The Dawzhan section was selected for this study (Figures 2 and 3). A total of 49 samples were collected from the field in the studied section. These samples were measured, described, and sampled for paleontological and petrographical studies. Each sample was examined at regular one-meter intervals using a 10X lens. Two thin sections were prepared perpendicular to each sample, numbered accordingly. Resulting in a total of 100 thin sections that were studied to analyze fossils. A binocular microscope was used at various magnifications to identify index fossils. All thin sections were documented at the University of Sulaimani. Previous studies by Seyrafian & Mojikhalifeh (2005) Gedik (2014), Roozpeykar & Moghaddam (2016), Serra-Kiel et al., (2016), and Ferrandez-Canadell & Bover-Arnal (2017) were consulted to identify benthic foraminifera.

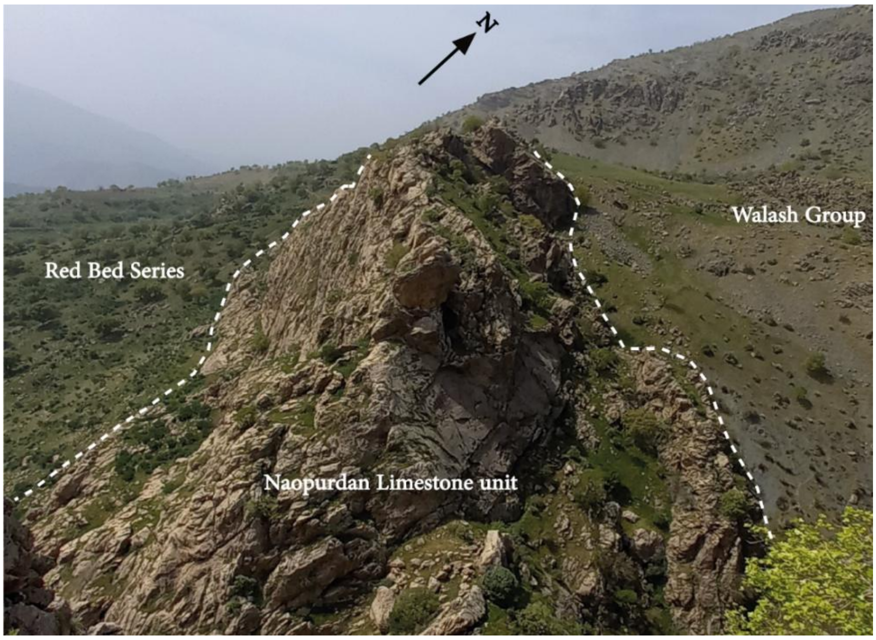

Figure 2. Field photograph showing the exposed Naopurdan Limestone unit of the studied area

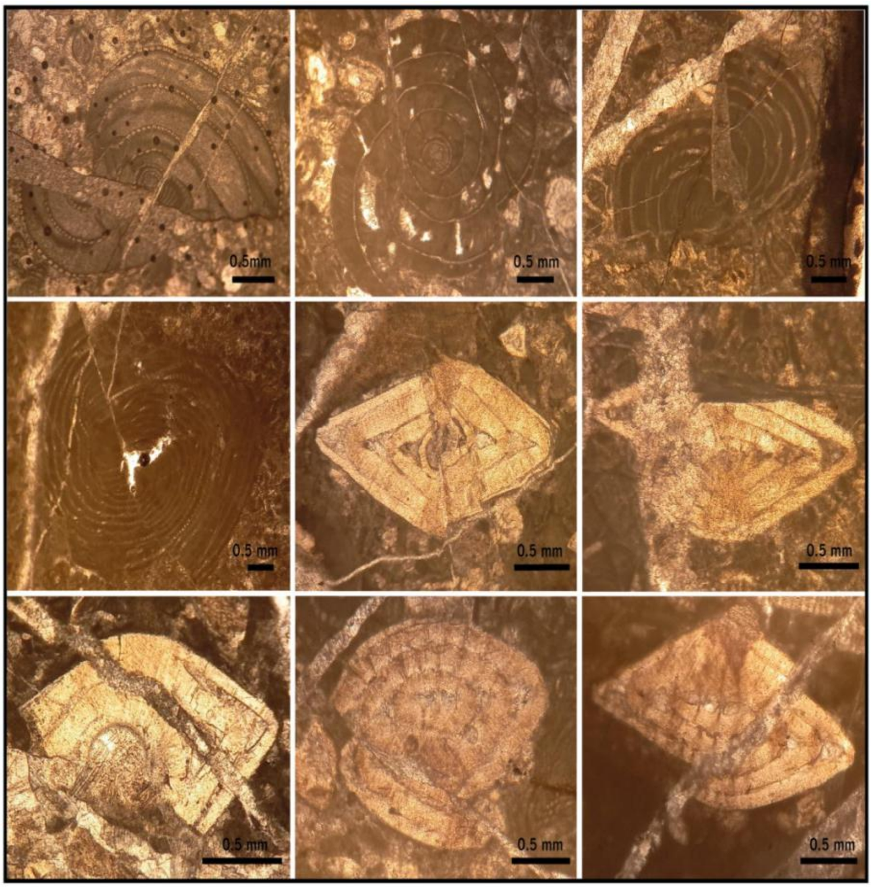

Figure 3. Field photograph showing microfossils from the Naopurdan limestone unit, including broken species, and displacement caused by high tectonic activity.

3. Results

3.1. Systematic Description and Taxonomy

Benthic foraminifera plays a crucial role in the Eocene succession. A systematic description and taxonomy of 49 species from 18 genera of benthic foraminiferas (Figures 4, 5 and 6) have been conducted based on the classification provided by (Bolli, 1957; Hadi et al., 2015 and 2016; Afify et al., 2016; Serra-Kiel et al., 2016; Boudaugher-Fadel, 2018; Hadi et al., 2019a; Hadi et al., 2019b; and Özcan et al., 2019)

Order Foraminiferida
Suborder Rotaliida Delage and Hérouard, 1896
Superfamily Nummulitoidea de Blainville, 1827
Family Nummulitidae de Blainville, 1827
Subfamily Nummulitinae de Blainville, 1827
Genus *Nummulites* de Lamarck, 1804
Nummulites subatacicus Douville, 1919
(Figure 4A)

2007 *Nummulites atacicus* Leymerie, Mirza, pl. 63-67, figs. a, b.
2013 *Nummulites atacicus* Leymerie, Zhang et al., p. 1437, fig. 9.6-8.

Nummulites subatacicus is typically the mesospheric form originating from *Nummulites atacicus*. It is characterized by a regularly opening spire with straight to inclined septa and was recorded in Sample 40. The age of this species is Early Eocene (Ypresian) according to Ahmad (2011). However, in this study, it was recorded from the Bartonian age.

Nummulites djokdjokartae Martin, 1881
(Figure 4B)

2002 *Nummulites djokdjokartae* Martin, Renema, p. 248-251, fig. 6.7, pl. 6, figs. a-b, g-j.
2014 *Nummulites djokdjokartae* Martin, Mirza *et al.*, pl. 77, fig. b; pls. 78-81, figs. a, b.

The test of *Nummulites djokdjokartae* is lenticular with a sharp edge, strongly biconvex, and has a large proloculus. The illustrated specimen is from the sample (34). Its age is Middle-Late Eocene according to Gupta (1965). In this study, this species was recorded from the Lutetian age.

Nummulites fabianii (Prever, 1905)
(Figures C and D)

2021 *Nummulites fabianii*, Kamran et al., p. 32, figs. 4a-c
2022 *Nummulites fabianii*, Ahmad et al., p. 57, fig. 4f.

The morphology of *Nummulites fabianii* is lenticular-flattened with a large proloculus, and the ornamentation consists of reticulate septal filaments and numerous granules. Illustrated specimens are from samples 39 & 42. Its range is Priabonian according to Bukhari et al. (2016), Almansinia (2017), Boudaugher-Fadel (2018), and Rashidi et al. (2024), and in this study, it was recorded from the Bartonian age.

Nummulites globulus Leymerie, 1846
(Figures E-G)

2018 *Nummulites globulus* Leymerie, Amirshahkarami and Zebarjadi, pl.3.
2022 *Nummulites globulus* Leymerie, Ahmad et al., p. 57, fig. 4g.

The shell of *Nummulites globulus* is small and biconical in shape, with a subacute to acute axial periphery. The spiral view is tight and compact in the first five whorls, gradually opening up more regularly in the later whorls. The illustrated specimens are from Samples 33, 42, and 46. *N. globulus* is extended to the Eocene age (Al-Sayigh, 1999; Afzal, 2011; Al-Dulaimi & Al-Dulaimi, 2017). However, this species from this study was recorded from the Ypresian-Bartonian age.

Nummulites partschi De la Harpe, 1880
(Figure 4H)

1996 *Nummulites partschi*, De La Harpe, Tosquella & Serra-Kiel, 1996, p. 57, pl. 7.
2009 *Nummulites partschi*, De La Harpe, Boukhary et al., p. 8, figs. 1-19; pl. 1.

The test of *Nummulites partschi* is lenticular, a more or less inflated shape with truncated or rounded poles The illustrated specimen is from Sample 39. According to Schaub (1981) and Boukhary et al. (2013), its age is Ypresian. In this study, it was observed to be from the Bartonian age.

Genus *Assilina* d'orbigny, 1839
Assilina granulosa d'Archaic, 1847
(Figure 4I)

1959 *Assilina granulosa* d'Archaic, Nagappa, Micropal. Vol. 5, No. 2, p. 189, pl. 8, figs. 4-6.
2019 *Assilina granulosa* D' Archiac, Daoud, p. 69, fig. 8.3

Assilina granulosa is characterized by a flat test, and lenticular shape with a large size, and a relatively thin, smooth center and sharp margins. The illustrated specimen is from Sample 36. According to Nagappa (1959), Weiss (1993), and Boudagher-Fadel (2008), its age is Early Eocene, while (Wan, 1990; Ahmad, 2011; Almansinia, 2017), assigned it to Ypresian-Lutetian, while (Mirza, 2007), assigned it as Eocene. In this study, this species was recorded from the Ypresian-Lutetian age.

Family Orthophragminidae Wedekind, 1937
Subfamily Discocyclininae Galloway, 1928
Genus *Discocyclina* Gumbel, 1870
Discocyclina archiaci Schlumberger, 1903
(Figure 4J)
1903 *Orthophragmina archiaci* Schlumberger, Soc. Geol. France, Bull., ser. 4, vol. 3, p. 277, pl. 8, figs. 5-7, 11, text fig. c.
2013 *Discocyclina archiaci bartholomei* Schlumberger, Egger et al., fig. 6a.

Discocyclina archiaci is a flat species without ribs, characterized by coarse pillars that are evenly distributed in the umbonal region. The illustrated specimen is from sample 45, and dated to the Early-Late Eocene according to Samanta (1965), Ozcan et al. (2006), Zakrevskaya, Stupin, and Bugrova (2009), Özcan et al. (2010, 2015, 2016, 2022), and Hadi et al. 2019b), Specifically alling into the Early Eocene period (Serra-Kiel et al., 1998). In this study, it was identified as being from the Bartonian age.

Discocyclina ranikotensis Davies, 1927
Discocyclina dispansa Sowerby, 1840
(Figure 4K)

2007 *Discocyclina dispansa* (Sowerby), Mirza, pls. 109-110, figs. a, b.
2021 *Discocyclina dispansa* Sowerby, Kamran et al., p. 33, fig. 5m.

Discocyclina dispansa is characterized by small to large size, flat to saddle-shaped, test with no ribs and archaic-type auxiliary chamberlets. The embryo is seminephro- to trybiololepidine, and the Protoconch is subspherical in shape. The illustrated specimens are from Sample 36. The oldest occurrence of *Discocyclina dispansa* was first recorded in the late Paleocene (late Thanetian) and extends to the Late Eocene (Priabonian) as studied by Serra-Kiel et al. (1998) and Afzal (2011), it was described by the Early Eocene, while (Boudagher-Fadel, 2008; Bukhari et al., 2016; Almansinia, 2017) assigned it to the Middle Eocene, and (Samanta, 1965; Wan, 1990) pointed out the range from Middle-Upper Eocene. In this study, this species was recorded from the Lutetian-Bartonian.

Order Miliolida Delage and Hérouard, 1896
Superfamily Alveolinoidea Ehrenberg, 1839
Family Alveolinidae Ehrenberg, 1839
Genus *Alveolina* d'Orbigny, 1826
Alveolina cosigena Drobne, 1977
(Figures 4 M-O)

1988 *Alveolina cosigena* Drobne, Hottinger & Drobne, pl. 2.
2007 *Alveolina cosigena* Drobne, Mirza, pls. 44-52, figs. a, b.

Alveolina cosigena has a small test, oval to subspherical in shape. The spherical-subspherical proloculus has a diameter ranging from 0.09 to 0.13 mm. The illustrated specimens are from Samples 32, 33 & 40. Mirza (2007) assigned a wide range for this species as Eocene, while (Serra-Kiel et al., 1998; Hadi et al., 2020b) restricted the species to the Ypresian age, in this study, this species from the Dawzhan section was recorded to range from the Ypresian to the Bartonian age.

Alveolina decipiens Schwager, 1883
(Figure 4P)

1883 *Alveolina decipiens* Schwager, pl. III (XXIV), fig. 1.
2020a *Alveolina decipiens* Schwager, Hadi et al., pl. 1, fig. 9.

Alveolina decipiens is characterized by a small size, spherical, oval, and slightly elongated form with dimensions of an axial diameter of 1.8 mm and an equatorial diameter of 1.5-1.8 mm. The illustrated specimen is from Sample 37. According to many authors, its age is Ypresian (Boukhary et al., 2013; Hadi et al., 2019a; 2019b; 2020b; 2021b). This study was recorded from the Lutetian age.

Alveolina elliptica Sowerby, 1840
(Figures 4 Q and R)

1972 *Alveolina elliptica* (Sowerby), Al-Hashimi, p. 338, pl. 4, figs. 2-5.
2007 *Alveolina elliptica* (Sowerby), Mirza, pl. 27-31, figs. a, b.

Alveolina elliptica described by wall porcellaneous, imperforate, medium-sized shell has an elongated-oval shape. The illustrated specimens are from Sample 46. This species has been identified by several authors in various biostratigraphic ranges. Amirshahkarami & Zebarjadi (2018) and Hadi et al. (2019c, 2019b, and 2020a) Found this species in the Ypresian age. According to Wan (1990), Mirza (2007), and Ahmad (2011). In this study, this species was recorded from the Ypresian-Bartonian age.

Alveolina globosa Leymerie, 1846
(Figure 4S)

1988 *Alveolina subpyrenaica var. globosa pars*., Hottinger & Drobne, pl. 1.
2021a *Alveolina globosa* Leymerie, Hadi et al., pl. 4, figs. 7-10; table 1.

Alveolina globosa has a small-sized spherical to elliptical porcellaneous imperforate wall as illustrated in the specimen from Sample 45. This species is recorded in the late Paleocene according to Ghafor and Baziany (2009). The Early Eocene was designated as the age of this species according to Hottinger (1960), Drobne et al. (2011), Boukhary et al. (2013), Amirshahkarami & Zebarjadi (2018), Boudagher-Fadel & Price (2021), and Hadi et al. (2021a). In this study, the distribution of this species was observed from the Bartonian age.

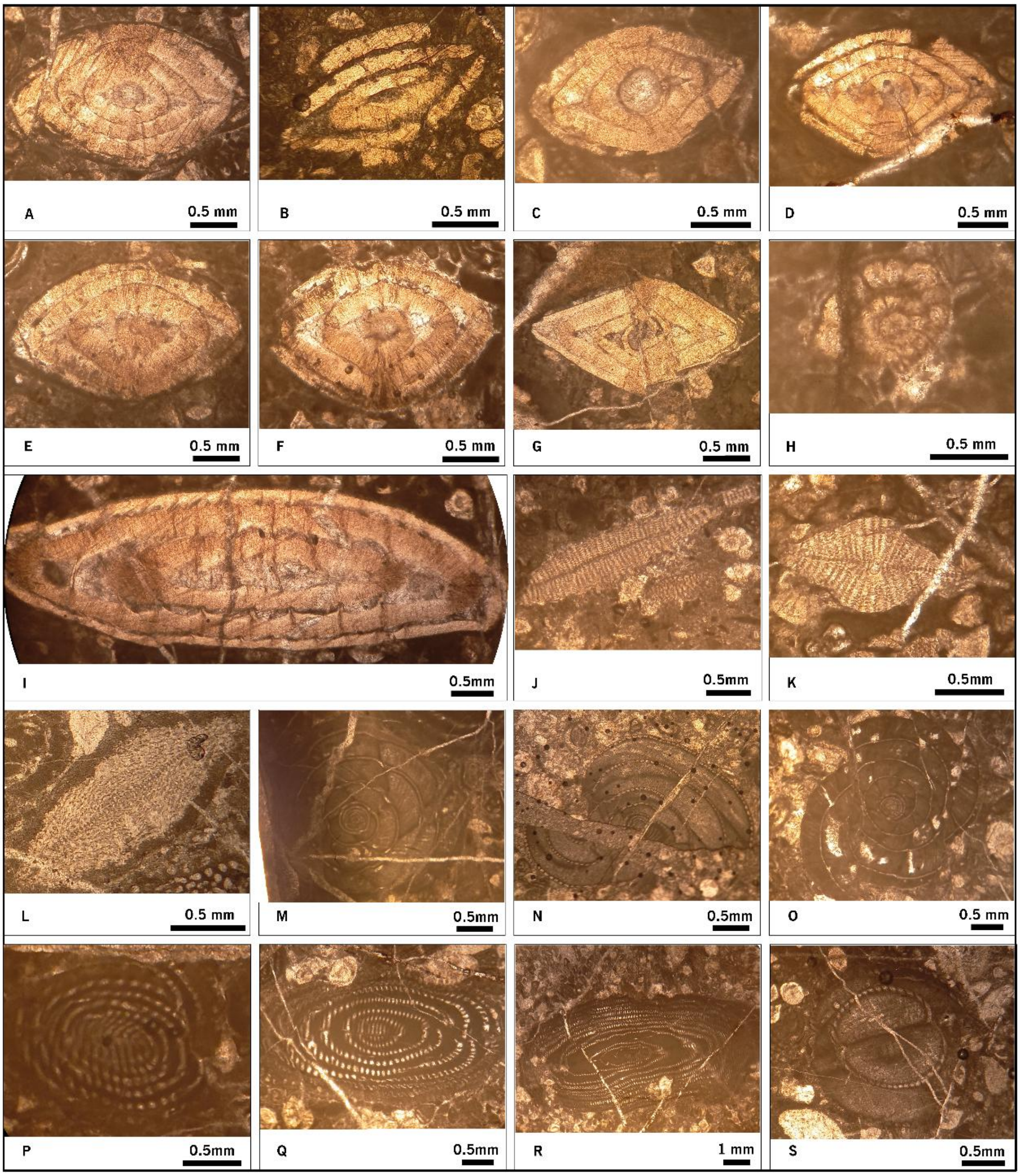

Figure 4. A) *Nummulites subatacicus*, axial section, sample no.40; B) *N. djokdjokartae*, sub-axial section, sample no. 34; C) *N. fabianii*, axial section, sample no. 42; D) *N. fabianii*, sub-axial section, sample no. 39; E) *N. globulus*, sub-axial section, sample no. 42; F) *N. globulus*, sub-axial section, sample no. 46; G) *N. globulus*, sub-axial section, sample no. 33; H) *N. partschi*, Sub-equatorial section, sample no. 39; I) *Assilina granulosa*, axial section, sample no.36; J) *Discocyclina archiaci*, sub-axial section, sample no. 45; K-)*D. dispansa*, axial section, sample no. 36; L) *Lepidocyclina* sp., oblique axial section, sample no. 48; M) *Alveolina cosigena*, axial section, sample no. 33; N) *A. cosigena*, axial section, sample no. 32; O) *A. cosigena*, axial section, sample no. 40; P) *A. decipiens*, axial section, sample no. 37; Q & R) *A. elliptica*, axial section, sample no. 46; S) *A. globose*, axial section, sample no 45.

Alveolina globula Hottinger, 1960
(Figures 5 A and B)

1988 *Alveolina subpyrenaica var. globosa pars*., Hottinger & Drobne, pl. 1.
2011 *Alveolina globula*, Ahmad, p. 226 & 228, fig. 7.2a; fig. 7.3d

The test of *Alveolina globula* is small, spherical, or slightly subspherical. The illustrated specimens are from Samples 33 & 41. This species was reported from Ypresian according to Hottinger (1960), Serra-Kiel et al. (1998), Ahmad (2011), and Hadi et al. (2020b and 2021a). In this study, this species was recorded from the Ypresian-Bartonian age.

Alveolina oblonga d'Orbigny, 1826
(Figure 5D)

1826 *Alveolina oblonga* d'Orbigny, 1826, figs. 28, 30, and 31.
2020a *Alveolina oblonga* d'Orbigny, Hadi et al., pl. 2, fig. 8.

Alveolina oblonga is characterized by subcylindrical to elliptical test, wall porcellaneous, and imperforate. The illustrated specimens are from Sample 29. The age of *Alveolina oblonga* is early Eocene (Ypresian) according to Boudagher-Fadel (2008), Almansinia (2017), and Amirshahkarami and Zebarjadi (2018). Ghafor & Baziany (2009) reported from the Middle Eocene. In this study, this species was recorded from the Ypresian-Bartonian age.

Alveolina aff. Haymanaensis Sirel, 1976
(Figure 5E)

2007 *Alveolina haymanaensis* Sirel 1976, Özgen-Erdem et al., fig. 9b
2019b *Alveolina haymanaensis* Sirel, Hadi et al., fig. 7.9

Generally the test of *Alveolina aff. Haymanaensis* is small and of oval shape. The illustrated specimens are from Sample 29. *Alveolina haymanaensis* was defined in the Ypresian by Hadi et al. (2019b, 2020b, and 2020a). In this study, this species was recorded from the Ypresian age.

Alveolina ilerdensis Hottinger, 1960
(Figure 5F)

2007 *Alveolina ilerdensis* Hottinger, Özgen-Erdem et al., fig. 6h.
2016 *Alveolina ilerdensis* Hottinger, Hadi, Mossadegh, et al., pl. 5, fig. 3.

The specimens of *Alveolina ilerdensis* are generally small to medium in size, oval to subcylindrical in shape with rounded to pointed poles. The illustrated specimens are from Sample 32. In the Dawzhan section. *A. ilerdensis* was reported from Ypresian by Hadi et al., (2019a) Hadi et al. (2020b), and Hadi et al. (2021a). In this study, it was recorded from the Ypresian age.

Alveolina laxa Hottinger, 1960
(Figure 5G)

2007 *Alveolina laxa* Hottinger, Özgen-Erdem et al., p. 920, text-fig. 7e; p. 921,
2021a *Alveolina laxa* Hottinger, Hadi et al., pl. 5, fig. 2; table 1.

The test of *Alveolina laxa* is small in size, ovoid, and rounded in shape with slightly truncated poles. The illustrated specimen is from Sample 46. The age of this species was described as Early Eocene (Ypresian) according to Hadi et al. (2015 and 2016) and Boudagher-Fadel & Price (2021) In this study, this species was recorded from the Ypresian-Bartonian age.

Alveolina leupoldi Hottinger, 1960
(Figure 5H)

2016 *Alveolina leupoldi* Hottinger, Özcan et al., pl. 21, fig. 5.
2021 *Alveolina leupoldi* Hottinger, Boudagher-Fadel & Price, pl. 4.

Alveolina leupoldi is characterized by a spherical with a diameter ranging from 3.4 mm. -3.9 mm. The illustrated specimens are from Sample 45. This species was described in the Early Eocene (Ypresian) by (Hottinger, 1960; Drobne et al., 2011; Özcan et al., 2016; Boudaugher-Fadel, 2018; Boudagher-Fadel & Price, 2021). In this study, this species was recorded from the Bartonian age.

Alveolina palermitana Hottinger, 1960
(Figure 5I)

1990 *Alveolina palermitana* Hottinger, Wan, pl. 1, figs. 19-20
2021 *Alveolina palermitana* Hottinger, Boudagher-Fadel & Price, pl. 5, fig. 7.

Alveolina palermitana has a subspherical to oval shape and is of small size, with flosculinized specimens with axial lengths ranging between 2 – 2.8 mm and equatorial diameters ranging between 1.9-2.4 mm. The illustrated specimen is from Sample 38. This species was first recorded during the Middle Eocene age (Hottinger, 1960; Boudaugher-Fadel, 2018; Boudagher-Fadel & Price, 2021) while Wan (1990)assigned it to the Early-Middle Eocene. In this study, this species was recorded from the Lutetian-Bartonian age.

Alveolina subovata Wan, 1990
(Figure 5J)

1990 *Alveolina subovata* sp. nov. Wan, pl. 1, figs. 21-27
2018 *Alveolina subovata* Wan, Amirshahkarami & Zebarjadi, p. 5, pl. 2, figs. 3, 5.

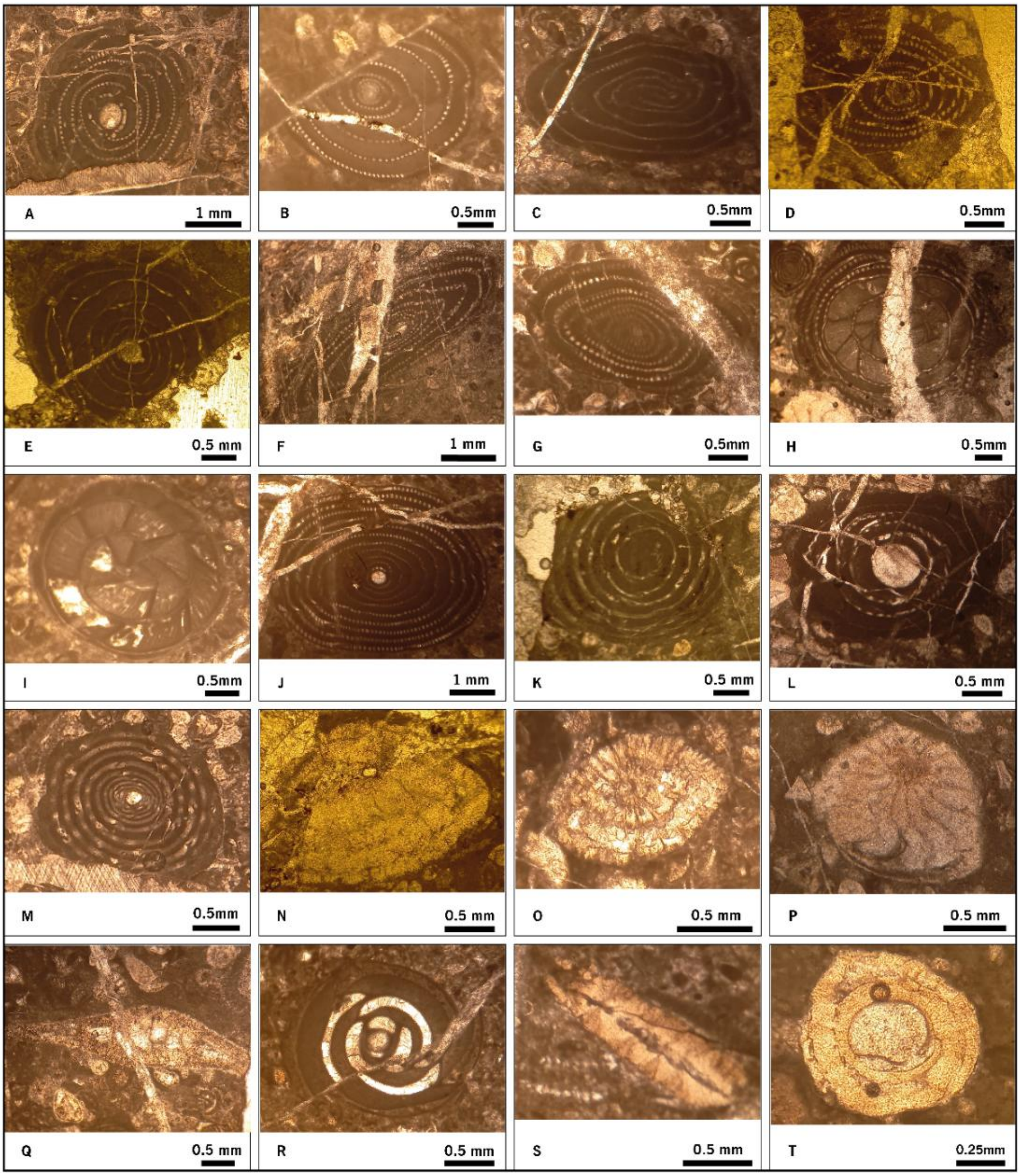

Figure 5: A) *Alveolina globula*, axial section, sample no. 33; B) *A. globula*, axial section, sample no. 41; C) *A.cf. munieri*, sample no. 38; D) *A. oblonga*, sample no. 29; E) *A.* aff. *haymanaensis*, axial section, sample no. 29; F) *A. ilerdensis*, axial section, sample no. 32; G) *A. laxa*, axial section, sample no. 46; H) *A. leupoldi*, axial section, sample no. 45; I) *A. palermitana*, axial section, sample no. 38; J) *A. subovata*, axial section, sample no. 45; K) *A. solida* Hottinger, sub-equatorial section, sample no. 29; L) *A. solida*, axial section, sample no. 36; M) *Glomalveolina lepidula*, axial section, sample no. 40; N) *Lockhartia conditi*, oblique section, sample no. 29; O) *L.* cf. *conditi* oblique section, sample no. 38; P) *L. hunti*, oblique to equatorial section, sample no. 47; Q) *Linderina chapmani*, axial section, sample no. 43; R) *Periloculina* sp., equatorial section, sample no. 35; S) *Trinocladus* sp., sample no. 35; T) Coral, sample no.33.

In the axial section, the test of *Alveolina subovata* is small to medium in size, oval to elliptical, and spherical proloculus. The illustrated specimen is from Sample 45. According to Amirshahkarami and Zebarjadi (2018), the age of *Alveolina subovata* is lower Eocene (Ypresian), while Wan (1990) reported a wide biostratigraphic range from Early- Middle Eocene. In this study, this species was recorded from the Bartonian age.

Alveolina solida Hottinger, 1960
(Figures 5 K and L)

2011 *Alveolina solida* Hottinger, Drobne et al., pl. 1.
2022 *Alveolina solida* Hottinger, Ahmad et al., p. 57, fig. 4e

The test of *Alveolina solida* is shaped like a sphere or oval, and it is small to medium in size. The illustrated specimens are from Samples 29 & 36. Early Eocene (Ypresian) was assigned to the age of this species according to Hottinger (1960) and Boudagher-Fadel & Price (2021). In this study, this species was recorded from the Ypresian-Bartonian age.

Genus *Glomalveolina* Hottinger, 1960
Glomalveolina lepidula (Schwager, 1883
(Figure 5M)

2005 *Glomalveolina lepidula* (Schwager), Özgen-Erdem et al., p. 413, fig. 10b.
2011 *Glomalveolina lepidula* (Schwager), Afzal, pl. 11, figs. 11-13.

Glomalveolina lepidula is characterized by a small test, and oval with tight coiling. The illustrated specimen is from Sample 40. According to many authors, the age of *Glomalveolina lepidula* is Early Eocene (Hottinger, 1960; Serra-Kiel et al., 1998; Afzal, 2011; Radoičić and Özgen-Erdem, 2014; Özcan et al., 2016; Bozkurt & Gormus, 2019; Boudagher-Fadel & Price, 2021). In this study, the species was recorded from the Bartonian age.

3.2. Benthic foraminiferal ranges

The studied sequence is 48 m thick and contains an enrichment of large benthic foraminiferal assemblages. There are 49 species belonging to 18 genera of benthic foraminifera and other microfossils present in the studied section (Figures 4 and 5). The geological range of the recognized benthic foraminifera has been extended from the Ypresian to the Bartonian age (Figure 6).

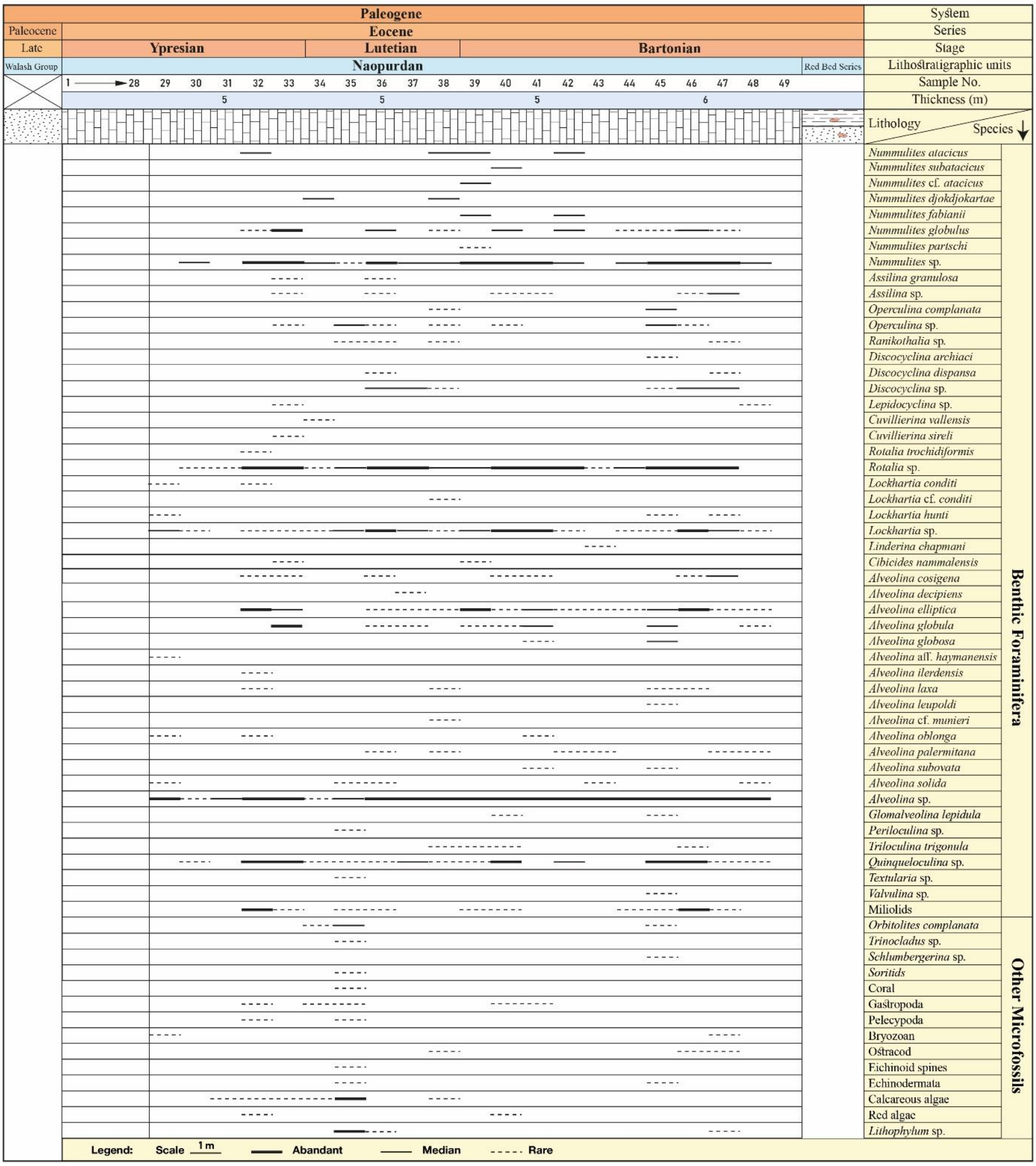

Figure 6: The distribution of microfossils in the Naopurdan Limestone unit was examined in the studied section.

3.3. Stratigraphical and paleoenvironmental interpretation

Well-preserved species of benthic foraminifera have been identified in the rock samples of the limestone unit in the studied section. These species belong to the genera *Alveolina*, *Nummulites*, *Lokhartia*, *Operculina*, *Assilina*, *Rotalia*, *Disclocyclina*, *Glomalvelina* and *Orbitolites*. *Alveolina* is the main and most important microfossil in this study represented by fifteen species of benthic foraminifera including:- *Alveolina archiaci*, *A. solilda*, *A. subovata*, *A. palermitana*, *A. oblonga, A. cf. munieri, A. leupoldi, A. laxa, A. ilierdensis, A. aff. haymanensis, A. globoas, A. globula, A. elliptica, A. decipiens, A. cosigena,* and *A.* sp., as well as *Lokhartia, Operculina, Assilina,* and *Orbitolites.* These species prefer environments deeper than approximately 80m under the sea, specifically outer-shelf areas. The limited presence of a small number of alveolinid taxa in shallow-depth habitats may be due to their transport along the shelf slope (Okur and Kutluk, 2020). The diversity of the fossil contents and their position in the section may indicate a middle shelf setting, extending down to depths of 40–80 m in the upper photic zone. According to Hottinger (1960), Tosquella (1995), and Drobne et al. (2011), alveolinids typically live at a depth of about 60 m., while other genera, such as *Nummulites*, *Assilina,* and *Orbitoites,* are known to inhabit environments deeper than approximately 80m in the lower shelf.

4. Discussion

The Naubordnian Limestone unit is situated above the Paleocene Red Bed Series and is part of the Walash Group, as noted by (Van Bellen et al., 1959). They discovered that the depositional sediments of the Iraqi red-bed basin were oriented from northwest to southwest, with a continental block to the northeast. The Dawzhan section, our study area, is rich in foraminifera particularly large benthic foraminifera, along with other microfossils such as coral, algae, and echnoid spines. The age of the Naopurdan limestone units ranges from the Ypresian to the Bartonian as determined by key index fossils of benthic foraminifera genera like *Alveolina oblonga* and *Nummulites djokdjokartae*, which are characteristic of the Ypresian age (Ghazi et al., 2010; Hadi et al., 2021a; Okur and Kutluk, 2020; Al-Juboury et al., 2021; Ghafor & Muhammad, 2022; Al-Taee et al., 2024; Rashidi et al., 2024). Associated with these benthic foraminifera, are *Alveolina laxa, A.globula, A.regularis, A. globosa, A. pastillicata, A. pissiformis, A. rakoveci gueroli, A. sirelii, Nummulites fraasi, N. solitaries, N. minutus, Lockhartia tipperi Davies, L. conditi,* and *Nummulites fabiani Alveolina leupoldi-Alveolina elliptica* have been identified from the Early Bartonian (Saraswati et al., 2012; Kövecsi et al., 2015; Ghafor & Muhammad, 2022). It is also interpreted that the distribution of alveolinids in the Dawzhan section of the studied area is limited to the platform of the basin in the upper photic zone.

5. Conclusions

The Naopurdan Group in the studied area is rich in various species of benthic foraminifera genera, including:- *Nummulites* spp.; *Alveolina* spp.; *Assilina* spp.; *Discocyclina* spp.; *Epicyclical* sp.; *Rotalia* spp.; *Triloculina* sp.; *Textularia* sp.; *Quinqueloculina* sp.; *Lockhartia* spp.; *Operculina* spp.; *Cuvillierina* spp.; *Linderina* spp.; *Orbitolites; Cibicides* sp.,; *Glomalveolina* sp.; *Periloculina* sp.; *Schlumbergerina* sp., and *Sortids* sp. Various species of microfossils, such as coral, algae, pelecypods, gastropods, bryozoans, and echinoid debris, were also identified in the Naopurdan Group. The Naopurdan Limestone unit ranges from the Ypresian to the Early Bartonian age. Ultimately, the Naopurdan Limestone Unit in the studied section was deposited under transgressive conditions.

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