New contribution to the biostratigraphy of Naopurdan limestone unit (Eocene), Bulfat area, Sulaimaniyah, Kurdistan Region, NE Iraq.

Imad Ghafor (imad.gafor@univsul.edu.iq)
University of Sulaymaniyah
Hemn Muhammad
University of Sulaymaniyah

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Abstract

Forty- nine samples were collected for a biostratigraphic study of the Naouprdan limestone unit to determine the age of its strata. The studied section is located within the Zagros High Fold and Thrust Belt. The lithology of the succession here is composed of grey fine-grain of limestone with *Nummulites* and *Alveoloina,* the whole section is highly deformed and fractured. Hence, for the first time, this limestone unit describes in detail; it is a 48 m bed of grey fine-grain, Alveolinidae-Nummulitidae limestone. It bears a frequent number of large benthic foraminifera that are concentrated within the limestone bed. It is detected within the Naopurdan succession from the Bulfat area, Sulaimaniyah, Kurdistan Region/northeastern Iraq. The identified-benthic foraminifera are of the groups: Nummulitidae; Alveolinidae; Acervulinidae; Acervulinidae; Rotaliidae; Linderinidae; Linderinidae; Hauerinidae; Textulariidae; Textulariidae. A detailed study of the benthic foraminiferal assemblages of the limestone unit revealed the occurrences of (104) species of benthic foraminifera belonging to (11) genera. The stratigraphic distribution of these species permits the recognition of four biozones. These are from the lower to upper part of the section: *Alveolina oblonga-Nummulites djokdjokartae* Interval Zone, *Nummulites djokdjokartae* Total Range Zone, *Nummulites fabiani* Total Range Zone and *Alveolina leupoldi-Alveolina elliptica* Interval Zone. This study demonstrates that the lithology of this limestone bed is equivalent to the Nummulitic Naopurdan group of the Zagros Low Fold and Thrust Belt since they have similar lithology and fossil contents. This section has not previously been described.

Introduction

Naopurdan limestone is cropped out in different localities in northeastern Iraq, among different outcrops the well-exposed and distant location is selected to study. The studied area is the Dawzhan section, which is located within Sulaimaniyah Governorate, geologically at the periphery of the Bulfat complexes. Dawzhan section, which is located 5 Km at NE of Issewa Sub-District directed to the north of Dawzhan village at latitude (N: 36° 3'0.87") and longitude (E: 45°21'10.83") nearly 68 km northwest of Sulaimaniyah city (Fig. 1).

Lithostratigraphy

The Naopurdan Group lithologically holds many varieties of rock types. They are divided into the Naopurdan-type subgroup, which comprises intercalated sedimentary and volcanic units, and the Sidekan-type subgroup, which is composed only of sedimentary rocks. The Naopurdan-type subgroup from the type locality was subdivided into six units according to Bolton (1958) from the bottom:

1. 500 m of grey shales with thin beds of green greywacke. Lenticular conglomerates (with pebbles of basic volcanic), Lenticular limestone, and sills of basic volcanic are associated with red mudstones, jaspers, limestones, and radiolarites.

2. 150 m of coralline limestone overlying by massive lenticular Nummulitic limestones capped by red shales; the *Nummulites* indicate a Paleocene-Early Eocene age.

3. 250 m of tuffaceous slates and shales with occasional basic pillow lavas.

4. 200 m of andesite volcanic, comprising lavas, agglomerates, and tuffaceous beds; this unit is laterally discontinuous.

5. 400 m of thin-bedded argillaceous conglomerates and grit, the pebbles and grains of which consist almost entirely of basic volcanic rocks.

6. An upper unit (thickness not measured) of thin-bedded, grey gritty greywacke alternating with sandy shale referred to as the Choman Clastics. The pebbles are mostly of volcanic origin. This unit is dated as the Late Paleogene-Miocene age by Bolton (1958), but he did not provide a fossil list.

The Sidekan-type subgroup was described by Cobbett (1957) on the north slopes of Jabal Hasr-i-Rust near Sidekan Town. This subgroup eas also subdivided into six units in ascending order:

1. Multicolor grit and sandstone.

2. Purple and green silty shales and marls with subordinate sandstone beds with *Nummulites* of Paleocene-Eocene age. This unit may be equivalent to the grey Shaly beds (1) of the Naopurdan-type locality

3. Black bituminous limestones with Paleocene-early Eocene fossils, Stevenson,)1957) may correlate with the coralline limestone horizon (2) of the Naopurdan-type area.

4. Reddish and greenish grits and slate with limestone and limestone breccia. These beds may correlate paLTRy with the coralline limestone horizon and paLTRy with the transitional horizon between units (1) and (2) of the type locality.

5. Naopurdan Needle Slate which may be equivalent to the slates of unit (3) of the Naopurdan type locality.

6. A Conglomerate, grit, and limestone unit. This unit is probably equivalent to the Choman clastics and of the Avdele Conglomerate.

The Naopurdan Group was deposited in a marine environment, while the Nummulitic facies are deposited as shoals. The clastic beds include turbidities and shales with planktonic foraminifera (Jassim and Goff 2006). In addition, they added the Naopurdan Shaly Group which consists predominantly of flysch with volcanic units and Nummulitic limestone lenses deposited in a fore-arc region.

Studied Section

The Naopurdan limestone unit in the Dawzhan section is reached approximately 48 meters, its color is somehow darker, the lower to middle parts of the section are free from fossils, and the limestones are very tough and fine-grained (Fig. 2). The whole section is highly deformed and fractured, this deformation as also supported by microscopic study (Fig. 3), and the section may contain some repeated intervals. a full lithological description of the Dawzhan section is described in Table (1). This study is the first attempt to study the mentioned section by means of paleontology and biostratigraphy

Table (1): Hand specimen descriptions for samples of the Naopurdan limestone unit from the Dawzhan section from bottom to top.

Sample No.	Hand Specimen Descriptions
1-2	Grey limestone, highly fractured contain styllolites, no fossils and recrystallized.
3	Milky limestone, highly fractured contain styllolites, no fossils and recrystallized.
4-8	Dark grey, brecciated highly fractured, slightly recrystallized
9	Milky recrystallized limestone, fractured, no fossils
10	Dark grey, brecciated highly fractured, slightly recrystallized
15 and 23	Grey recrystallized limestone, vuggy and fractured.
11-14, 16-22, 24-28	Light grey to grey recrystallized limestone, fractured no fossils observed.
29-31	Milky limestone, vuggy and brecciated, contain ghost of *Alveolina* and slightly recrystallized.
32	Grey limestone, highly fractured, contain ghost of Alveolina, slightly recrystallized.
33	Grey limestone fractured, contain *Nummulites*, *Alveolina*, bioclast and lithoclast.
34	Light grey fine-grain limestone with small *Nummulites*.
35-36	Grey limestone contain *Alveolina*, bioclast and lithoclast.
37	Grey limestone contains *Alveolina*, bioclast, and lithoclast, slightly recrystallized.
38-43	Grey limestone contain *Nummulites*, *Alveolina*, bioclast and lithoclast.
44	Fine grain limestone fractured and slightly recrystallized, contain ghoste of *Alveolina*
45-46	Grey limestone contain *Alveolina*, bioclast and lithoclast.
47-48	Milky limestone is highly fractured with small *Alveolina*.
49	Fine grain limestone fractured and slightly recrystallized, no fossil can be observed.

Geological Setting

The studied area is located within the Zagros Suture Zone, specifically in the Penjwen-Walash subzone (Fig. 1), and tectonically, it is very complex in terms of structure, stratigraphy, and metamorphism (Jassim and Goff 2006). They added that it represents the deformed oceanic domain of the middle part of the Neo-Tethys, which is made up of unmetamorphosed Paleogene fore-arc and volcanic arc rocks that formed during the final closure of the Neo-Tethys.

The outcrops in the study area elongate from the Iranian border near Penjwen town as a belt toward the NW which consists of sedimentary and metamorphic rocks. The metamorphism is concentrated in the central part of the Mawat and Bulfat Ophiolite complexes. These two complexes are surrounded by the Red Bed series and the Walash Naopurdan group (Al-Mehaidi 1975). The main structural features of the zone are thrust sheets sometimes dislocated by reverse faults and consist of the top Qandil (structurally highest at the top), the middle Walash, and the structurally lowest Naopurdan (Jassim and Goff 2006). Karim (2005) clarified that the Naopurdan Series has a relatively wider distribution of outcrops in the Chwarta and Mawat areas compared to the neighboring areas due to indirect evidence of the subsidence of that area. The Naopurdan group cropped-out areas are subjected to different studies in the literature, which are summarized here. Northeastern Iraq is suggested to be a nappe zone, which they divided by Heron and Lees (1943) (in Al-Mehaidi 1975) into three units: a) an anticline of Triassic limestone and shale, b) a folded mass of radiolarian chert and shale, c) a nappe of igneous and metamorphic rocks. There is a tripartite division by (Bolton 1957, in Al-Mehaidi 1975) from northeast to southwest of the thrust zone: -

1. The Thrust Zone (the igneous and metamorphic nappe of Heron and Lees), which consists of three tectonically bounded units, from bottom to top are the Naopurdan series, Walash series, and Qandil series.
2. The intermediate zone comprises the Cretaceous Qulqula series (units (a) and (b) of Heron and Lees) and the Red Beds series.
3. The Folded Zone.

Bolton's intermediate zone was separated into two divisions by Smirnov and Nelidov (1962): The Qulqula uplift and the "intermountain troughs" (The Red Beds). Buday (1973) established the following classifications according to previous studies with some field research:

1) The Thrust Zone

a-The External Zagros Suture Zone (Qulqula subzone and Walash-Naopurdan subzone)

b-The Internal Zagros Suture Zone (equivalent to the Qandil series of Bolton)

2-The Imbricated Zone (including the Red Beds and the most northeastern part of the Fold Zone).

The outcrops of the Naopurdan Group extend into Iran where they are mapped as thrust sheets of an unnamed unit of shale and limestone with volcanic rocks of Eocene age. In SE Turkey,
the group can be correlated with parts of the 2000 m Urse Formation of the Hakkari Complex. It may also correlate with the Cungus Formation (middle Eocene). Similarly, the Durnnkayn Formation may be equivalent to parts of the Naupordan Group (Jassim & Goff 2006). Karim & Al-Bidry (2020) explained that all exposed rocks in the Bulfat Metamorphic Core Complex consist of either fresh volcaniclastic sediments (sandstone, conglomerate, greywackes, and shale) or their regional metamorphosed equivalent rocks. According to field observation area around both studied sections appeared to be in robust agreement with the previously mentioned literature. The limestone unit of the Naopurdan Group in both sections appears to be thrust over the Walash Group.

Materials and Methods

Surveying the area and collecting data are the first step for this study. Additionally, fieldwork
and sampling are good sources for obtaining data. Dawzhan section was selected for this study, (Figs. 5 and 6). Several field trips were conducted at different times to obtain more information and accurate data about the studied area.

Totally 49
samples were collected, and each sample was inspected with a 10X hand lens. 38 samples were taken at regular intervals of one meter. Each sample was described and inspected by a 10x hand lens, from each sample, two thin sections were prepared in the perpendicular direction. The thin sections were studied under a binocular microscope to identify their foraminifera contents, and suitable pictures were taken for each index fossil using different
magnifications. All thin sections were prepared in the workshop of the Department of Geology, College of Science, University of Sulaimani. The biozonation of the foraminifera is based on (Serra-Kiel et al. 1998, 2016; Sirel and Acar 2008).

The main aims of this study are as follows:

1-To identify the foraminiferal assemblages that occur in the studied Naopurdan limestone unit.

2-to establish the biostratigraphic zones and correlate them with their equivalent biozones in and outside Iraq in order to determine the age of the studies sections

Previous Work

Since the early 1940s, research on the thrust sheet of northeastern Iraq has continued to obtain better insight into the area, and the research work of numerous authors has focused on the Naopurdan group. Bolton (1958) determined that the age of the group was proven by fossils as Paleocene-Oligocene or possibly Miocene. The limestone unit of the Naopurdan Shaly Group was originally dated using a biostratigraphic study by Al-Hashimi (1975), who estimated its age to be lower-middle Eocene. Al-Mehaidi (1975), studied the Tertiary nappes in the Mawat range and stated that this nappe is underlain by Red Bed Series and Cretaceous rocks. Early Eocene strata from the Sinjar area, NW Iraq have been studied by (Al-Shaibani et al. 1993; Ghafor 1988). According to Jassim and Goff (2006), the Naopurdan Group was deposited in the Paleogene. Surdashy (1997), determined the depositional environment of the limestone unit in the Naopurdan group from outcrops at the Chwarta and Mawat localities, depending on the microfacies and paleo communities, he recognized that this limestone unit was deposited during regression by the effect of the uplifting orogenic facies on the subduction zone of the Zagros in three major environments: a) the lower part deposited in the deep shelf margin, b) the middle part deposited in the open slope, and c) the upper part deposited in the shallow platform. Furthermore, he also proved the relationship between tectonism and sedimentation at the time of postdeposition. Ghafor and Karim (1999) studied the Eocene rocks from Northeastern Iraq. The Early to Late Danian rocks in the Shaqlawa area, NE Iraq, has described by Ghafor (2000), using spores and pollen. Ghafor and Baziany (2009), studied larger foraminifera from the former Qulqula Conglomerate Formation, Kurdistan Region, northeastern Iraq, and gave the age of the recorded fossils from upper Paleocene to middle Eocene which more likely belongs to the Walash-Naopurdan source area that was deposited during the upper Paleocene to middle Eocene. Three groups of larger foraminifera from the Red Bed Series, have been described by Ghafor and Qadir (2009) which more likely belong to Walash–Naopurdan group. Planktic and benthic foraminifera are used to study the early Eocene rocks in North and Northeastern Iraq Sharbazheri et al. (2009, 2011). Ali et al. (2017) shows that the composition of the Walash and Naopurdan clastic deposits varied systematically from Eocene to Oligocene time in response to changes in the rock types exposed to erosion in the back-arc and island arc environments prior to the closure and obduction of the Neotethys basin. Daoud (2019), during his study on the Nummulitic limestone of the Naopurdan group from the Chwarta area, recognized four depositional microfacies (Packstone, Floatstone, Boundstone, and Wackestone) and established nine levels of microfauna distribution. In addition, the new paleoenvironment of the group was determined from the subtidal to the outer ramp, also confirming the age of the late Paleocene to the middle Eocene. Karim and Al-Bidry (2020), studied the Zagros Metamorphic Core Complex from Bulfat Mountain, Qala Diza Area, Kurdistan Region, Northeast Iraq. They mentioned the absence of igneous rocks and what previously called igneous rocks are metamorphosed greywacke of Walash-Naopurdan. Al Nuaimy, et al. (2020) separated the Eocene sediments from Northeastern Iraq, based on the planktic and benthic foraminifera.

Walash and Naopurdan Groups are autochthonous sedimentary stratigraphic units that are metamorphosed regionally inside the two complexes (Karim and Ghafor 2021). Karim and Hamza (2021) considered the Walash, Kolosh, and Naopurdan groups (formations) as one sedimentary succession that was deposited in one basin during the same age and changed the name of the Walash group and Naopurdan group to the Walash Formation and Naopurdan Formation, respectively. Ahmad et al. (2022) studied the new contribution to the biostratigraphy of a foraminiferal-condensed section within the Naopurdan Group, confirming the Lutetian age of the succession and demonstrating that the lithology of this limestone/condensed section is equivalent to that of the Avanah Formation. Finally, Ghafor & Muhammad (2022) studied the microfossils and biostratigraphy of marine Eocene deposits in the Naopurdan Group, Chwarta area, and assigned the age of the group as Ypresian-early Bartonian (early to middle Eocene).

Results and discussion

Biostratigraphy

The study of 49 samples taken from the Dawzhan section, led to the identification of 104 species from 51 genera of Larger Benthic Foraminifera (LBF) and other microfossils such as Echinoid fragments, bryozoans, red algae, green algae, bivalve fragments, coral, gastropods, and pelecypods (Fig. 7, plates 1, 2). Based on the larger benthic foraminifera, which appeared in relatively high variety and very abundant, four biostratigraphic zones were identified, from the lower part of the Dawzhan section, there is no evidence of fossils present, which may be due to recrystallization because the section is located in the high tectonic activity zone, the recognized biozones are described below, starting from older to younger:

1- Alveolina oblonga-Nummulites djokdjokartae Interval Zone.

Definition

Biostratigraphic interval of this zone characterized by the interval of the nominate taxa (*Alveolina oblonga* d'Orbigny, 1826 and *Nummulites djokdjokartae* Martin, 1881) Boundaries: The lower boundary of this zone is marked by the First Appearance Datum (FAD) of *Alveolina oblonga*, whereas its upper boundary is marked by the First Appearance Datum (FAD) of *Nummulites djokdjokartae.*

Remarks: The thickness of this zone is equal to 5m from samples 29 to 33 (Fig. 4.2). The most diagnostic species include *Nummulites atacicus* Leymerie, 1846, *Nummulites globulus* Leymerie 1846, *Nummulites* sp., *Assilina granulosa* d'Archaic, 1850, *Assilina* sp., *Operculina* sp., *Lepidocyclina* sp., *Cuvillierina sirelii* Inan, 1988, *Rotalia trochidiformis* Lamarck, 1804, *Rotalia* sp., *Lockhartia conditi* Nuttall, 1926, *Lockhartia hunti* Ovey, 1947, *Lockhartia* sp., *Cibicides nammalensis* Haque, 1956, *Alveolina cosigena* Drobne, 1977, *Alveolina elliptica* Sowerby, 1840, *Alveolina globula* Hottinger, 1960, *Alveolina* aff. *Haymanaensis* Sirel, 1976, *Alveolinailerdensi s*Hottinger,1960, *Alveolina laxa* Hottinger,1960, *Alveolinaoblonga*d'Orbigny,1826, *Alveolina solida* Hottinger,1960, *Alveolina* sp., Q*uinqueloculina* sp., Miliolid sp., Gastropod, Pelecypod, Bryozoan,Calcareous algae

Correlation: This zone is equivalent to the *cucumiformis-ellipsoidalis-moussoulensis- corbarica-trempina-oblonga-dainellii-violae* Alveolinid biozone of Hottinger (1960) of the Ypresian age and correlated to the SBZ 5–12 of Serra-Kiel et al. (1998) and to the BFZK 1B - BFZK2- BFZK 3A- BFZK 3B of Ahmad (2011), who considered it of the Ypresian age. Additionally, correlated to *pernotus- burdigalensis burdigalensis- burdigalensis cantabricus- campesinus* Nummulitid biozones of Schaub (1981). It is equivalent to the *Nummulites globulus-Nummulites planulatus* zone of Ghafor and Muhammad 2022. (Table 2).

Age

Early Eocene (Ypresian).

2-*Nummulites djokdjokartae* Total Range Zone

Definition

Biostratigraphic interval of this zone is characterized by the total appearance of

Nummulites djokdjokartae Martin, 1881. Boundaries: The lower boundary of this zone is marked by the First Appearance Datum (FAD) of *Nummulites djokdjokartae*, whereas its upper boundary is marked by the Last Appearance Datum (LAD) of *Nummulites djokdjokartae*

Remarks: The thickness of this zone is equal to 5m from samples 34 to 38 (Fig. 4.2). The most diagnostic species include *Nummulites atacicus* Leymerie, 1846, *Nummulites globulus* Leymerie 1846, *Nummulites* sp., *Assilina granulosa* d'Archaic, 1850, *Assilina* sp., *Operculina complanata* Defrance in Blainville, 1822, *Operculina* sp., *Ranikothalia* sp., *Discocyclina dispansa* Sowerby, 1840, *Discocyclina* sp., *Cuvillierina vallensis* Ruiz De Gaona, 1948, *Rotalia* sp., *Lockhartia* cf. *conditi*, *Lockhartia* sp., *Alveolina cosigena* Drobne, 1977, *Alveolina decipiens* Schwager, 1883, *Alveolina elliptica* Sowerby, 1840, *Alveolina globula* Hottinger, 1960, *Alveolina globosa* Leymerie 1846, *Alveolina laxa* Hottinger, 1960, *Alveolina* cf. *munieri*, *Alveolina palermitana* Hottinger, 1960, *Alveolina solida* Hottinger, 1960, *Alveolina* sp., *Periloculina* sp., *Triloculina trigonula* Lamarck, 1804, *Quinqueloculina* sp., Textularia sp., Miliolid sp., *Orbitolites complanatus* Lamarck, 1801, *Trinocladus* sp., *Soritid*, Corals, Gastropod, Pelecypod, Ostracod, Echinoid spines, Echinodermata, Calcareous algae and *Lithophylum* sp.

Correlation: This zone is apparently equivalent to the *stipes-munieri-prorrecta* Alveolinid biozone, which is described by (Hottinger 1960), of Lutetian age, and correlated to the SBZ 13–16 of Serra-Kiel et al. (1998) to the BFZK 4- BFZK 5- BFZK 6 of Ahmad (2011), and to the to the *gallensis-obesus-beneharnensis-crasus-atauricus* Nummulitid biozones of Schaub (1981). Locally in Iraq, this zone is correlated with the *Nummulites gizehensis* zone of Al- Kubaysi (2014), to the *Hantkenina alabamensis-Acaranina bulbrooki* zone of Karim and Al-Kubaysi (2015), to the *Acaranina bulbrooki-Catapsydraz dissmilis-Morozovella lehneri* zone of Ghafor and Al-Qayim (2021) and finally to the *Nummulites gizehensis- Nummulites mouculatus* zone of Al-Qayim and Ghafor (2022), who considered it of Lutetian age. It is equivalent to the *Nummulites mamillatus-Nummulites alshahrani-Nummulites fabianii-Nummulites exponens* zone of Ghafor and Muhammad 2022 (Table 2). Age: middle Eocene (Lutetian)

3- *Nummulites fabiani* Total Range Zone

Definition

Biostratigraphic interval of this zone is characterized by the total appearance of *Nummulites fabiani*

Boundaries: The lower boundary of this zone is marked by the First Appearance Datum (FAD) of *Nummulites fabianii*, whereas its upper boundary is marked by the Last Appearance Datum (LAD) of *Nummulites fabianii*

Remarks: The thickness of this zone is equal to 5m from samples 39 to 43 (Fig. 4.2). The most diagnostic species include *Nummulites atacicus* Leymerie, 1846, *Nummulites subatacicus* Douvillé, 1919, *Nummulites* cf. *atacicus*, *Nummulites globulus* Leymerie 1846, *Nummulites partschi* de La Harpe, 1880, *Nummulites* sp., *Assilina* sp., *Operculina* sp., *Rotalia* sp., *Lockhartia* sp., *Linderina chapmani* Halkyard, 1918, *Cibicides nammalensis* Haque, 1956, *Alveolina cosigena* Drobne, 1977, *Alveolina elliptica* Sowerby, 1840, *Alveolina globula* Hottinger, 1960, *Alveolina globosa* Leymerie 1846, *Alveolina oblonga* d'Orbigny, 1826, *Alveolina palermitana* Hottinger, 1960, *Alveolina subovata* Wan, 1990, *Alveolina solida* Hottinger, 1960, *Alveolina* sp., *Glomalveolina lepidula* Schwager, 1883, *Triloculina trigonula* Lamarck, 1804, *Quinqueloculina* sp., Miliolid sp., Gastropod, and Red algae.

Correlation: This zone is apparently equivalent to the lower part of Alveolinid elongata zone described by Hottinger (1960) of early Bartonian age, correlated to the SBZ 17 of Serra-Kiel et al. (1998), and correlated to the lower part of the Nummulitid *perforatus* zone of Schaub (1981). Locally in Iraq, this zone is correlated with the lower part of Miliolids-peneroplid zone of Al- Kubaysi (2014), to the *Globigerina semiinvoluta- Hantkenina alabamensis* of Ghafor and Al- Qayim (2021), and finally, to the lower part of *Assilina spira-Lokharatia* hunti zone of Al- Qayim and Ghafor (2022), who considered it of early Bartonian age. It is equivalent to the lower part of *Nummulites fabiani- Assilina exponens* zone of Ghafor and Muhammad 2022. (Table 2).

Age: Middle Eocene (Bartonian).

4-*Alveolina leupoldi-Alveolina elliptica* Interval Zone

Definition

Biostratigraphic interval of this zone is characterized by the interval of the nominate taxa (*Alveolina leupoldi* Hottinger, 1960 and *Alveolina elliptica* Sowerby, 1840)

Boundaries: The lower boundary of this zone is marked by the Fast Appearance Datum (FAD) of *Alveolina leupoldi*, whereas its upper boundary is marked by the Last Appearance Datum (LAD) of *Alveolina elliptica.*

Remarks: The thickness of this zone equal to 6m from samples 44 to 49 (Fig. 4.2). The most diagnostic species include *Nummulites globulus* Leymerie 1846, *Nummulites* sp., *Assilina* sp., *Operculina complanata* Defrance in Blainville, 1822, *Operculina* sp., *Ranikothalia* sp., *Discocyclina archiaci* Schlumberger, 1903, *Discocyclina dispansa* Sowerby, 1840, *Discocyclina* sp., *Lepidocyclina* sp., *Rotalia* sp., *Lockhartia hunti* Ovey, 1947, *Lockhartia* sp., *Alveolina cosigena* Drobne, 1977, *Alveolina elliptica* Sowerby, 1840, *Alveolina globulina*

Hottinger, 1960, *Alveolina globosa* Leymerie 1846, *Alveolina laxa* Hottinger, 1960, *Alveolina leupoldi* Hottinger, 1960, *Alveolina palermitana* Hottinger, 1960, *Alveolina subovata* Wan, 1990, *Alveolina solida* Hottinger, 1960, *Alveolina sp*., *Glomalveolina lepidula* Schwager, 1883, *Triloculina trigonula* Lamarck, 1804, *Quinqueloculina* sp., *Valvulina* sp., Miliolid sp., *Orbitolites complanata* Lamarck, 1801, *Schlumbergerina* sp., Bryozoan, Ostracod, Echinodermata and *Lithophylum* sp.

Correlation: This zone is apparently equivalent to the upper part of Alveolinid elongata zone described by Hottinger (1960) of early Bartonian age, correlated to the SBZ 18 of Serra-Kiel et al. (1998), and correlated to the upper part of Nummulitid *perforatus* zone of Schaub (1981). Locally, in Iraq, this zone is correlated with the upper part of Miliolids-peneroplid assemblage zone of Al-Kubaysi (2014), and finally to the upper part of *Assilina spira- Lokharatia* hunti zone of Al-Qayim and Ghafor (2022), who considered it of early

Bartonian age. It is equivalent to the upper part of *Nummulites fabiani- Assilina exponens* zone of Ghafor and Muhammad 2022. (Table 2).

Age: Middle Eocene (Bartonian

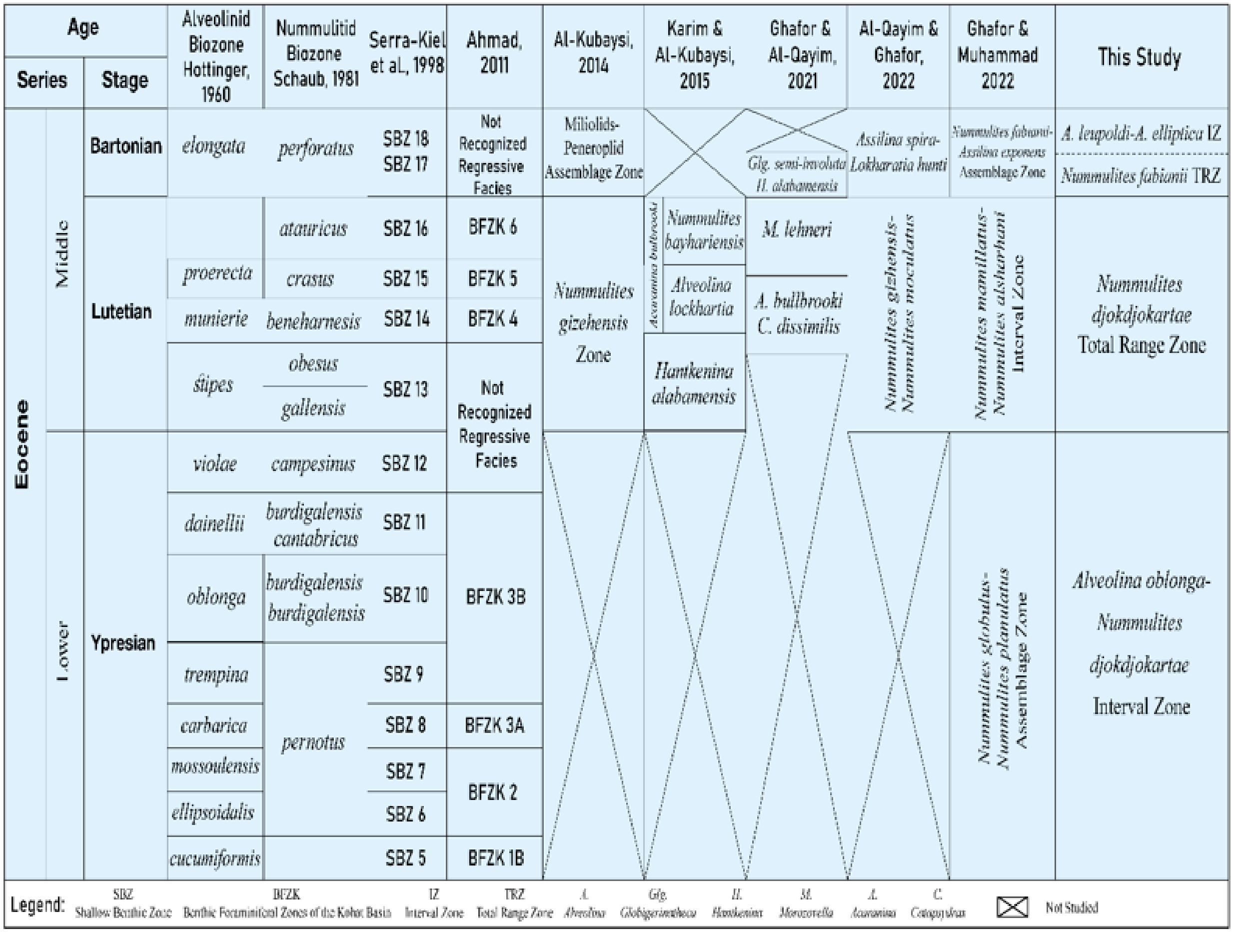
Figure (6): Biostratigraphic range chart of Benthic Foraminifera (BF), and other microfossils in the Dawzhan section.

Plate 1: A- *Nummulites subatacicus* Douvillé,1919, axial section, sample no.40; B-*Nummulites djokdjokartae* Martin, 1881, axial section, sample no. 34; C- *Nummulites fabianii* Prever, 1905, sub-axial section, sample no. 42; D- *Nummulites fabianii* Prever, 1905, sub-axial section, sample no. 39; E- *Nummulites globulus* Leymerie, 1846, sub-axial section, sample no. 42; F- *Nummulites globulus* Leymerie, 1846, sub-axial section, sample no. 46; G- *Nummulites globulus* Leymerie, 1846, sub-axial section, sample no. 33; H- *Nummulites partschi* de la Harpe, 1880, equatorial section, sample no. 39; I- *Assilina granulosa* d'Archiac, 1850, axial section, sample no.36; J- *Discocyclina archiaci* Schlumberger, 1903, oblique to axial section, sample no. 45; K- *Discocyclina dispansa* Sowerby, 1840, axial section, sample no. 36; L- *Lepidocyclina* sp., axial section, sample no. 48; M- *Alveolina cosigena* Drobne, 1977, axial section, sample no. 33; N- *Alveolina cosigena* Drobne, 1977, axial section, sample no. 32; O- *Alveolina cosigena* Drobne, 1977, axial section, sample no. 40; P- *Alveolina decipiens* Schwager 1883, axial section, sample no. 37; Q-R- *Alveolina elliptica* Sowerby, 1840, axial section, sample no. 46; S-*Alveolina globose* Leymerie, 1846, axial section, sample no 45.

Plate 2: A- *Alveolina globula* Hottinger, 1960, axial section, sample no. 33; B- *Alveolina*

globula Hottinger, 1960, axial section, sample no. 41; C- *Alveolina* cf. *munieri* axial section, sample no. 38; D- *Alveolina oblonga* d'Orbigny, 1826, axial section, sample no. 29; E- *Alveolina* aff. *haymanaensis* Sirel, 1976, axial section, sample no. 29; F- *Alveolina ilerdensis* Hottinger 1960, axial section, sample no. 32; G- *Alveolina laxa* Hottinger, 1960, axial section, sample no. 46; H- *Alveolina leupoldi* Hottinger 1960, axial section, sample no. 45; I- *Alveolina palermitana* Hottinger 1960, axial section, sample no. 38; J- *Alveolina subovata* Wan, 1990, axial section, sample no. 45; K- *Alveolina solida* Hottinger, 1960, axial section, sample no. 29; L- *Alveolina solida* Hottinger, 1960, axial section, sample no. 36; M- *Glomalveolina lepidula* Schwager, 1883, axial section, sample no. 40; N- *Lockhartia conditi* Nuttall, 1926, oblique section, sample no. 29; O- *Lockhartia* cf. *conditi* oblique section, sample no. 38; P- *Lockhartia hunti* Ovey, 1947, oblique to equatorial section, sample no. 47; Q- *Linderina chapmani* Halkyard, 1918, axial section, sample no. 43; R- *Periloculina* sp., equatorial section, sample no. 35; S- *Trinocladus* sp., axial section, sample no. 35; T- Calcareous algae, axial section,sampleno.33.

Table (2): Comparisons of zonal schemes of the studied section with other studies



Discussion

The stratigraphic succession of the Naopurdan Group at the Dawzhan area has a difference in age, the Nummulitic limestone of the Naopurdan Group is considered the lower part of the Walash Group, which overlays the Red Bed Series of the Paleocene. The depositional sediments of the Iraqi red-bed basin were oriented NW–SE and bordered by the sea to the SW and a continental block to the NE (Bellen et al. 1959). The paleogeography of the continental block that acted as the source for most of the red-bed components is composed of three main units: (1) the Zagros Fold belt; (2) the narrow Zagros Thrust Zone; and (3) the Sanandaj–Sirjan Zone that forms the western area of the Iranian plate.

According to the previous studies, larger benthic foraminifera in the section implies shallowing of the depositional environment. (Al-Banna and Al-Mutwali 2008; Daoud 2019; Ghafor and Muhamma, 2022), Upper Paleocene–Middle Eocene was determined for Walash-Naopurdan Group sediments. Al-Qayim et al. (2014) recorded the Early Eocene age of the group by direct dependence on the assemblages of foraminifera. Middle Eocene (Lutetian) age was recorded for Walash-Naopurdan Group by Al-Banna and Al-Mutwali (2008), and Kharajiany (2018). Daoud (2019) studied the Nummulitic Limestone of the group and determined the Late Paleocene - Early Eocene age. Ahmad et al. (2022) recorded the Eocene/Lutetian age of the group, finally, Ghafor and Muhammed, 2022, recorded Ypresian-Bartonian age of the Naopurdan group.

The interpretation of the present work which is studied for the first time in detail with the viewpoint of microfossils and biostratigraphy is interpreted that the studied area is rich in large benthic foraminifera with very few planktic foraminifera in addition to other microfossils, and the age of Naopurdan Group is shown to be close to Ypresian- Bartonian as follows:

1-*Alveolina oblonga-Nummulites djokdjokartae* Interval Zone.

Alveolina oblonga and *Nummulites djokdjokartae* recognized from the Ypresian age (Ghazi et al. 2010; Racy (2016); Shreif et al. 2019; Hadi et al. 2021; Okur and Kutluk 2020; Ghafor and Muhammad, 2022) associated with this benthic foraminifera, *Alveolina laxa,* *Alveolina globula, Alveolina regularis, Alveolina globosa, Alveolina pastillicata, Alveolina pissiformis, Alveolina rakoveci gueroli, Alveolina sirelii, Nummulites fraasi, Nummulites solitaries, Nummulites minutus, Lockhartia tipperi Davies, Lockhartia conditi.*

2- *Nummulites djokdjokartae* Total Range Zone.

Nummulites djokdjokartae extended from Ypresian- Lutetia*n* according to Olempska (1973) and Boukhary et. al. (2002), associated with this benthic foraminifer for the Lutetian age (*Nummulites alsharhani, Discocyclina varians, Discocyclina ranikotensis*).

3- *Nummulites fabiani* Total Range Zone, and *Alveolina leupoldi-Alveolina elliptica* Interval Zone *Nummulites fabiani; Alveolina leupoldi-Alveolina elliptica* have been recognized from early Bartonian (Kövecsi et. al. 2015; Saraswati et al. 2017; Ghafor and Muhammad 2022

Conclusions

This study revealed the following conclusions:

1-The Naopurdan group of the study area is rich benthic foraminifera belonging to the following genera: -

Nummulites; Alveolina; Assilina; Discocyclina; Lepidocyclina; Amphistegina; Heterostegina; Sphaerogypsina; Triloculina; Textularia; Quinqueloculina; Orbitolites; Lockhartia; Rotalia; Asterocyclina; Operculina; Cuvillierina; Linderina; Cibicides; Pyrgo; Glomalveolina; Periloculina; Schlumbergerina; Sortids.

2-In addition to Larger Benthic Foraminifera (LBF) assemblages, some species of other microfossils were identified in the Naopurdan group such as coral, algae, pelecypods, gastropods, bryozoans, and fragment spines of echinoids.

3- Four Larger benthic foraminiferal biozones are recognized that unified from old to young: -

Alveolina oblonga-Nummulites djokdjokartae Interval Zone; *Nummulites djokdjokartae* Total Range Zone; *Nummulites fabianii* Total Range Zone; *Alveolina leupoldi-Alveolina elliptica* Interval Zone. From this, it is concluded that the age of the section extends from Early to Middle Eocene (Ypressian to Early Bartonian).

4-The biostratigraphic zones established in this study were correlated with other early-middle Eocene biozones inside and outside Iraq.

Declarations

Conflict of interest. The author(s) declare that they have no competing interests.

References

1. Ahmad MP, Kharajiany S.OA, .Al Khafaf. AOS (2022) New contribution to biostratigraphy of a foraminiferal condensed section within the Naopurdan Group, Chwarta, Sulaimani, Kurdistan Region/Iraq. Carbonates and Evaporites, 37(3): 1-10, https://doi.org/10.1007/s13146-022-00797-y
2. Ahmad S (2010) Paleogene Larger Benthic Foraminiferal Stratigraphy and Faciesdistribution: Implications for Tectonostratigraphic Evolution of the Kohat Basin, Potwar Basin and the Trans Indus Ranges (TIR) northwest Pakistan. Ph. D. Thesis, University of Edinburgh.
3. Al-Banna N, Al-Mutwali M (2008) Microfacies and age determination of the sedimentary sequence withinWalash volcano-sedimentary group, Mawat Complex, northeast Iraq. Tikrit J Pure Science 13:88–95. I G
4. Al-Fattah AN, Al-Juboury AI, Ghafor IM (2018) Rock Magnetic Properties during the Paleocene-Eocene Thermal
5. Maximum (PETM): Records from P/E boundary Sections (Sinjar, Shaqlawa) in Iraq. Iraqi National Journal of Earth Sciences, 18(1): 55-74. DOI: 10.33899/earth.2018.159279.
6. Al Fattah AN, Al-Juboury AI, Ghafor IM (2020) Paleocene-Eocene Thermal Maximum Record of NorthernIraq: Multidisciplinary Indicators and an Environmental Scenario. Jordan Journal of Earth and Environmental Sciences, 1(2):126-145.
7. Al Fattah AN, Al-Juboury AI, Ghafor IM (2020) Significance of Foraminifera during the Paleocene-Eocene Thermal Maximum (RETM) in the Aaliji and Kolosh Formation, North and Northeast Iraq. Iraqi Bulletin of Geology and Mining, 16(2):33-50

8. Ali SA, Sleabi RS, Talabani MJ, Jones BG (2017) Provenance of the Walash- Naopurdan back-arcearc clastic sequences in the Iraqi Zagros Suture Zone, Journal of African Earth Sciences, 125:73-87.
9. Al-Kadhimi JA, M. Sissakian VK Fattah AS Deikran DB (1996) Tectonic map of Iraq, scale 1: 1000000, 2nd edit , Geosurv, Baghdad, Iraq, pp. 1-3.
10. Al-Mehaidi HM (1975) Tertiary Nappe in Mawat Range, N.E Iraq, Jour. Geol. Soc. Iraq, 8, pp. 31-44.
11. Al Nuaimy QA, Sharbazheri KM, Ghafor IM (2020) Cretaceous / Paleogene Boundary Analysis by Planktic Foraminiferal Biozonation in the Western Zagros Fold-Thrust Belt (Smaquli valley), Sulaimani Governorate, NE- Iraq, Kirkuk University Journal Scientific Studies (KUJSS), 15(3):45-81. http://dx.doi.org/10.32894/kujss.
12. Al-Kubaysi KN (2014) The biostratigraphy, microfacies and depositional environment of the Damam Formation In Borehole No.1, South Samawa area,Southern Desert, Iraq, Iraqi Bulletin of Geology and Mining,10(1):1-20. Al-Qayim B, Ghafor IM, Jaff R (2014)Contribution to the stratigraphy of the Walash Group, Sulaimani area, Kurdistan, Iraq. Arabian Journal of Gescience, 7(1):181-192. DOI 10.1007/s12517-012-0809-x.
13. Al-Qayim B, Ghafor IM (2022) Biostratigraphy and Paleoenvironments of Benthic Foraminifera from Lower Part of the Damlouk Member, Western Desert, Iraq. Iraqi Journal of Science, (IJS), 63 (11):4799-4817.
14. Al-Shaibani SK, Al-Hashimi, HAJ, Ghafour IM (1993) Biostratigraphy of the Cretaceous-Tertiary boundary in well Tel Hajar no. 1, Sinjar area, northwest Iraq. Iraqi Geological Journal, 26(2):77–97
15. Bolton CMG, (1958d) The geology of the Ranya area. Manuscript report, (271), GEOSURV, Baghdad. Boukhary M. Abdelghany O, Bahr S (2002) Nummulites alsharhani n.sp. (Late Lutetian) from Jabal Hafit and Al Faiyah: Western side of the Northern Oman Mountains, United Arab Emirates, Revue Paléobiol., Genève, 21 (2):575-585.
16. Bolli HM (1966) Zonation of Cretaceous to Pliocene marine sediments based on planktonic foraminifera. Bol. Inform.Assoc. Vonezolana Geol. Min. Ret. En 9(1): 3-32.
17. Buday T (1980) The Regional Geology of Iraq. Stratigraphy and Palaeogeography. GEOSURV, Baghdad, Iraq, 445P.
18. Buday T, Jassim, SZ (1987) The Regional geology of Iraq: Tectonism Magmatism, and Metamorphism. M.J Abbas and Jassim, S. Z (Eds), GEOSURV, Baghdad, Iraq, 445 P. Daoud HS (2019) Microfaunal Assemblages and microfacies of Nummulitic Limestone of Naopurdan Groupfrom
19. Chwarta Area, Sulaimaniya Governorate, Northern Iraq, JZS 21 (1): (Part-A). DOI: https://dx.doi.org/10.17656/jzs.10745.
20. Ferrandez-Canadell C, Bover-Arnal T (2017) Late Chattian larger foraminifera from the Prebetic Domain (Se Spain): New Data on Shallow Benthic Zone 23. Palaios, 32(1):83–109. DOI: https://doi.10.2110/palo.2016.010.
21. Ghazi S, ALIA Hsnief T, Sharif S, Arif SJ (2010) Larger Benthic Foraminifera Assemblages from the Early Eocene Chor Galiformation, Saltrange, Pakistan, Geol. Bull. Punjab Univ. 45: 83-91.
22. Gedik, F (2014) Benthic Foraminiferal Fauna of Malatya Oligo- Miocene Basin, (Eastern Taurids, Eastern Turkey). Bulletin of the Mineral Research and Exploration , 149(149):93–136.
23. Ghafor IM (1988) Planktonic foraminifera and biostratigraphy of the Aaliji Formation and the nature of its contact with the Shiranish Formation in Well Tel-Hajar No. 1. Sinjar area, Northwestern Iraq. Unpublish. Thesis, Geol. Dept. Univ. Salahaddin, Iraq, 206 P.
24. Ghafor IM, Kareem KH (1999) Biostratigraphy of Upper part of the Kolosh Formation from Sartaq-Bamo Northeastern Iraq. Proceedings of the FIRST SCIENTIFIC CONFERENCE, 27-29/April/1999. Special Issue, 2(4): 493-510.
25. Ghafor IM (2000) A spores and pollen of Upper Cretaceous Lower Tertiary in Hijran area, Kurdistan, Iraq. ZANCOJOURNAL OF PURE AND APPLIED SCIENCES- SALAHADDIN UNIVERSITY, 12(2): 47-62.
26. Ghafor IM, Qadir MM (2009) Larger foraminifera (Alveolinidae, Soritidae, and Nummulitidae) from the former Qulqula Conglomerate Formation, Kurdistan Region, Northeastern Iraq. Iraqi Journal of Earth Sciences, 9(1):35- 54. DOI: 10.33899/earth. 2009.40591
27. Ghafor IM, Al-Qayim B (2021) Planktic Foraminiferal Biostratigraphy of the Upper Part of the Damlouk Member, Ratga Formation, Western Desert, Iraq, Iraqi National Journal of Earth Sciences, 21(2):49-62.DOI: https://doi.10.33899/earth.2021.170385.
28. Ghafor IM, Muhammad HF (2022) Biostratigraphy of Eocene Sediments from Naopurdan Group, Chwarta Area,
29. Kurdistan Region, NE Iraq: Paleogeographic Implication, Iraqi National Journal of Earth Science, 22, (2):192- 206. DOI: 10.33899/earth.2022.135618.1031

30. Hadi M, Consorti L, Vahidinia, M, Parandavar M,. Zoraghi M (2021) Ypresian Alveolina and calcareous nannofossils from the south Sabzevar area (Central Iran): biostratigraphic, taxonomic and paleobiogeographic implications. Micropaleontology, 67(1):31-52. http://doi.org/10.47894/mpal.67.1.04.
31. Heron AM, Lees CM (1943) The zone of Nappe in Iraq Kurdistan. Min. of Development Report, SOM Library, No.132, Baghdad.
32. Hottinger L (1960) Recherches sur les Alvéolines du Paléocène et de l'Eocène. Schweizerische Palaeontologische Abh & lungen 75-76, 243 P.
33. Jassim, SZ, Goff JC (2006) Geology of Iraq. Dolin, Prague and Moravian Museum, Brno, 341 P.
34. Karim KH (2004) Basin analysis of Tanjero Formation in Sualiamniyah area, NE. Iraq, Unpublished, Ph. D. Thesis, University of Sulaimani, Iraq.Imad M. Ghafor and Hemn F. Muhammad 203
35. Karim KH (2005) Some sedimentary and structural evidences of a possible Graben in Mawat-Chuwarta area, NE Iraq. Iraqi. Journal Earth Science, 5(2):9-18.
36. Karim SA, Al-Kubaysi KN (2015) New occurrence of Ratha Formation (Eocene) in some subsurface sections in Nasirya, Southern desert, Iraq, Iraqi Bulletin of Geology and Mining, 11(1):27-43.
37. Kharajiany SO, (2018) Calcareous nannofossils from the Eocene sequence of the Naopurdan Group, Betwat locality, Sulaimaniyah, Kurdistan Region, Iraq.Iraqi Bulletin of Geology and Mining, 14 (2):17-30.
38. Kövecsi SZA, Less, GY, Silye L, Filipescu S1 (2015) New data on the middle Eocene(Bartonian) Nummulites perforatus "banks" from the Transylvanian Basin (Romania), The 10th Romanian Symposium of Paleontology, October 16-17, 2015.
39. Loeblich JR, Tappan H (1988) Foraminiferal genera and their classification, Van Nostrand Reinhold. 305 P.
40. Numan NM S, (1997) Aplate tectonic scenario for the phanerozoiuc succsssion in Iraq. Iraqi Geological Journal, 30(2):85-110.
41. Olempska E (1973) The Genus Discocyclina (Foraminiferida) from the Eocene of the Tatra Mts, Poland, Acta paleontological Polonica, 18:(1)
42. Okur K, Kutluk H (2020) Benthic foraminiferal assemblages from the Safranbolu Formation (Cuisian, Eocene), Northwest Anatolia, Turkey. Journal of Palaeogeography, 9 (6):1-21.https://doi.org/10.1186/s42501- 020-0054-2.
43. Racy A (2016) New nummulite (Foraminiferida) species from the Eocene of Northern Oman, University of Cambridge on June 16, http://doi.jm.lyellcollection.org.
44. Roozpeykar A, Moghaddam IM (2016) Benthic foraminifera as biostratigraphical and paleoecological indicators: an example from Oligo- Miocene deposits in the SW of Zagros basin, Iran. Geosci Front 7(1):125-140. https://www.sciencedirect.com/science/article/
45. Saraswati PK, Anwar D, Lahiri A (2017) Bartonian reticulate Nummulites of Kutch, Geodinamica Acta, 29(2): 14–23, http://dx.doi.org/10.1080/09853111.2017.1300847.
46. Serra-Kiel J, Gallardo-Garcia A, Razin P, Robinet J, .Roger J, Grelaud Robin CC (2016) Middle Eocene-Early Miocene larger foraminifera from Dhofar (Oman) and Socotra Island (Yemen). Arab J Geosci, 9:(5). https://doi.org/10.1007/s12517-015-243-3.
47. Serra-Kiel J, Hottinger L, Caus E, Drobne K, Ferandez C, Jauhri AK, Less G, Pavlovec R, Pignatti J, Samso JM, Schaub H, Sirel E, Strougo A, Tambareau Y, Tosquella, Y, Zakrevskaya E (1998) Larger foraminiferal biostratigraphy of the Tethyan Paleocene and Eocene. Bulletin de la Société Géologique de France, 169:281-299.
48. Seyrafian A, Mojikhalifeh AR (2005) Biostratigraphy of the Late Paleogene-Early Neogene succession, north- central border of the Persian Gulf. Carbonates Evaporites, 20(1): 91–97. https://doi.org/10.1007/BF03175452.
49. Sharbazheri KM, Ghafor IM, Mohammed QA (2009) Biostratigraphy of the Cretaceous/Tertiary boundary in the Sirwan Valley (Sulaimani Region, Kurdistan, NE Iraq), Geologica Carpathica, 60 (5):381-396. https://doi.10.2478/v10096-009-0028-x.
50. Sharbazheri KM, Ghafor IM, Mohammed QA (2011) Biostratigraphy of the Cretaceous/Paleogene boundary in the Dokan area, Sulaimaniyah, Kurdistan Region, NE Iraq, Iraqi Bulletin of Geology and Mining, 7(3):1-24.
51. Shreif A, Boukhary M, Abul-Nasr RA, Obaidalla, NA (2019) Ypresian Nummulites and their stratigraphic significance from El-Guss Abu Said plateau, Farafra Oasis, Biostratigraphy of Eocene Sediments from Naopurdan Group, Chwarta Area, Kurdistan …… 204 Western Desert, Egypt. Arabian Journal of Geosciences, 12(72):1-14. https://doi.org/10.1007/s12517-018-4195-
52. Sirel E, Özgen-Erdem N, Kangal Ö (2013) Systematics and biostratigraphy of Oligocene (Rupelian-early Chattian) foraminifera from lagoonal-very shallow water limestone in the eastern Sivas basin (central Turkey). Geologia Croatica, 66(2):83-110.https://doi.org/10.4154/GC.2013.07.

53. Surdashi AM (1997) Depositional and post depositional deformation of Naopurdanlimestone Unit from Chuwarta- Mawat area, Northeast of Iraq. Iraqi Geological Journal, 30 (2):118-12.

Figures

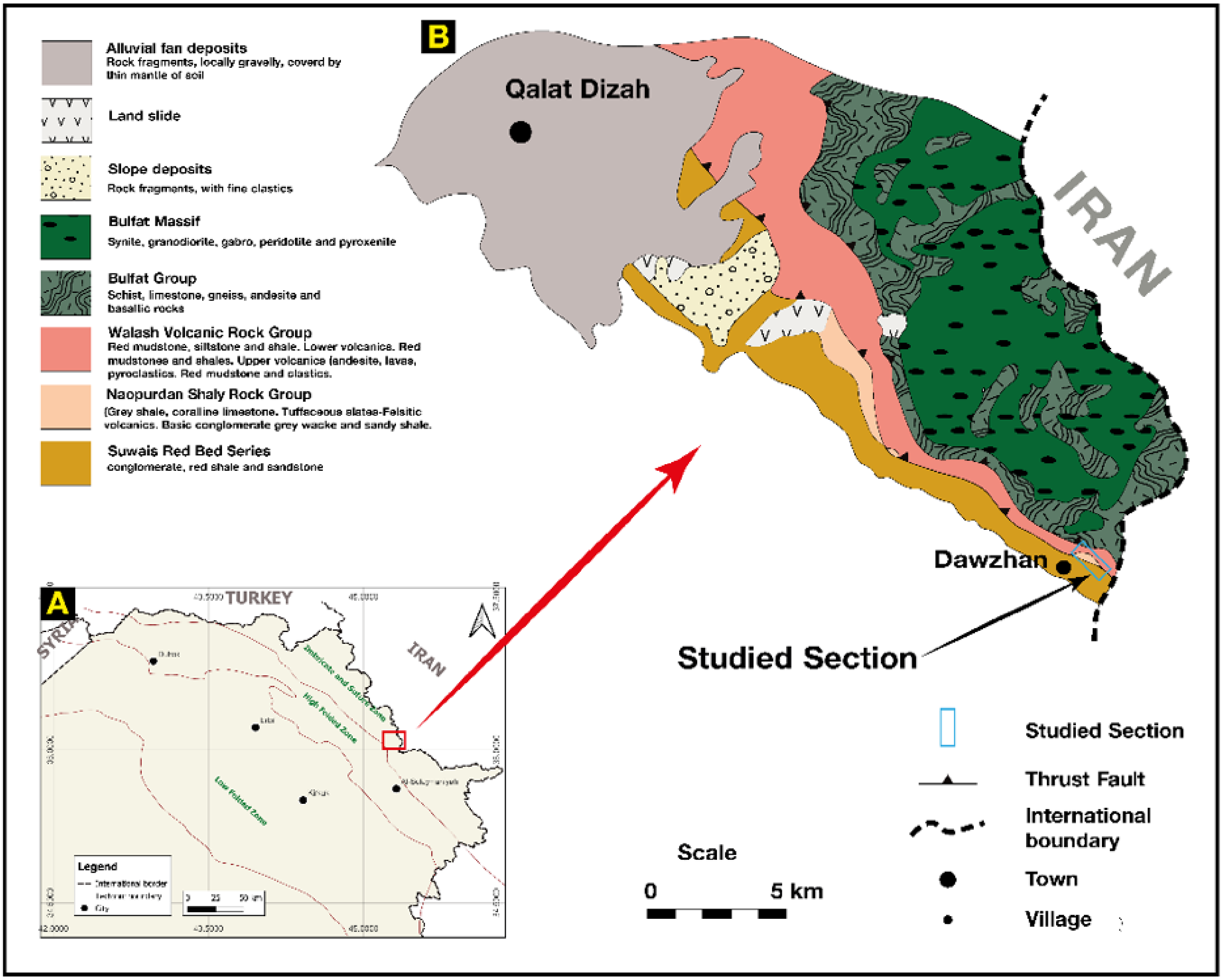


Figure 1

Location map of the studied section; (**A**) Tectonic map of Iraq after (Al-Kadhimi et al. 1996). (**B**) Location map of the study area.

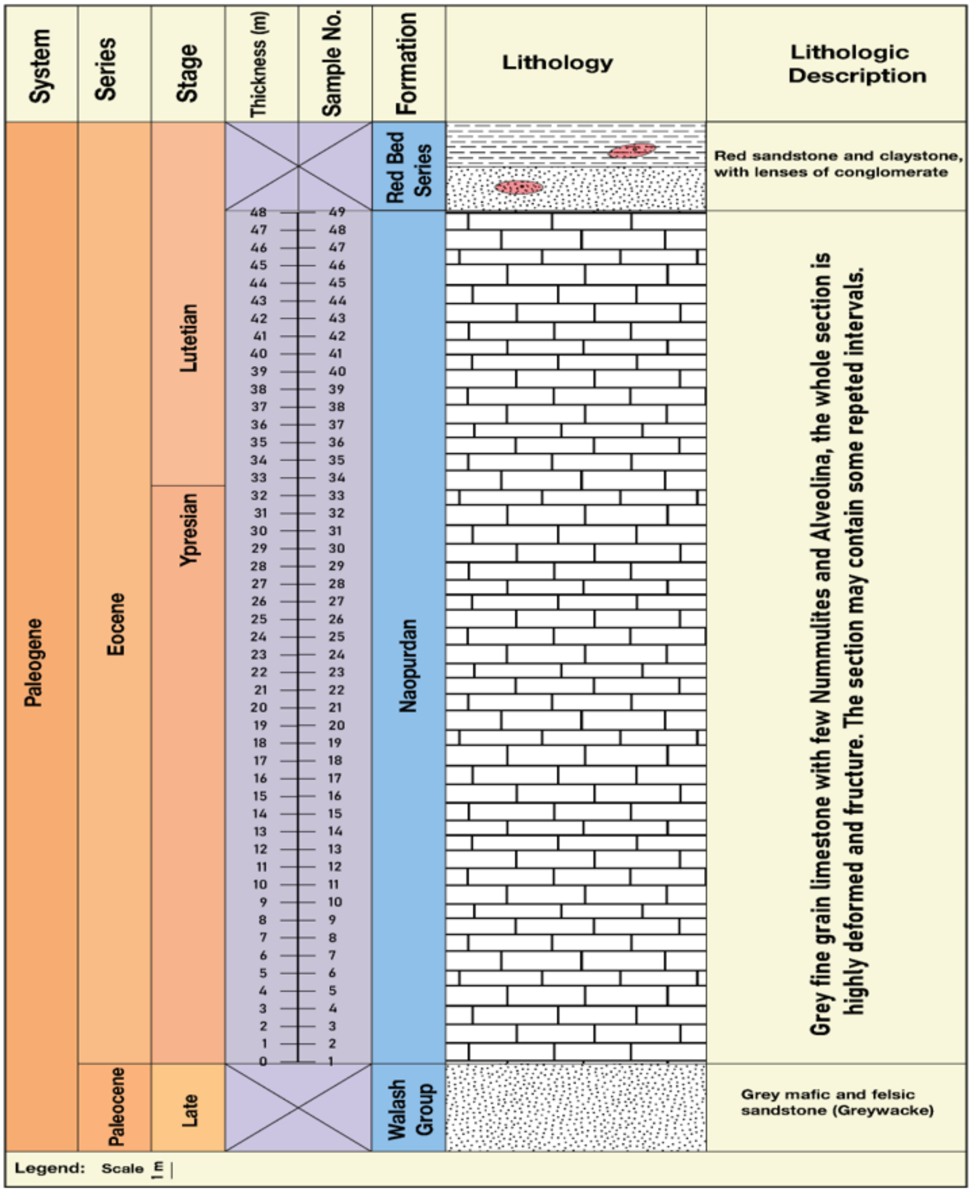


Figure 2

lithostratigraphic column of Late Paleocene- Early Eocene from Dawzhan section, Issewa Sub-District, Sulaimani city.

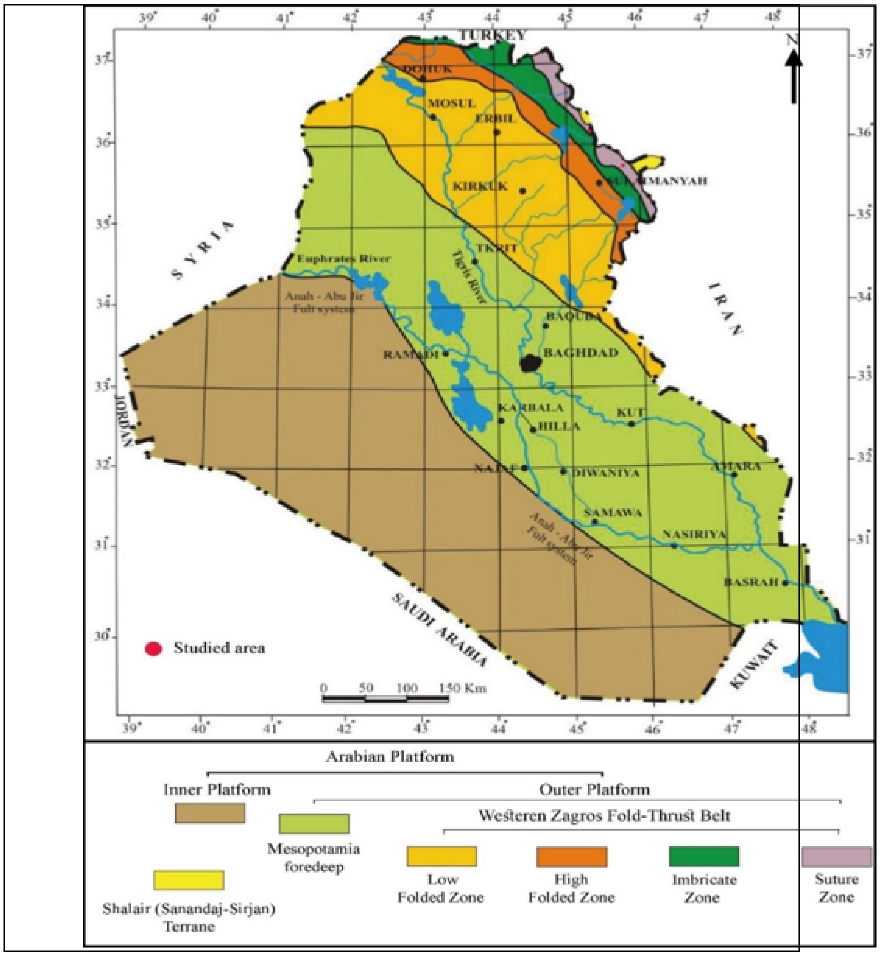


Figure 3

Fig. (4): Tectonic divisions of Iraq (Fouad 2015).

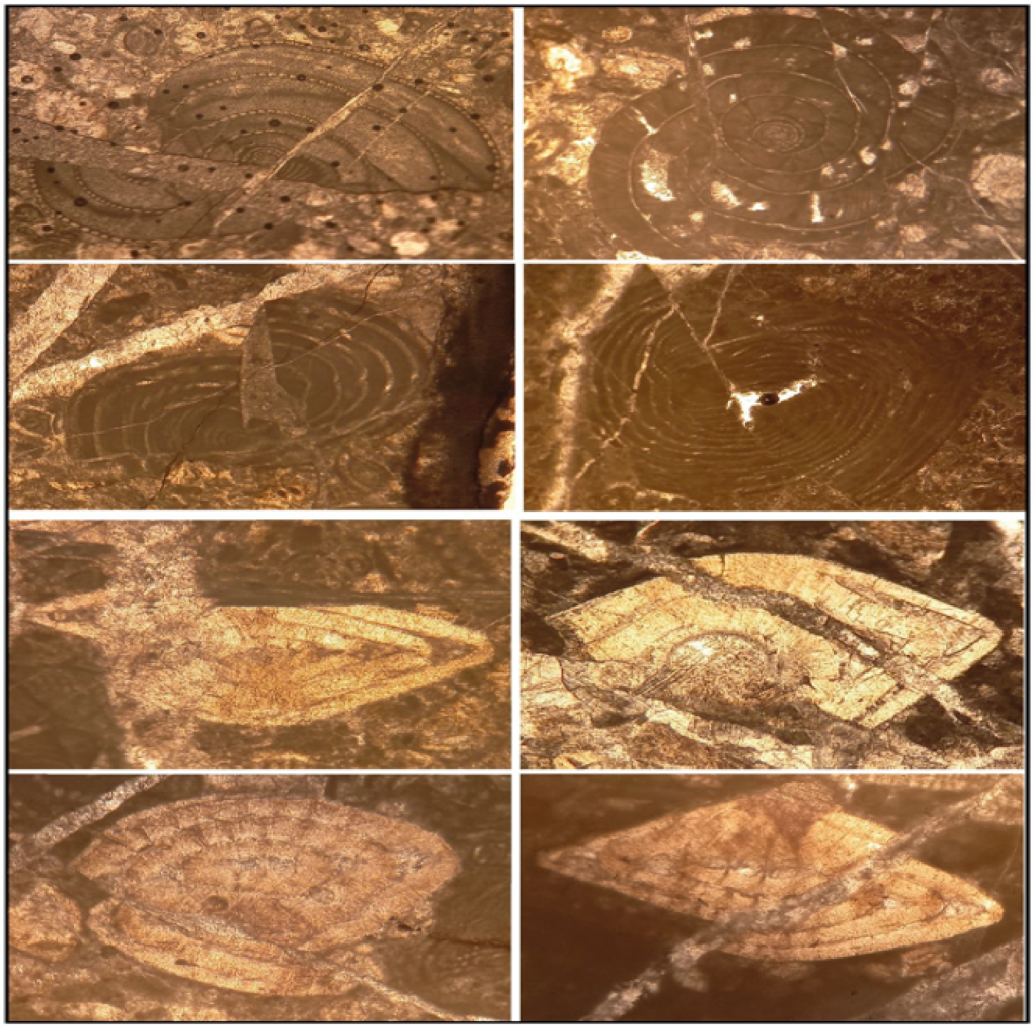


Figure 4

Broken species and displacement due to high tectonic activity within the studied section.

Figure 5

Field photograph showing the exposed lithostratigraphic units, viewed toward the northwest, Dawzhan section.

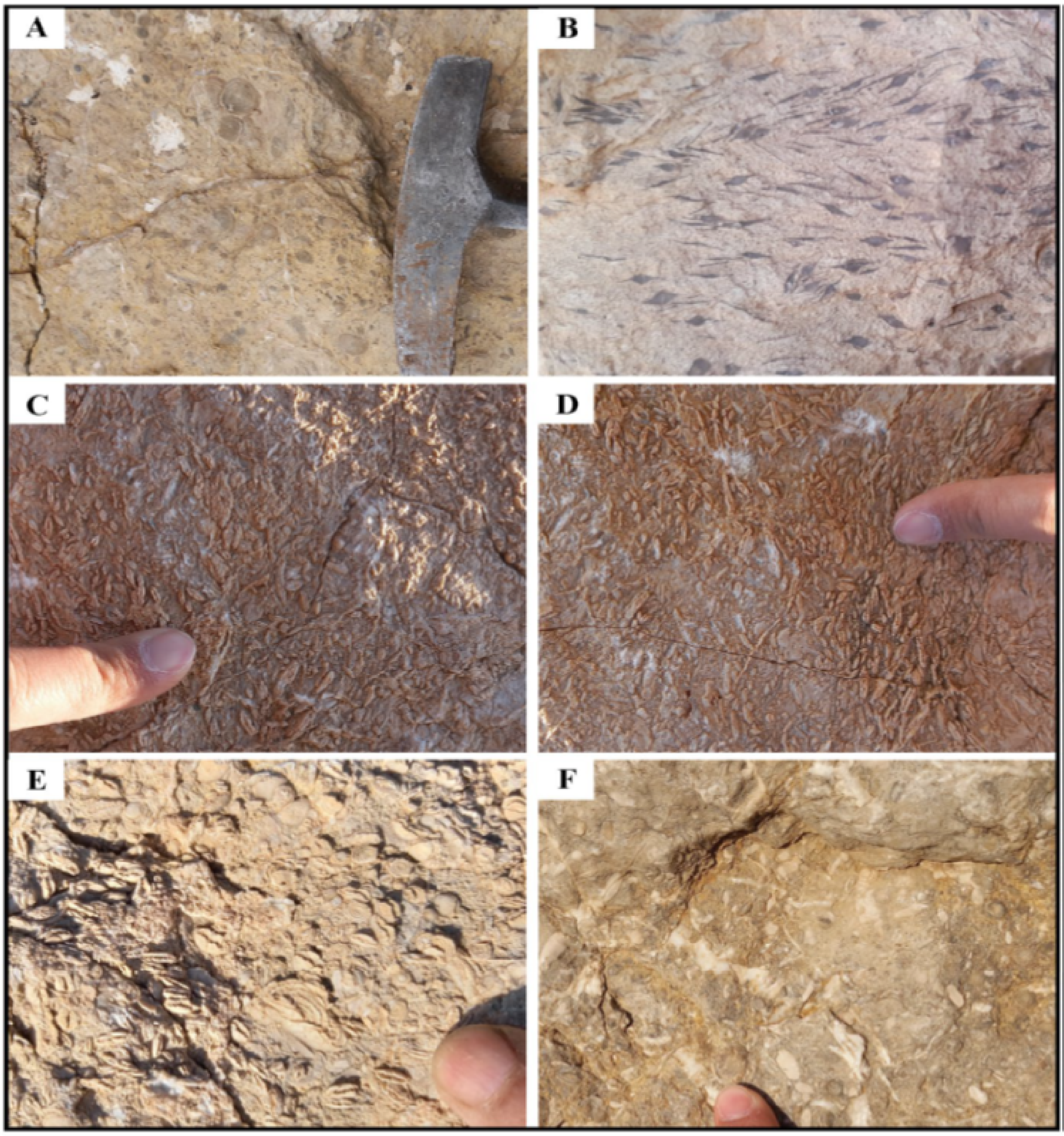


Figure 6

Field photograph showing the microfossils from the Naopurdan limestone unit, (A, C, D and E): genera of *Nummulites*, *Assilina* and *Alveolina*, (B) *Discocyclina*, (F) *Nummulites,* and Algae.