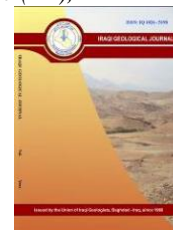




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Middle Eocene Succession of Dammam Formation, Biostratigraphy and Microfacies Study, North Karbala Area, Western Iraq

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Abstract

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Stratigraphic and sedimentary study to Dammam Formation (Eocene age) at well Kr-1, Karbala Government, Western Desert of Iraq. Lithologically, Dammam Formation consists of Nummulitic limestone and dolomitic limestone. The contact between the upper and lower of Dammam Formation is unconformable, the lower contact is represented by Umm Er-Radhuma Formation by the unconformable surface in the Upper Paleocene age, while the upper is an unconformable surface with Euphrates Formation in the Early Miocene age. The rock section of the well Kr-1 is divided into several beds depending on Petrographical and paleontological contents, the results of the identified foraminifera are indicated to several groups and genera which are: *Nummulites*, *Lindrina*, *Lockhartia*, Rotaliid, Miliolid, also other groups of fossils like Ostracoda, Echinoderms, Bryozoa, Gastropod, Pelecypod, and different fragments. Based on the petrographic study and type of microfacies, the formation was divided into three main and secondary microfacies which are: *Nummulitic* packstone, Dolomitic and Bioclastic Packstone, and Floatstone. One main biozone was recognized in the studied section which is *Nummulites gizehensis- Nummulites planulatus - Nummulites discorbinus* Assemblage Zone with age Middle Eocene (Lutetian), this biozone is divided into two secondary biozones: *Nummulites millecaput* Rang zone Middle Eocene (Middle-Upper Lutetian) age and *Nummulites elevate* Rang zone Middle Eocene (Late Upper Lutetian) age. After collecting all the sedimentary and planetology data for the studied section, the Dammam Formation was deposited in shallow warm marine, tropical water, as well as, the absence of planktonic foraminifera crowds is another evidence that the environment is a shallow basin close to the coast. The basin is located at the Interior Platform represented by the evaporites basin, the restricted, and then the open sea environments.

Keywords: Dammam Formation; M. Eocene; biostratigraphy; Microfacies; Western Iraq

1. Introduction

The Eocene Epoch witnessed the development of a carbonate platform covering a huge area of Iraq (Al-Hashimi, 1972; Al-Kubaysi, 2013; Al-Dulaimi and Al-Wa'aly, 2016). The foraminiferal contents of the Eocene platform were the target for many previous studies in the Western-South Desert of Iraq (Amer, 1980; Mohmood, 1983; Al-Mutter, 1984). From its typical type section in the Dammam area in Saudi Arabia, Sandrey (1952) in Bellen et al. (1959) provided the initial description of the Dammam Formation. Owen and Nasr (1958) documented a supplemental-type section in Iraq from B.P.C. Oil Well Zubair 3 in the Basra area of southern Iraq. The following coordinates define it: 30°23'01" latitude; DOI: [10.46717/igj.56.2A.16ms-2023-7-25](https://doi.org/10.46717/igj.56.2A.16ms-2023-7-25)

47°43'29" longitude. According to lithology, the additional type section's formation is composed of whitish-gray, porous, dolomitized limestone, which can occasionally be chalky (Owen and Nasr, 1958).

Thirty-seven samples were taken from borehole No. Kr-1, in North Karbala City in the Western Desert of Iraq, was used to study the Dammam Formation paleontologically, at 32° 33' 05" N and 43° 20' 21" E, (Fig.1), which GEOSURV drilled in 2009–2010 while carrying out a thorough geological survey in Karbala city (Mohammad, 2010).

From the oldest to the youngest, the investigated samples revealed the presence of the Dammam Formation (Middle Eocene) and the Euphrates Formation (Early Miocene).

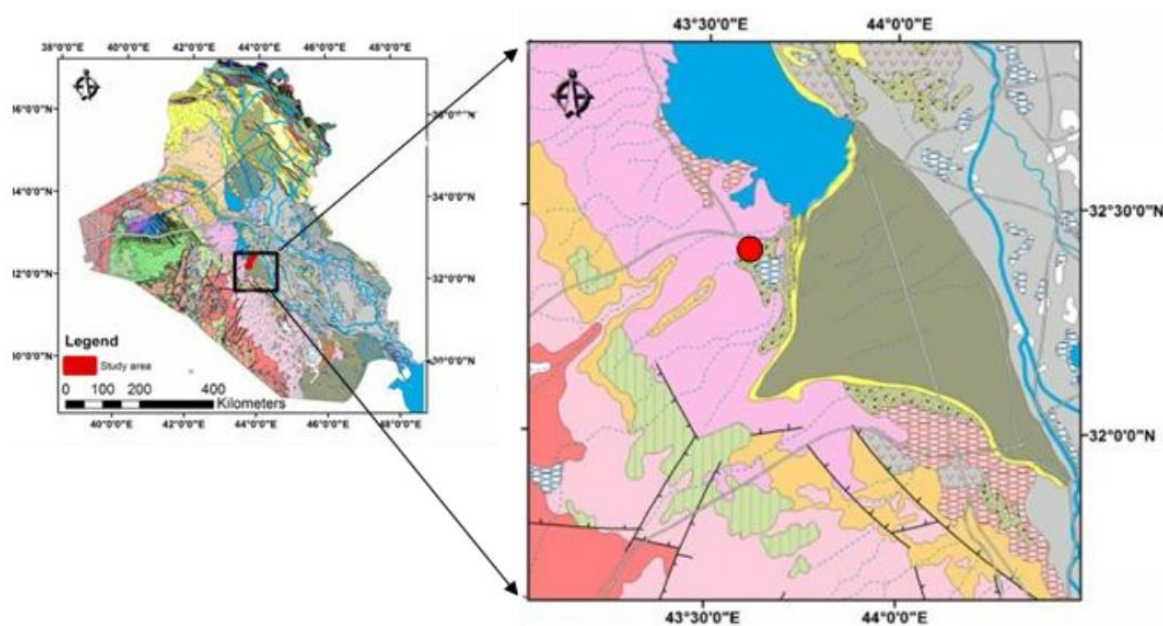


Fig. 1. Location map of borehole within the study area, North Karbala Area, W. Iraq (Sissakian, V., 2000).

The study will review the most important references related to the current study. Al-Hashimi (1974) and Amer (1980) studied the micropaleontology of the Dammam Formation in the Samawa and Najaf area, where Yousif (1981); Mohmood (1983) Al-Mutter (1983); Muniem (1983); Yousif (1983); Al-Mutter (1984) concentrated on the biostratigraphic side of the Dammam Formation in the Samawa, Najaf and Karbala areas, while Tamar-Agha (1984); Raji and Said (1984); Sissakian et al. (2006) studied the sedimentary rocks of Dammam Formation. Also, So'od and Al-Bassrawi (2006); Al-Jiburi and Al-Bassrawi (2012); and Mohammad (2010) studied the hydrology system in the Dammam Formation. Al-Kubaysi (2013) and Al-Dulaimi and Al-Wa'aly (2016) focused on the stratigraphy of the studied formation.

The aim of the study is to determine the biostratigraphy of the studied section in accurate way, depending on identified the important fossils and microfossils.

2. Methodology

This study is based on thirty-seven samples collected from the borehole (Kr-1). The carbonate rocks of this formation is classified after Dunham (1962) with modification of Embry and Klovan (1971), depending on the depositional texture of the rocks. Grain types such as bioclasts and intraclasts may qualify for this classification. The modified Dunham classification (1962) by Raymond (1995) is also adopted in this work.

The identified carbonate microfacies of the formation is compared with Standard Microfacies Types from well-known environments (e.g., Wilson, 1975 and Flugel, 2010). Depositional environments of the carbonate microfacies are discussed mostly according to their petrographic characteristic (Flugel, 2010) and also according to Al-Hashimi and Amir (1985).

Work takes two directions:

- In order to achieve the aim of the present study, soft samples were collected from the borehole Kr-1. At least 250 gm was taken from each sample to extract the microfaunal contents. The samples were soaked in a hydrogen peroxide solution concentration of 30% or acetic acid that a concentration of 60 %. The samples were washed under running water and sieved using a 63 μm sieve (Al-Shawi et al., 2019; Al-Ali et al., 2020). The residue was dried and separated into several fractions to facilitate the picking of different microfossils using a binocular microscope. The picked foraminiferal tests were identified to species level and photographed.
- More core samples collected from borehole no. Kr-1 drilled by GEOSURV, made thin sections in this work at their laboratories.

3. Stratigraphy of Dammam Formation

During the Eocene, the initial collision stage happened, when the Arabian continental plate's edge starts to rise and stretch as it bends around the outer swell just before being drawn into the subduction system by the descending slab, this is the first sign that a collision is about to happen (Al-Muturi and Alasadi, 2008; Handhal and Mahdi, 2016; Al-Kaabi et al., 2023). In the borehole, Kr-1 is represented by 64 m thick (drilling depth 41–105 m) of the Dammam and Euphrates formations. *Nummulites* sp. first appearance as broken fragments at depth of 105 meters, and its last appearance was at a depth 49.5 meter. Dammam Formation has been divided paleontologically into one member in the study area:

3.1. Middle Member

It consists mainly of light grey to white, medium hardness to hard and Nummulitic limestone, alternating with white massive recrystallized sugary and dolomitic limestone followed by whitish grey, hard, fossiliferous dolomitic limestone (Figs. 2A, B and 4).

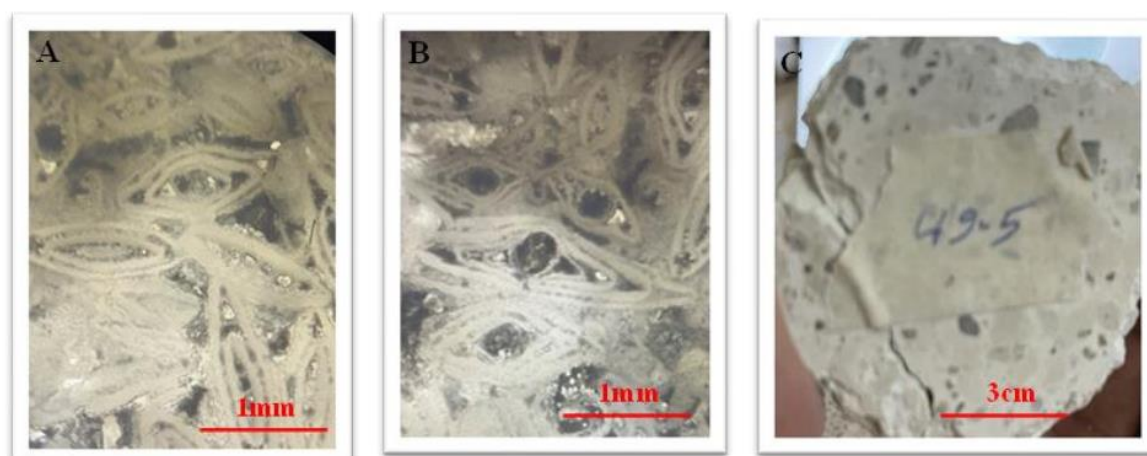


Fig. 2. A. and B. Nummulitic dolomitic limestone facies, C. breccia lithofacies, Kr-1 well

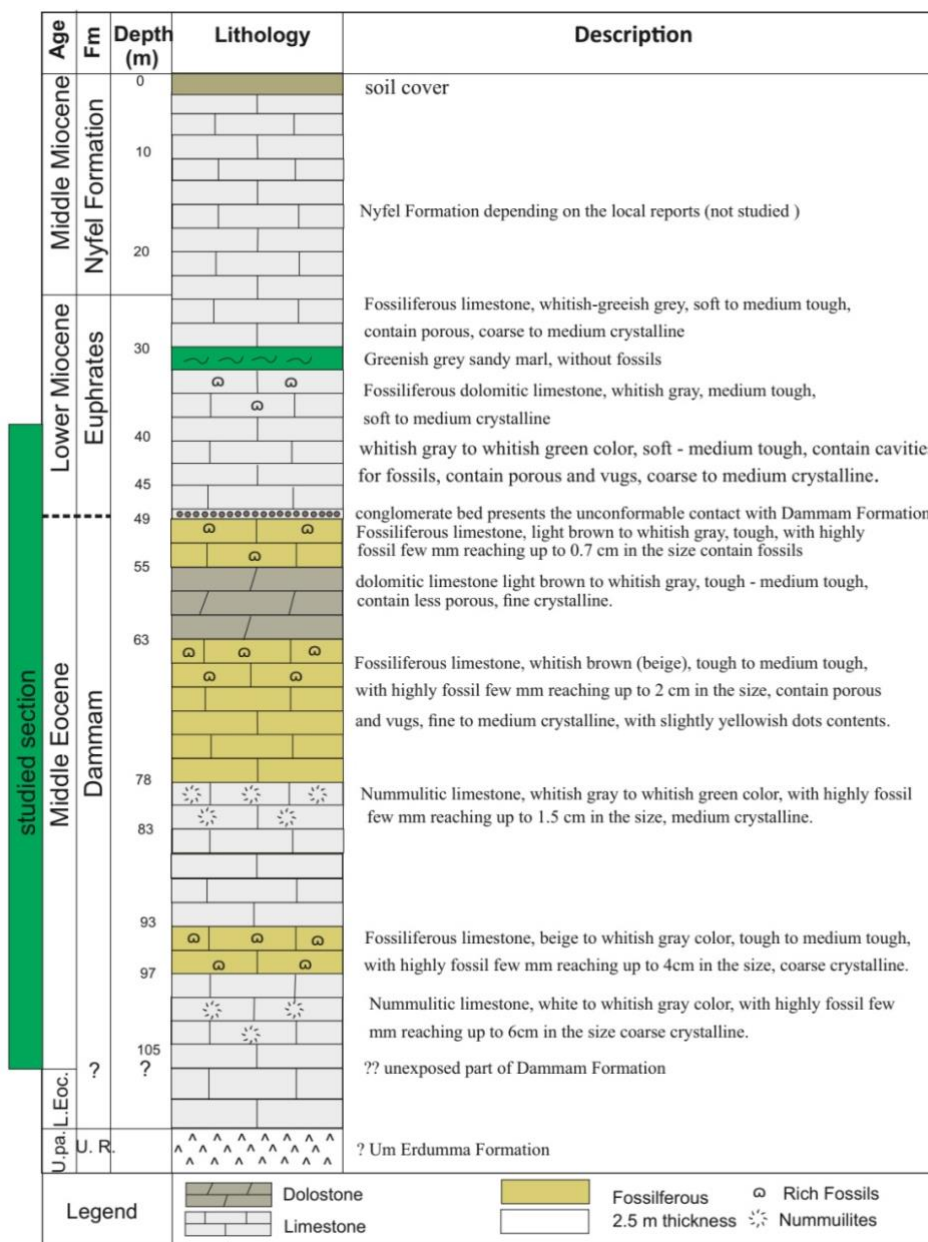


Fig. 3. Stratigraphic column of the studied borehole, Karbala, other information from (Jassim et al., 1984).

The lowermost of the upper part of the Dammam Formation consists of grey, thick-bedded, very hard, recrystallized and dolomitic limestone, whereas the uppermost of the upper Dammam Formation consists of grey massive, fossiliferous, dolomitic limestone, with silicified bands, with a thickness of 55.5 m (drilling depth 49.5-105 m) in well Kr-1. *Nummulites* sp. the last appearance in Dammam Formation is at depth of 49.5 meters and its first appearance is at a depth of 105 meters.

3.2. Upper contact of the Dammam Formation

The upper contact of the Middle Member of the Dammam Formation is unconformable with the Euphrates Formation. It is sharp contact represented by the disappearance of *Nummulites gisehensis* which is considered an index fossil to the Middle Member and larger Foraminifera depending on the paleontological study and the basal conglomerate (Brecciated limestone or dolomitic limestone

lithofacies (Fig. 2 C) at the bottom of the Euphrates Formation which was studied approximately 5 meters thickness and indicating of Oligocene absence. The thickness of the basal conglomerate is 3.5 meters at a study area above the Nummulitic packstone. Van Bellen et al. (1959) and Al-Hashimi (1973) suggested that the upper contact with overlain of Euphrates Formations may be unconformable.

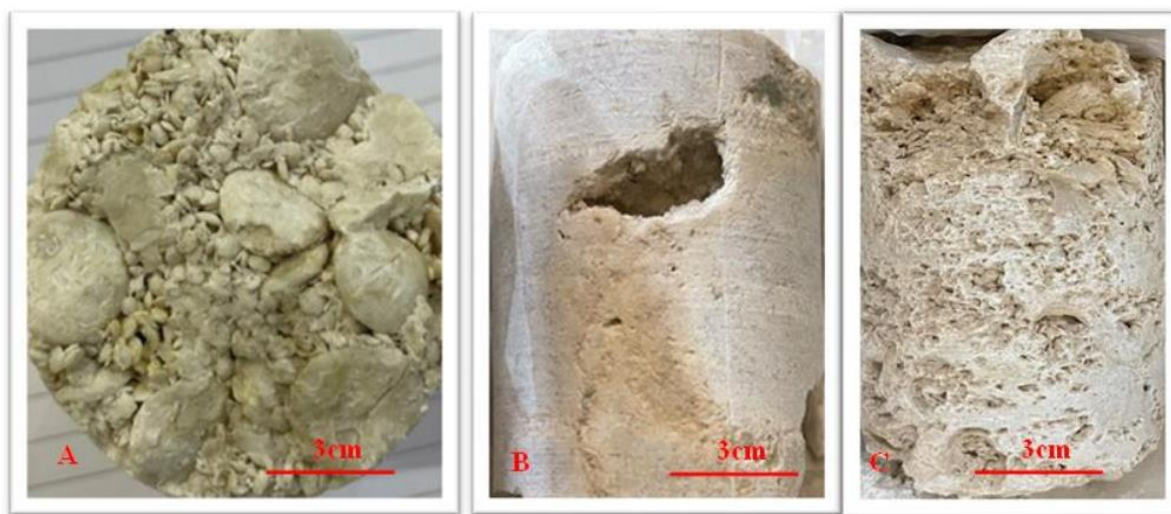


Fig. 4. Core samples of Dammam Formation limestones: A-B) Nummulitic limestone with macro-pores of *Nummulites* tests, C- Fossiliferous limestone with molds of gastropod shell.

4. Biostratigraphy

The examined samples contained numerous foraminifera species that were recognized. One biozone was first separated into two subbiozones (Fig. 5), which are explained below:

Nummulites gizehensis- *Nummulites planulatus* -*Nummulites discorbinus* Assemblage Zone: The initial appearance of the excellent index fauna *Nummulites gizehensis zeitteli* (DE LA HARPE) (Fig. 6(7)), *Nummulites discorbinus* (SCHLOTHIEM), and *N. planulatus* (LAMARCK) (Fig. 6(1)) are characteristic of this zone, which has a thickness of 55.5 m. and last appearance of *Nummulites discorbinus* (SCHLOTHIEM) (Fig. 7(3-5)) and its upper limit by the complete disappearance of larger Foraminifera, and other associated fauna like: *Nummulites gizehensis* (FÖRSKAL), *N. elevata* (AL-HASHIMI AND AMER) (Fig. 6(6)), *Nummulites bayhariensis* (CHECCHIA-RISPOL) (Fig. 7(7)), *N. perforates* (MONTEORT) (Fig. 6(2)), *N. murchisoni* (RUTIMEYER), *N. atacicus* (LEYMERIE) (Fig. 7(10)), *N. globulus* (LEYMERIE) (Fig. 6(3)), *N. millicaput* (BOUBEE) (Fig. 7(1)), *N. beaumonti* (D'ARCHIAC) (Fig. 6(4)), *N. lyelli* (D'ARCHIAC) (Fig. 7(11)), *Nummulites* sp., *Assilina* sp. (Fig. 6(5 and 9)), *Linderina brugesii* (SCHLUMBERGER), *Linderina* sp., *Lockhartia alveolata* SILVESTRI (Fig. 7(8 and 9)), *Lockhartia* sp., Ostracods, algae, echinoids, Rotaliids, Bryozoa, and pelecypod fragments.

Age: The *N. gizehensis* FRSKAL represents good index species of Middle Eocene age, according to Al-Hashimi (1972); Karim (1977); Al-Mutter (1979) and Amer (1980). It is characterized by the abundance of large sized *N. gizehensis* (up to 20mm. diameter) in the same group, but apparently only indirect related to *N. planulatus*; therefore, the study is determining the Middle Eocene age for the Middle Member of the studied formation; depending on the presence of this biozone. According to Said (1950); Naqappa (1959); Samata (1968) and Fahmy et al. (1969). Gastropod (Fig. 8 (1 and 2)), *Ammonia beccarii* Sp., (Fig. 8 (3 and 7)), *Guemblina* sp., (Fig. 8(6)), Miliolids (Fig. 8(5)), *Miogypsina* sp. (Fig. 8(4)), *Rotalia* sp. (Fig. 8(8)) these fossils belong to Euphrates Formation (Early Miocene).

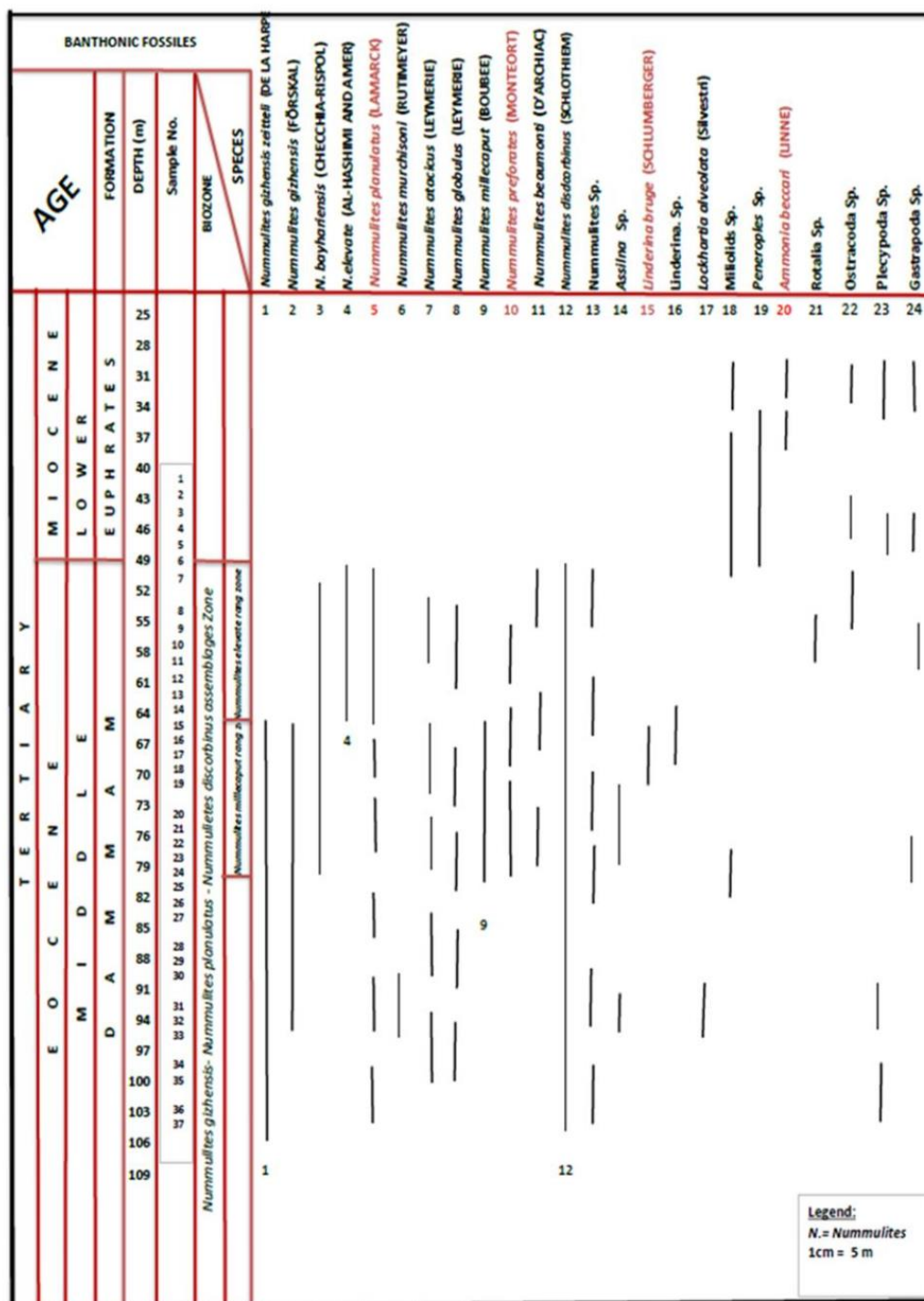


Fig. 5. Stratigraphic range and biozonation of the benthonic fossils of Dammam Formation in well (Kr-1), W. Iraq.

The species *Nummulites gizehensis* is considered excellent marker fossils for the Late Lutetian age. Other species such as *Nummulites atacicus* (LEYMERIE), *Nummulites discorbinus* (SCHLOTHIEM), *alveolines* ext. is known, so far only from the Middle Eocene (Ellis and Messina, 1966). The age of the Dammam Formation depending on the presence of *Nummulites gizehensis* Zone is Middle Eocene (Late Lutetian) for Middle Member of Dammam Formation (Amer, 1980). The above fossils assemblages are more similar to the Middle Eocene (Late Lutetian), which were recognized in the supplementary type

section in Iraq, in Al-Hajara section, S.W. Iraq; in well Zabair-3 (subsurface section), Samawa area, West Najaf – Nukhaib area, South Najaf area, and South Nukhaib area, Southern Iraq and in wade Swab, Ratba and Hauran area, Western Desert (Bellen et al., 1959; Al-Hashimi, 1972, 1973 and 1974; Amer, 1980; Yousif, 1981; Al-Mutter, 1983; Jassim et al., 1984 and Al- Kubaysi, 2013). The upper boundary of this zone marked the Middle / Late Eocene boundary. This boundary is marked by the disappearance of almost all spinose benthonic species (e.g., *N. gizehensis* and the large *Nummulites* ssp.) (Al-Hashimi, 1972; Al-Kubaysi, 2013).

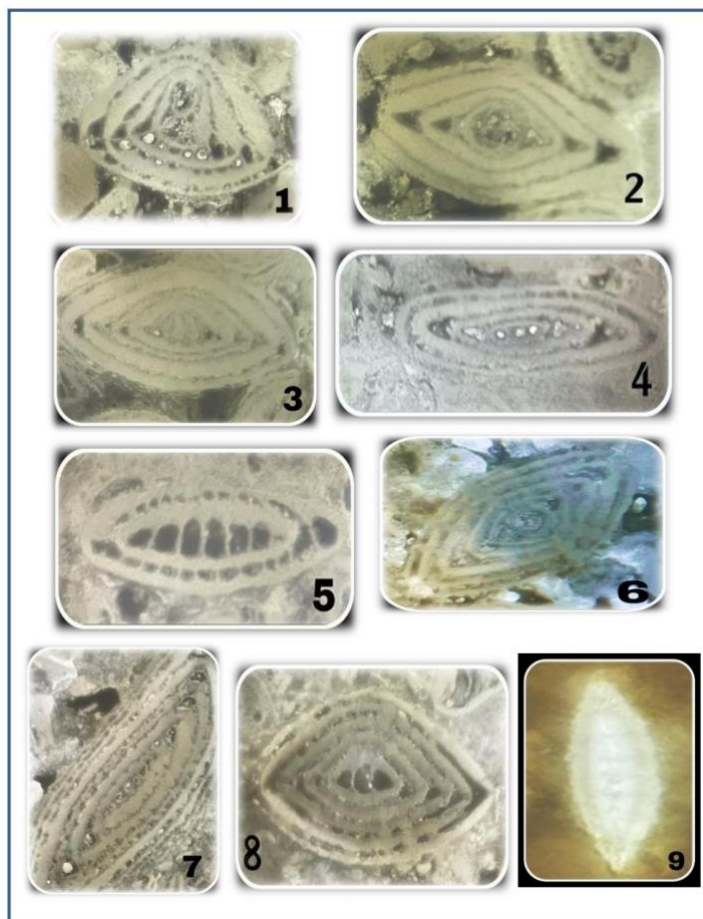


Fig. 6. The identified foraminifera: 1. *Nummulites planulatus* (LAMARCK), X4; 2. *Nummulites preforates* (MONTEORT), X4; 3. *Nummulites globulus* (LAMARCK), X4; 4. *Nummulites beaumonti* (D'ARCHIAC), X4; 5. *Assilina* sp; 6. *Nummulites elevata* (AL-HASHIMI AND AMER), X4; 7. *Nummulites gizehensis zeitteli* (DE LA HARPE), X2; 8. *Nummulites* Sp; 9. *Assilina* cf. *laminosa* (GILL), X5.

A -*Nummulites milacapat* rang Zone. This subzone is distinguished by the emergence of *N. milacapat* (BOUBEE) in the lower limit and first appearances of *Nummulites elevata* (AL-HASHIMI AND AMER) and the last appearances of *Nummulites gizehensis* and *Nummulites milacapat* this species present as the upper limit, through the thickness of 15 m and is associated with fossils such as *N. bayhariensis* (CHECCHIA-RISPOL), *N. planulatus* (LAMARCK), *N. preforates* (MONTEORT), *N. discorbinus* (SCHLOTHIEM), *N. globulus* (LEYMERIE), *N. atacicus* (LEYMERIE), *N. beaumonti* (D'ARCHIAC), *N. lyelli* (D'ARCHIAC), *Nummulites* sp., *Linderina bruge* (SCHLUMBERGER), *Linderina* sp., shell fragments, echinoid spines, Gastropod, Miliolids, and Ostracods.

Age: The above fossil assemblage is more closely similar to the Middle Eocene fossils (middle Upper Lutetian) in the supplementary type sections in Iraq such as Al-Hajara section, SW Iraq; well

Zubair No.3 section (subsurface section) southern Iraq; Samawa area (Bellen et al., 1959; Al-Hashimi, 1972, 1973, 1974; and Jassim et al., 1984). The *Nummulites gizehensis* Zone is correlated with the Middle Eocene the *Nummulites gizehensis* Zone (in part) of Iran (Sampo, 1969). The age of the Middle Member of the Dammam Formation is Middle Eocene since it contains large foraminifera such as *Nummulites* and *Linderina*.

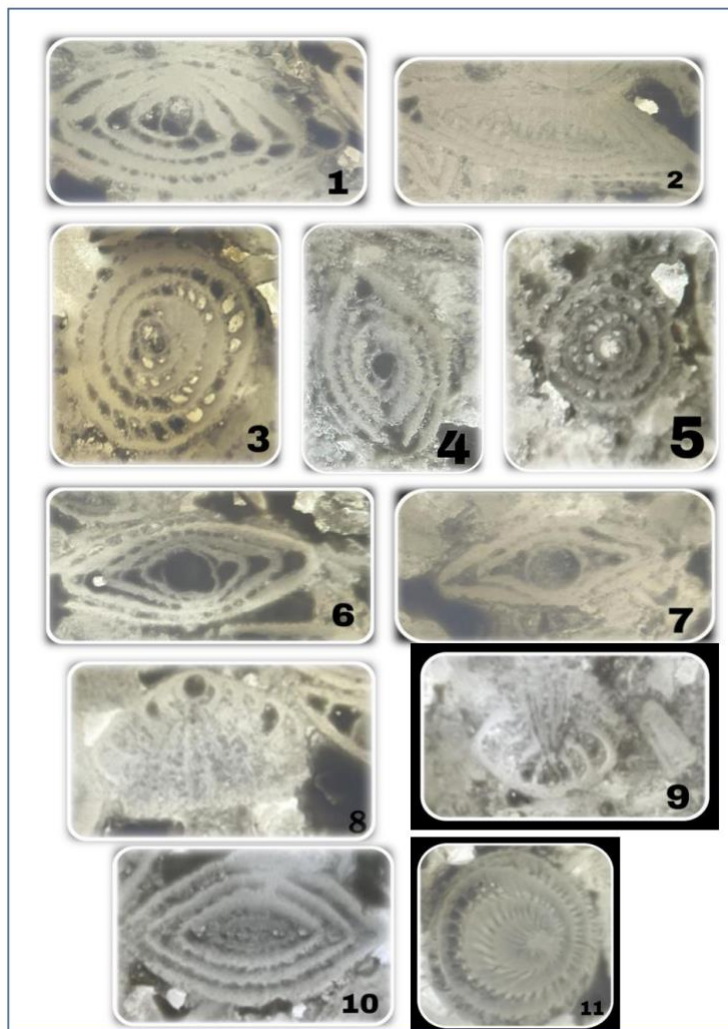


Fig.7. The identified foraminifera and other organism: 1. *Nummulites millecaput* X4; 2. *Lockhartis tipper*, X4; 3 and 5. *Nummulites. discorbinus*, X4; 6 and 7-*Nummulites bayhariensis* (CHECCHIA-RISPOL), X2; 8 and 9. *Lockhartis aleveolata* X5; 10. *Nummulites atacicus*, X4; 11. *N. lyelli* (D'ARCHIAC), X2.

B -*Nummulites elevate* Rang zone: This subzone is noticeable by the first recorded of *Nummulites elevate* (AL-HASHIMI AND AMER) and the last appearances of *Nummulites gizehensis* and *Nummulites milacaput*, this species as a lower limit and the disappearance of *N. elevate* as the upper limit, with a thickness of 15 m and is associated with fossils similar to: *N. planulatus* (LAMARCK), *N. bayhariensis* (CHECCHIA-RISPOL), *N. preforates* (MONTEORT), *N. discorbinus* (SCHLOTHIEM), *N. globulus* (LEYMERIE), *N. atacicus* (LEYMERIE), *N. beaumonti* (D'ARCHIAC), *Nummulites* sp., *Linderina chapmani* (HALKYARD), rotaliids, shell fragments, echinoid spines, algae, ostracods, Gastropod, and pelecypods in the upper part of the zone.

Age: for the Upper Member of Dammam Formation; depending on the presence of the assemblage fossils. It is located worldwide. However, some of these occurrences were recorded by a number of researchers e.g. Daci (1951) in Al-Hashimi (1972), Al-Hashimi and Amer (1985), and Al-Dulaimi &

Al-Wa'aly (2016). Therefore, in this study, this assemblage zone indicates the late Middle Damman Formation, which represents Middle Eocene (Late Upper Lutetian) age. According to (Jassim *et.al.*, 1984) many assemblages of the fossils above mentioned have existed within this zone. The *Nummulites gizehensis* Zone has existed in many countries, such as Iran as mentioned by Bozorgania, Benefit (1964) and Sampo (1969); Syria (Ejel, 1969); Egypt by Fahmy, (1969) and Said and Kerdany (1961); Pakistan by Kurreshy (1969).

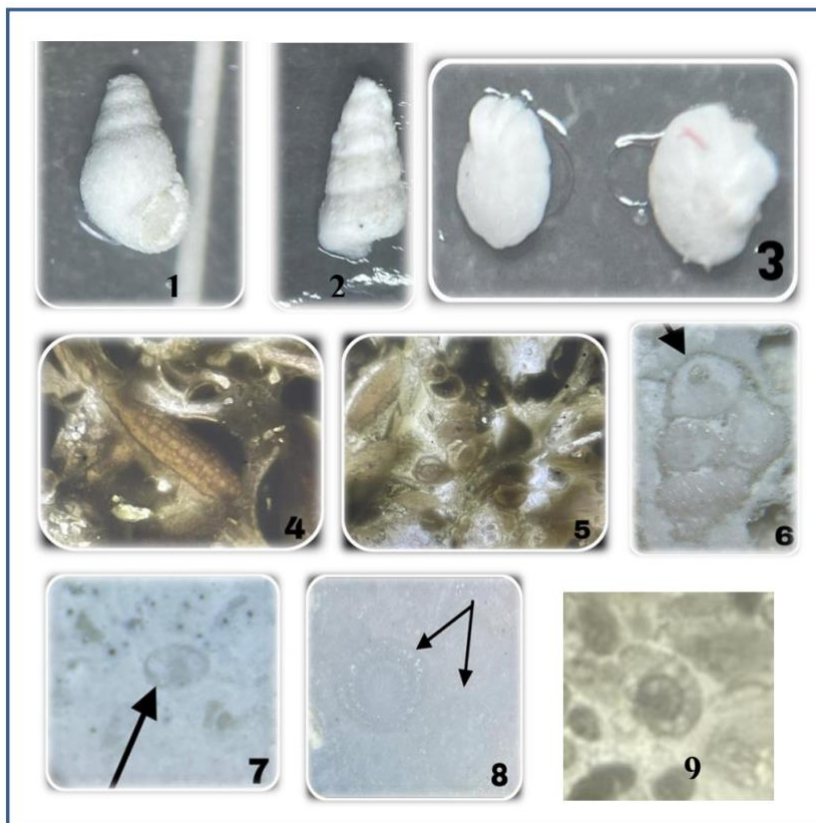


Fig. 8. The identified foraminifera and other organism: 1. Gastropoda (*Pacaudiella cf. flammulata*) X4; 2. Gastropoda Sp., X4; 3 and 7. *Ammonia beccarii* Sp., X20; 4. *Miogypsina globulina* (MICHELOTT), X1; 5. *Quinqueloculina* sp. with Gastropods; 6. *Guemblina* sp., X4; 8. *Rotalia* sp.x4; 9. *Peneroplis* sp. 4x.

5. Microfacies

Vertical alterations in lithology and faunal assemblages define it depending on the skeletal and non-skeletal components. As a result, many facies are seen during the formation's succession. In this investigation, two main microfacies were recorded, these are:

5.1. Packstone microfacies

this facies divided into two submicrofacies, these are:

5.1.1 Nummulitic packstone microfacies

This microfacies is characterized by prevailed of Foraminifera (Fig. 9A). The colors of these rocks are whitish grey, pale brown, brownish grey, and medium tough to tough. The recognized fossils are *Nummulites gizehensis zeitteli*, *Nummulites gizehensis* (FRSKAL), *Nummulites bayhariensis*, *N. elevata*, *N. planulatus*, *N. preforates*, *N. murchisoni*, *N. atacicus*, *N. globulus*, *N. millecaput*, *N.*

beaumonti, *Nummulites* sp., *Linderina bruce*, Rotaliids, with a little percent of echinoid spines, Gastropod, and shell fragments. It consists of bioclasts partially replaced by calcite crystals. The bearing microfacies for this assemblage is at a depth of 79.5 -82.5 m, The bioclasts are badly preserved as a result of severe silicified and remain as ghosts and biomoldic. These molds are thought to represent the space left by most of the completely dissolved fossils (Nummulites-shaped molds) (Fig. 4-c). The presence of larger foraminifera, miliolid, rotaliid, ostracods or maybe pelecypods, and quartz grains within the fossiliferous packstone is similar to ramp microfacies RMF16, which is packstone with abundant miliolid that deposited at characterizes restricted environment, which is deposited within the restricted platform (Flügel, 2010). Also, the *Nummulites*-gastropod association indicates the proximity of relatively restricted settings (Moody, 1987).

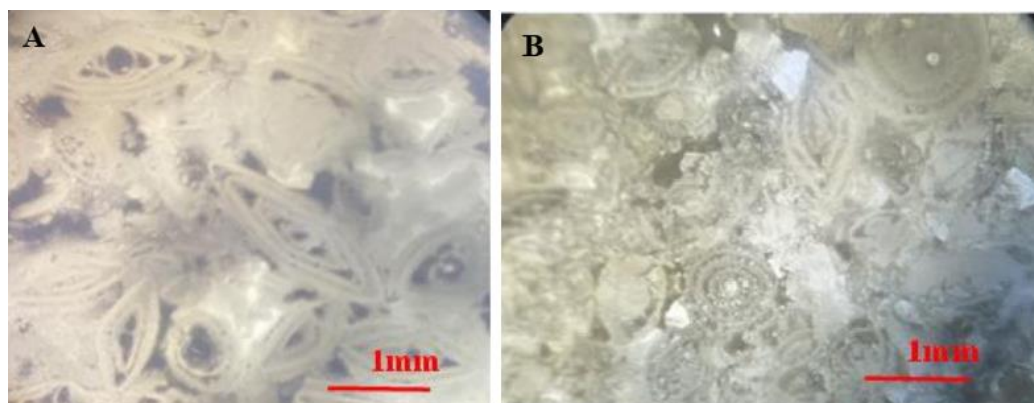


Fig. 9. A. Nummulitic packstone micofacies, depth 80m, B. Dolomitic and Bioclastic Packstone, depth 59 m. Kr-1, W. Iraq.

5.1.2. Dolomitic and Bioclastic Packstone microfacies

This microfacies contain different types of fossils besides the *Nummulites* swarms. The colors of these rocks are white to white grayish to gray, white to yellowish brown, grayish brown, light brown, fine crystalline, and medium tough to very tough. The identified fossils are: *Nummulites gizehensis zeitteli* (DE LA HARPE), *Nummulites bayhariensis*, *N. elevata*, *N. planulatus*, *N. mpreforates*, *N. ataticus*, *N. globulus*, *N. millecaput*, *N. beaumonti*, *Nummulites* sp., *Assilna* sp, pelecypods, ostracods, algae, echinoid spines, bryozoa, and shell fragments. It is considered to show an open marine condition, especially with the presence of bioclasts (Echinod fragments, shell fragments, *Lindrina* sp., *Assilina* sp., bryozoa, and other small foraminifera),

The main diagenetic processes that are affected in these facies are silicification, dissolution development, Biomolds, vugs, intercrystallite pores, and intraparticle with clear dispersion to the dolomite (Fig. 9 B).

The texture is a mixture of these bioclast presented as packstone (Fig.10), the matching of microfacies with ramp microfacies RMF 20 that deposited at restricted environments, it could be shallowed sometimes with abundant algae, in addition to the presence of dolomitic beds that effected with lagoon environment (Flügel, 2010).

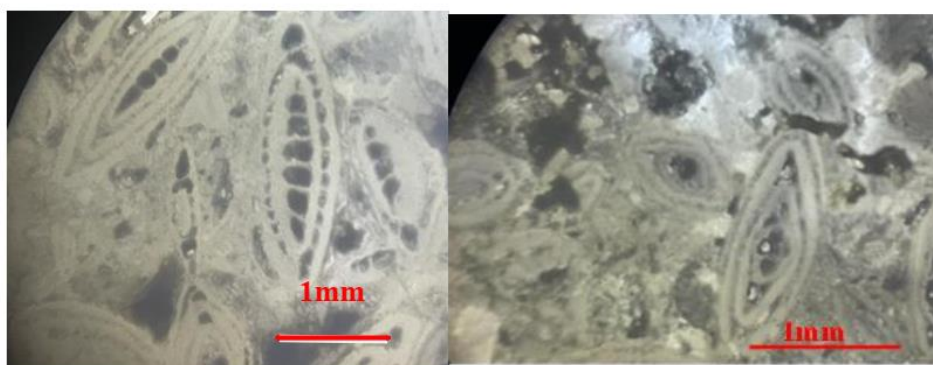


Fig.10. Bioclastic Packstone microfacies, depth 53m, Kr-1. W.Iraq.

5.2. Nummulitic Floatstone microfacies

The final microfacies presents a collection of different types of foraminifera (larger and smaller) with other fossils, most of the fossils exceed the 2mm size (Fig. 11(A, B and C)). The rocks of these facies are represented by white to whitish gray to gray, fine to medium crystalline, and medium tough to tough. The recognized fossils are *Nummulites gizehensis zeitteli*, *N. gizehensis*, *N. elevata*, *N. bayhariansis*, *N. planulatus*, *N. munchisoni*, *Nummulites* sp., *Linderina chapmani*, *Li. brugesi*, *Linderina* sp., ostracods, echinoids, and shell fragments. The observed diagenetic processes in these microfacies are: recrystallization, dissolution (vugs, intraparticle, intercrystallite, and fracture), and effected in the cementation by calcite. This facies is equivalent to the ramp microfacies RMF 26, which is deposited at open marine. The larger Nummulitic Floatstone at a depth of 63.5 m and a depth of 94.5 m are dominant skeletal grains. Reekman and Friedman (1982) suggested that the larger size of the grain (*Nummulites* sp. in the current study) would be a perfect indicator of shoal or barrier.

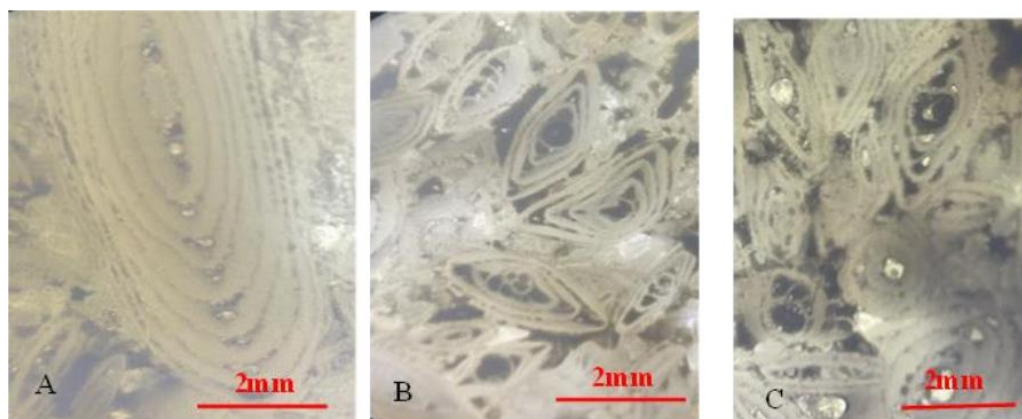


Fig. 11. Nummulitic Floatstone Facies, A; depth 63 m, B and C depth 77 m. Kr-1. W. Iraq.

6. Depositional environment of the Dammam Formation

The depositional environment of *Nummulites* accumulations is often challenging to interpret because *Nummulite*'s paleoecology is poorly understood (Racey, 2001), details gained from textural and faunal properties helped in the designation of microfacies zones leading to environmental subdivisions for suggested ramp platform. For the Dammam formation: restricted, shoal, and open marine environments.

Nummulites sp. is the index fauna of the Dammam Formation. It is found both as whole tests and broken ones. *Nummulites* sp. is found within different assemblages of fossils. *Nummulites* sp. It

characterizes shallow waters both inner and outer platform or ramp (Flügel, 2010). Sartorio and Ventarini (1988) suggested a platform-edge environment. Larger foraminifera has been a common constituent of shallow-marine shelf carbonates formed in warm water environments since the Late Paleozoic. Extensive Cretaceous and Cenozoic shelf carbonates were produced by large benthic foraminifera (Hallock 1981).

Depending on the samples of a borehole (Kr-1) in deducing the microfacies. Different authors in various locations have provided descriptions of the depositional environment that resulted in the Middle Member of the Dammam Formation. According to Henson (1950), Porkony (1958), and Al-Hashimi (1973 and 1974), it deposited in a neritic sublittoral fore reef shoal zone of shallow warm water temperature. Amer (1980) noted that the Middle Dammam Formation's sediment and accompanying fauna were laid down in a neritic sublittoral fore reef shoal zone of shallow warm water temperature. Buday (1980) came to the conclusion that the Western and Southern Deserts' creation took place predominantly in a shallow neritic environment. In the southwest of Busaiya, it is tropical and subtropical marine with a depth of not more than 20 m (Al-Sharbati and Ma'ala, 1983), according to Al-Mubarak and Amin's (1983) description of the Middle Member as shallow marine tropical-subtropical with a depth of not more than 100 m. It is tropical and subtropical marine to the south of Samawa (Al-Ani and Ma'ala, 1983). According to Jassim et al. (1984), the environment consisted of an inner shelf to shelf depth shallow marine environment that was followed by well-defined warm normal marine conditions that gave rise to vast shoals of enormous nummulites and Mollusca fauna. Miliolids and alveolinids were in large quantities, which suggested that these conditions were more salinized. Al-Hashimi and Amer (1985) hypothesized that the region of the Dammam Formation deposition, which is distinguished by dolomitic limestone and predominate occurrences of miliolids and *Peneroplis*, was covered by generally confined maritime platform (lagoon) facies. Mahdi and Youkhanna (1996) identified the tropical-subtropical shallow marine depositional environment of the Middle Member of the Dammam Formation as having a depth of not more than 100 m. In this study, the Middle Member of the Dammam Formation is dated to the Middle Eocene. The presence of *Nummulites gizehensis* and large *Nummulites* sp., which were deposited in shallow warm tropical water and marine environments, as well as the lack of planktonic foraminifera.

7. Conclusions

This study has the following conclusions:

One biozone was recognized, *Nummulites gizehensis*- *Nummulites planulatus* - *Nummulites discorbinus* Assemblage Zone of Middle Eocene (Upper Lutetian) age. It is divided into two subbiozone.

a- *Nummulites elevata* Rang zone (Late Upper Lutetian age).

b- *Nummulites millecaput* Rang zone (Middle Upper Lutetian age).

This biozone indicates the Middle Eocene (Late Lutetian) age for the Middle Member of the Dammam Formation. Three main and secondary microfacies were recognized in the Dammam Formation from Borehole (Kr-1), these are: Nummulitic packstone, Dolomitic and Bioclastic Packstone, and Floatstone. Depending on microfacies and biostratigraphy, the Dammam Formation was deposited in different environments including a restricted-marine platform, open interior platform, and platform margin sand shoals or lagoon. In the current study, the *Miogypsina* sp. (index fossil of the Euphrates Formation).

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