THE BIOSTRATIGRAPHY, MICROFACIES AND DEPOSITIONAL ENVIRONMENT OF THE DAMMAM FORMATION IN BOREHOLE NO.1, SOUTH SAMAWA AREA, SOUTHERN DESERT, IRAQ

Kifah N. Al-Kubaysi[1]

Received: 28/ 07/ 2013, Accepted: 05/ 02/ 2014
Key words: Dammam Formation, Microfacies, Eocene, *Nummulites*, Iraq

ABSTRACT

This study deals with the biostratigraphy, microfacies and depositional environments of the rocks of the Dammam Formation (Eocene) encountered in Borehole No.1 in South Samawa, Southern Desert, Iraq. Seventy four samples were studied and three formations were identified, they are from the oldest to the youngest: Rus Formation (Early Eocene), Dammam Formation (Middle – Late Eocene) and Euphrates Formation (Early Miocene). Different species of the foraminifera were identified within the Dammam Formation, two biozones were recognized; they are from the older to the younger:

- *Nummulites gizehensis* Zone of Middle Eocene (Late Lutetian) age
- Miliolids – Peneroplid Assemblage Zone of Late Eocene (Bartonian) age

The first biozone indicates Middle Eocene age for the Middle Member of the Dammam Formation and the second biozone indicates Late Eocene age for the Upper Member of the formation.

The Dammam Formation revealed three microfacies depending on the fossils content and lithological characters, these are from top to bottom:

- Dolomitic Wackestone – Packstone Facies
- Foraminiferal Dolomitic Packstone Facies
- Nummulitic Dolomitic Packstone – Floatstone Facies

The depositional environment of the Dammam Formation was determined by application of the environment triangle depending on the species of different groups of foraminiferal assemblages, which show that the depositional environment of the Dammam Formation extends from shelf sands area (winnowed edge sands FZ6) and the shoal to the open platform area (shelf lagoon open circulation FZ7) and its continuation to the restricted platform area (restricted circulation inner shelf and tidal flats FZ8).

الطباقية الحياتية، السحنات الدقيقة والبيئة الترسيبية لتكوين الدمام في بئر رقم 1، جنوب السماوة، الصحراء الجنوبية، العراق

كفاح نوري الكبيسي

المستخلص

تمت دراسة الطباقية الحياتية لتكوين الدمام (عمر الإيوسين) في بئر رقم 1، جنوب السماوة، الصحراء الجنوبية في العراق. وذلك من خلال دراسة 74 نموذج ووجد أن العمود الطباقي في البئر يتمثل بثلاث تكوينات هي من الأقدم الى الأحدث: تكوين الرص (الإيوسين المبكر)، تكوين الدمام (الإيوسين الأوسط – المتأخر) وتكوين الفرات (المايوسين المبكر). تم تمييز أنواع مختلفة من الفورامنيفيرا ضمن تكوين الدمام وتم تمييز نطاقين حياتيين وهما:

- *Nummulites gizehensis* Zone of Middle Eocene age (Late Lutetian) age
- Miliolids Peneroplid Assemblage Zone of Late Eocene age (Bartonian) age

[1] Senior Chief Geologist, Iraq Geological Survey

حدد النطاق الأول عمر الإيوسين الأوسط للعضو الأوسط لتكوين الدمام، بينما حدد النطاق الثاني عمر الإيوسين المتأخر للعضو الأعلى للتكوين.

أظهرت الدراسة ثلاث سحنات دقيقة لتكوين الدمام اعتمادا على التغير الحاصل في الوصف الصخاري والحياتي، وهي من الأعلى الى الأسفل:

- سحنة الحجر الجيري الدولومايتي الواكي – المرصوص
- سحنة الحجر الجيري الدولومايتي المرصوص الحامل للفورامينيفيرا
- سحنة الحجر الجيري الدولومايتي النيميولايتي المرصوص – الفلوتستون

تم استنباط البيئة الترسيبية للصخور الجيرية لتكوين الدمام وذلك بتطبيق مثلث البيئة باستخدام أفراد مجاميع الفورامنيفيرا المختلفة بصورة أساسية، حيث تبين أن منطقة ترسيب التكوين تمتد من منطقة رمال الرصيف، حيث يتكون جسم الحيد من الفورامينيفيرا الكبيرة (النيميولايت) الى منطقة الرصيف القاري المفتوح وعلى امتداده وصولا الى منطقة المياه المحصورة.

INTRODUCTION

The Dammam Formation was first described by Sandrey (1952) in Bellen *et al*. (1959) from its type locality in the Dammam Dome in Saudi Arabia. A supplementary type section in Iraq was described by Owen and Nasr (1958) from B.P.C. Oil Well Zubair 3, in Basrah area, South Iraq. It is defined by the following coordinates:

Longitude 47° 43' 29" E Latitude 30° 23' 01" N

Lithologically, the formation in the supplementary type section consists of whitish grey, porous, dolomitized limestone; the limestone is sometimes chalky (Owen and Nasr, 1958).

The Dammam Formation was studied paleontologically through 74 samples collected from Borehole No.1, which was drilled by GEOSURV, during execution of detailed geological mapping in South Samawa in 2010 – 2011 (Ajar *et al*., 2011). Three formations were recognized from the studied samples; these are from the oldest to the youngest:

- Rus Formation (Early Eocene)
- Dammam Formation (Middle – Late Eocene)
- Euphrates Formation (Early Miocene)

▪ Location

The studied borehole is located south of Samawa area, Iraqi Southern Desert, at the following coordinates (Fig.1.):

Longitude 45° 07' 00" E Latitude 31° 05' 00" N

▪ Aim

The aim of this study is to give an idea about the stratigraphy, the microfacies and the depositional environment of the Dammam Formation by application of the environment triangle suggested by Hallock and Glenn (1986).

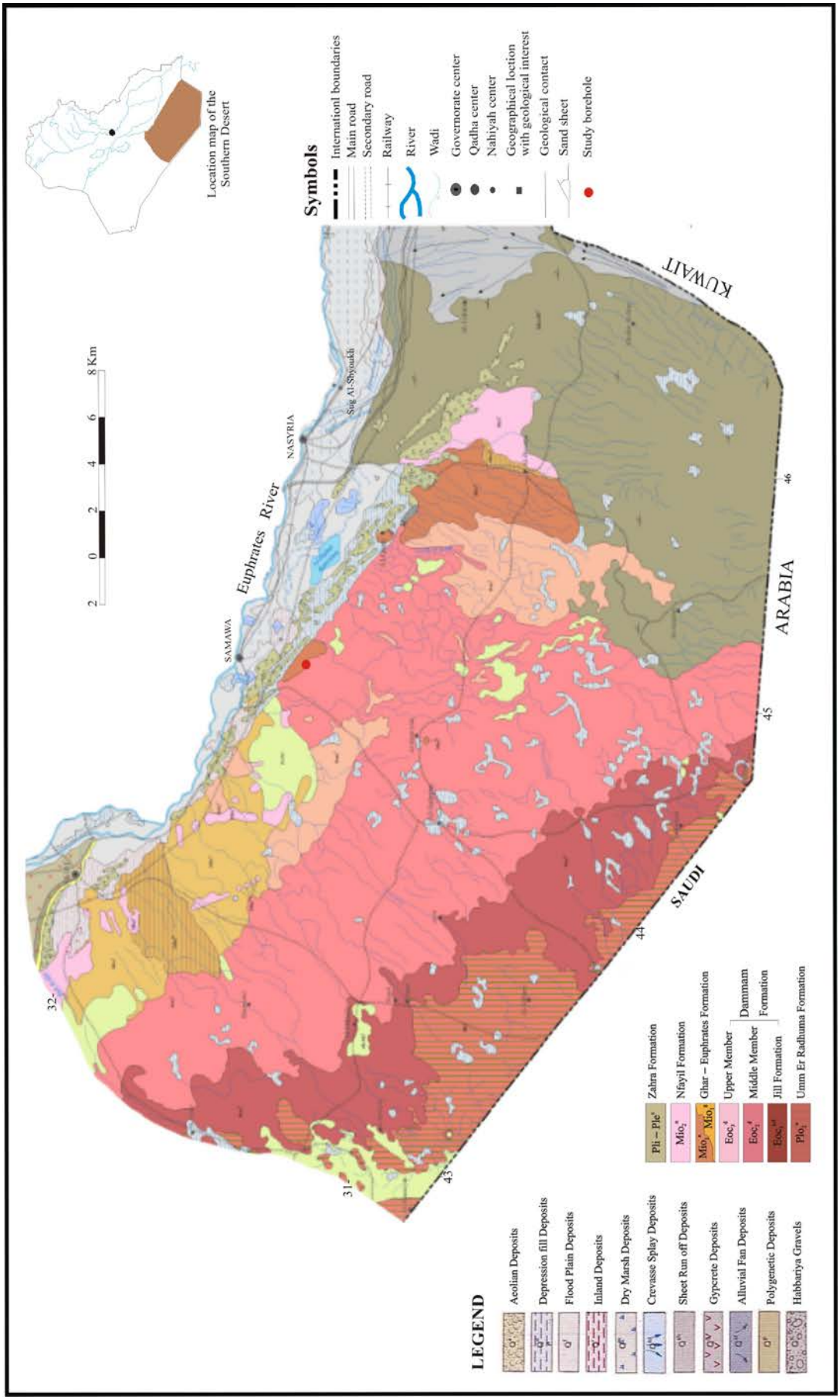

Fig.1: Geological map of the Iraqi Southern Desert (after Sissakian and Fouad 2012)

▪ **Previous Work**

The following works were executed concerning the Dammam Formation:

– Al-Hashimi (1974), studied the stratigraphy and paleontology of the Dammam Formation (Middle Eocene) from subsurface rocks of Samawa area, and divided the formation into two lithological units and four biostratigraphic zones.
– Amer (1980), studied the biostratigraphy and micropaleontology of the Dammam Formation (Early – Middle Eocene), from West Najaf – Nukhaib area, and divided the formation into three biostratigraphic zones.
– Yousif (1981), studied the biostratigraphy and paleoecology of the Dammam Formation (Early – Middle Eocene), from South Nukhaib area, and recognized three lithological units (Wagsa, Shabicha and Shawiya).
– Mohmood (1983), studied the biostratigraphy and paleontology of the Dammam Formation (Early – Middle Eocene) from Shabicha area, Southern Desert, and divided the formation into two biostratigraphic zones.
– Al-Mutter (1983), studied the biostratigraphy of the Dammam Formation (Early – Middle Eocene) from South Najaf area, and divided the Formation into four biostratigraphic zones.
– Muniem (1983), studied the biostratigraphy of Early Eocene – Late Miocene of West Samawa area, Southern Desert, and divided the Dammam Formation into five biostratigraphic zones.
– Yousif (1983), studied the micropaleontology and biostratigraphy of the Dammam Formation in Borehole No.7, Abu Rudham, and indicated one biostratigraphic zone.
– Al-Mutter (1984), studied the biostratigraphy of the Dammam Formation (Early – Middle Eocene) from South Salman area, and divided the formation into four biostratigraphic zones.
– Raji and Said (1984), studied the paleontology of the Dammam Formation (Late Eocene) in South Samawa area, and they divided the formation paleontologically into two members.
– Al-Kubaysi (2013), studied the biostratigraphy of the Dammam Formation (Middle – Late Eocene) from subsurface rocks of South Samawa area, and divided the formation paleontologically into two members.

BIOSTRATIGRAPHY

The biostratigraphy, fossils and age of the Dammam Formation are briefly mentioned hereinafter.

▪ **Stratigraphy**

In this study, three formations are recognized from the studied samples. These are described from oldest to youngest hereinafter (Fig.2).

– Rus Formation: The Rus Formation represents the oldest recognized formation in the borehole. It is dominated by dolomite, marl and gypsum with 14.1 m thick (drilling depth 115.9 – 130 m). This formation is not exposed on the surface; but it is encountered in most subsurface wells of south and southwest Iraq (Al-Hashimi and Amer, 1985).

– Dammam Formation: The Eocene sediments were deposited during the final phase of subduction and the closure of the remnant Neo-Tethys Ocean (Buday and Jassim in Jassim and Goff, 2006). One formation is exposed within this period in the Southern Desert, which is represented by 112.9 m thick (drilling depth 3.0 – 115.9 m) of the Dammam Formation. It has been divided paleontologically into two members, these are:

Middle Member: It consists of limestone, dolomitic limestone, clayey limestone and nummulitic dolomitic limestone, with thickness of 64.9 m (drilling depth 51.0 – 115.9 m).

Upper Member: consists of dolomite, dolomitic limestone**,** fossiliferous limestone and biomoldic limestone, with thickness of 48.0 m (drilling depth 3.0 – 51.0 m).

– Euphrates Formation: The Euphrates Formation represents the youngest recognized formation in the borehole. It is dominated by breccia, composed of rock fragments of dolomitic limestone, rusty material, veins full with crystals of calcite. The thickness is 2.5 m (drilling depth 0.5 – 3.0 m).

- **Fossils**

Different species of the foraminifera were identified in the studied samples, which represent the Dammam Formation. They represent two biozones (Fig.3), which are described hereinafter from oldest to youngest:

– *Nummulites gizehensis* Zone: This zone (with thickness of 62.5 m) is marked by the first appearance of excellent index fauna, *Nummulites gizehensis* FÖRSKAL (Fig.4.1) and other associated fauna like: *Nummulites bayhariensis* CHECCHIA-RISPOL (Fig.4.2), *N. elevata* (AL-HASHIMI AND AMER) (Fig.4.3), *N. planulatus* (LAMARCK) (Fig.4.4), *N. gizehensis zeitteli* DE LAHARPE (Fig.5.1), *N. murchisoni* (RUTIMEYER), *N. striatus* (BRUGUIERE), *Nummulites* sp. (fragments), *Linderina chapmani* HALKYARD (Fig.5.2), *L. brugesi* SCHLUMBERGER (Fig.5.3), *Linderina* sp., *Spiroculina depressa* D'ORBIGNY (Fig.5.4), *Alveolina munieri* HOTTINGER (Fig.5.5), *Alveolina* sp., *Lockhartia alveolata* SILVESTRI (Fig.6.1), *Lockhartia* sp., *Rotalia trochidiformis* LAMARCK (Fig.6.2), *Rotalia* sp., *Bolivina* sp., *Coskinolina* sp., *Heterostegina* sp., miliolids, ostracods, algae, echinoid, brozyoa (Fig.6.3) and shell fragments.

– Miliolids – Peneroplid Assemblage Zone: This zone is marked by abundant appearances of assemblage fauna of miliolids and peneroplid, with thickness of 48.0 m and is associated with fauna like: *Lituonella* sp. (Fig.7.1), *Rhapydionina urensis* HENSON (Fig.7.2), *Rhapydionina* sp., *Praerhapydionina huberi* HENSON, *Praerhapydionina* sp., *Spiroculina* sp., *Rotalia* sp., *Peneroplis* sp. (Fig.7.3), *Coskinolina* sp. (Fig.8.1) *Nummulites* sp., *Textularia* sp., *Alveolina* sp., *Pyrgo* sp., *Bolivina* sp., *Bigenerina* sp. (Fig.8.2), *Elphidium* sp. (Fig.8.3), rotallids, shell fragments, echinoids, algae (Fig.8.4), ostracods and corals.

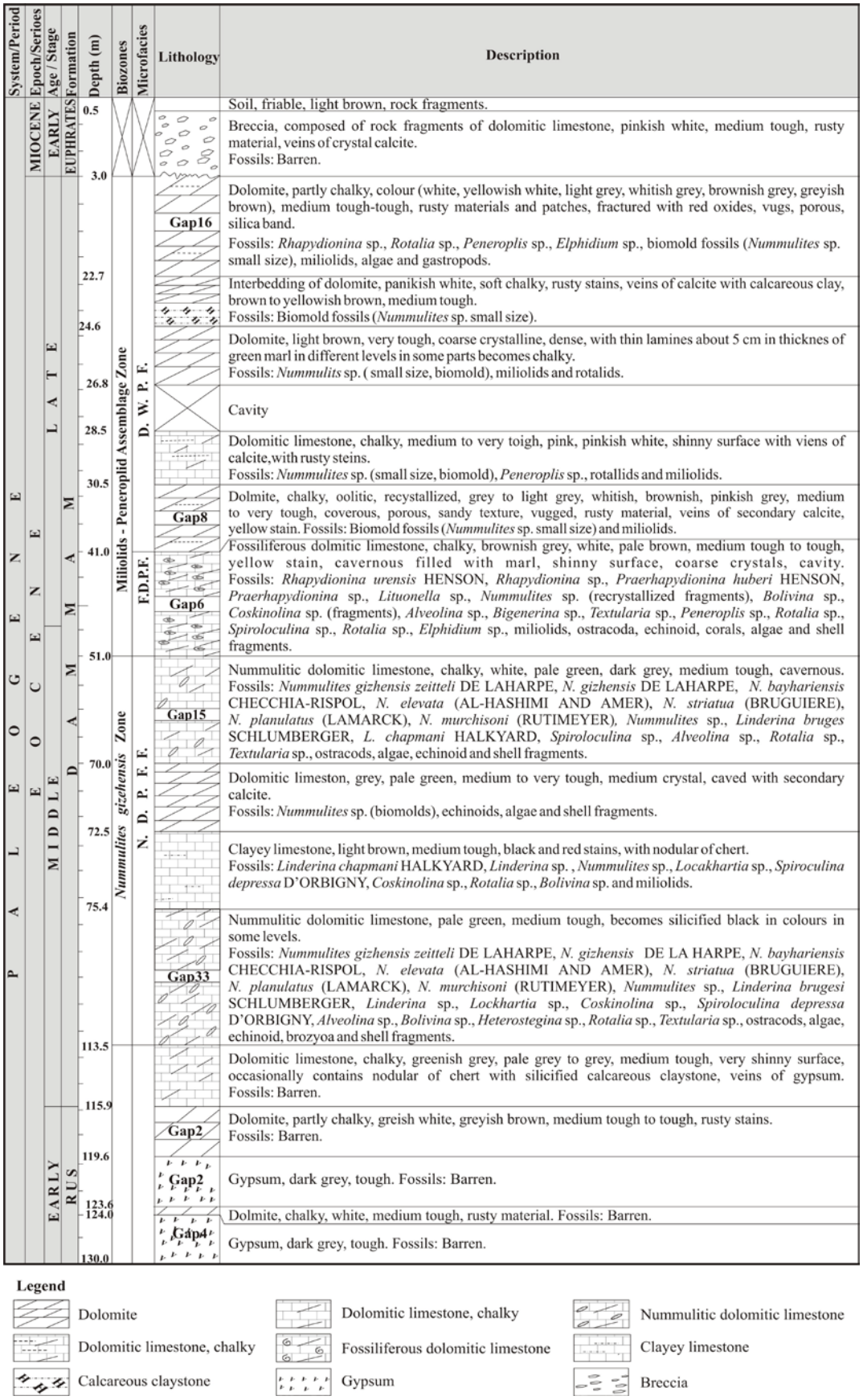

Fig.2: Stratigraphic column of Borehole No.1

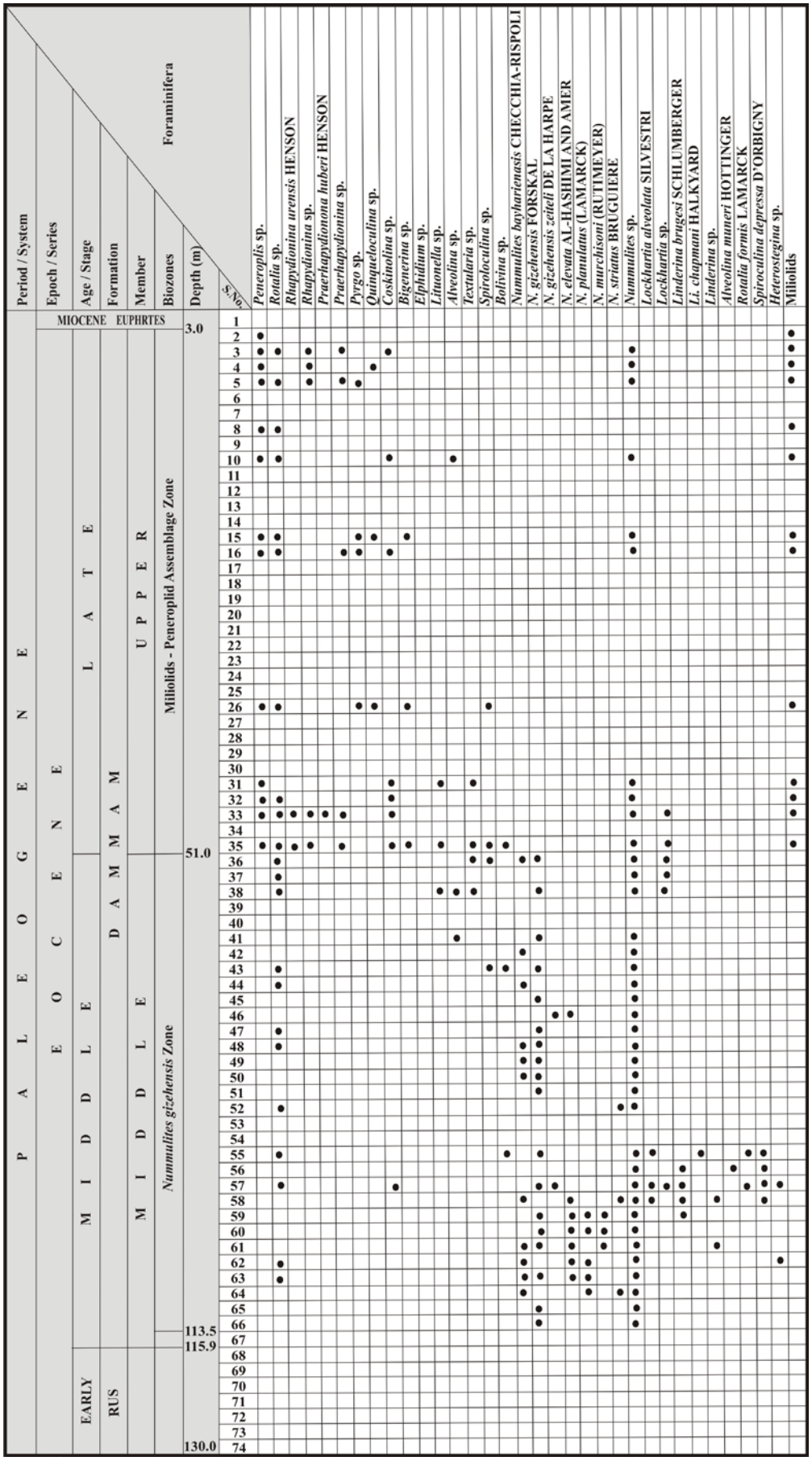

Fig.3: Distribution chart of the foraminifera in the studied samples of the Borehole No.1

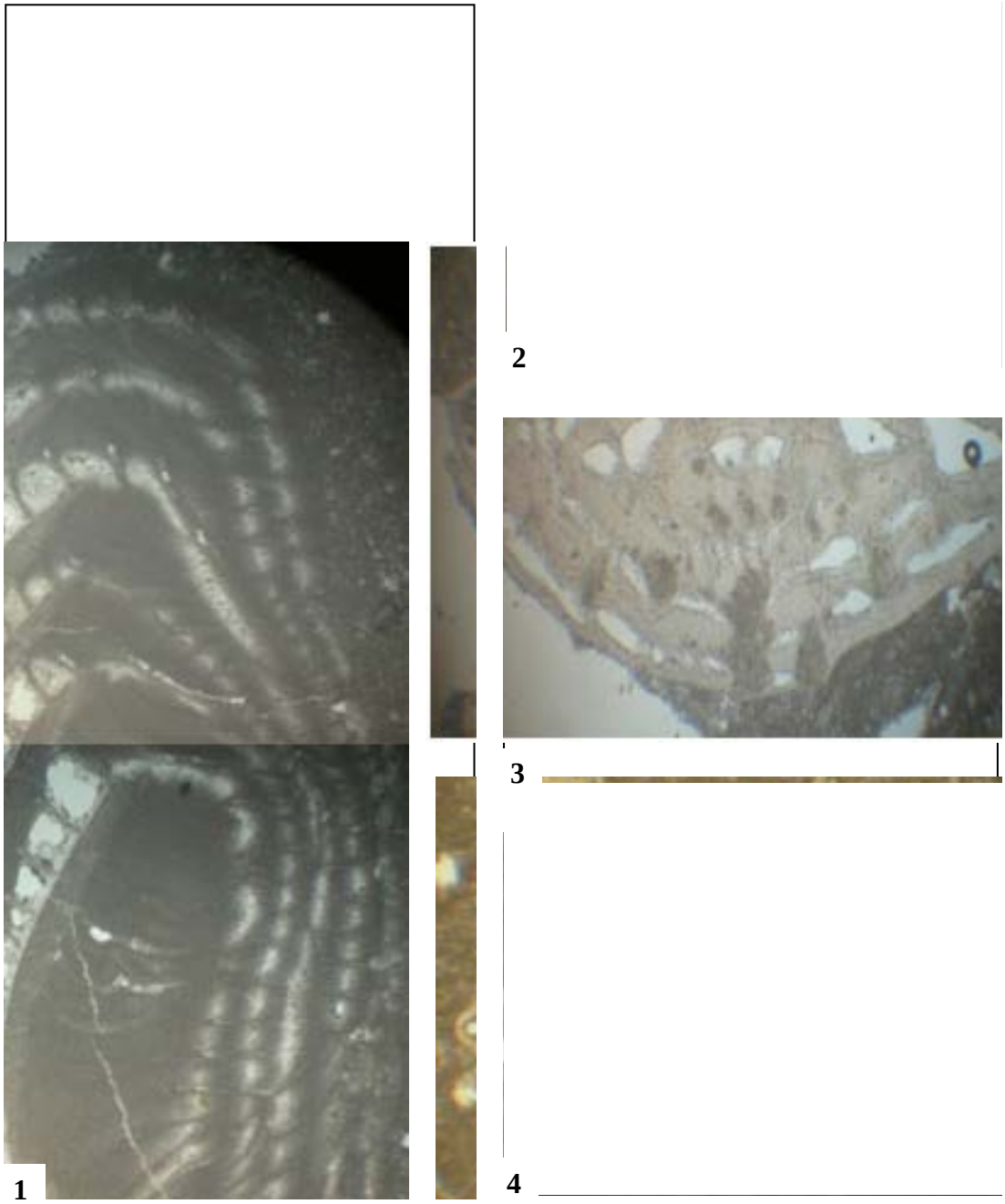

Fig.4: The indentified foraminifera:

1. *Nummulites gizehensis* FÖRSKAL, X2.5
2. *Nummulites bayhariensis* CHECCHIA-RISPOL, X4
3. *Nummulites elevata* (AL-HASHIMI AND AMER), X4
4. *Nummulites planulatus* (LAMARCK), X4

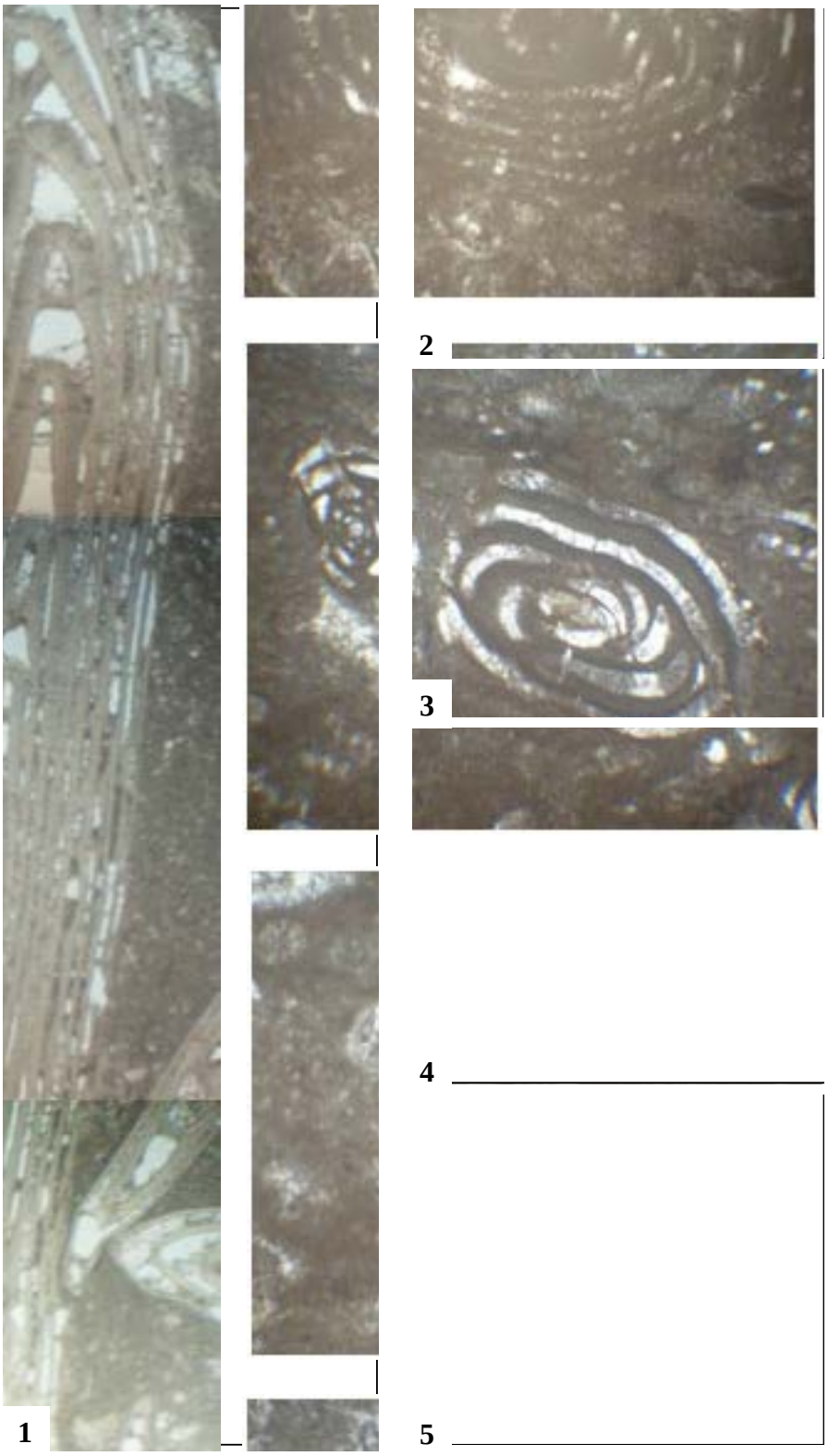

Fig.5: The indentified foraminifera:

1. *Nummulites gizehensis zeitteli* DE LA HARPE, X2.5
2. *Linderina chapmani* HALKYARD, X10
3. *Linderina brugesi* SCHLUMBERGER, X10
4. *Spiroculina depressa*, D'ORBIGNY, X5
5. *Alveolina munieri* HOTTINGER, X5

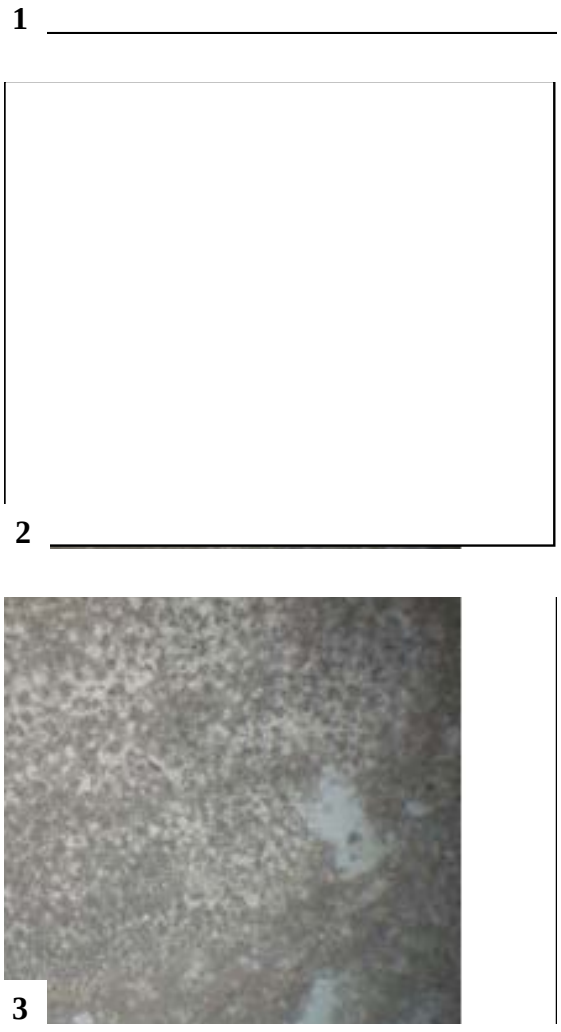

Fig.6: The indentified foraminifera:
1. *Lockhartia alveolata* SILVESTRI, X10
2. *Rotalia trochidiformis* LAMARCK, X10
3. Brozyoa, X6.3

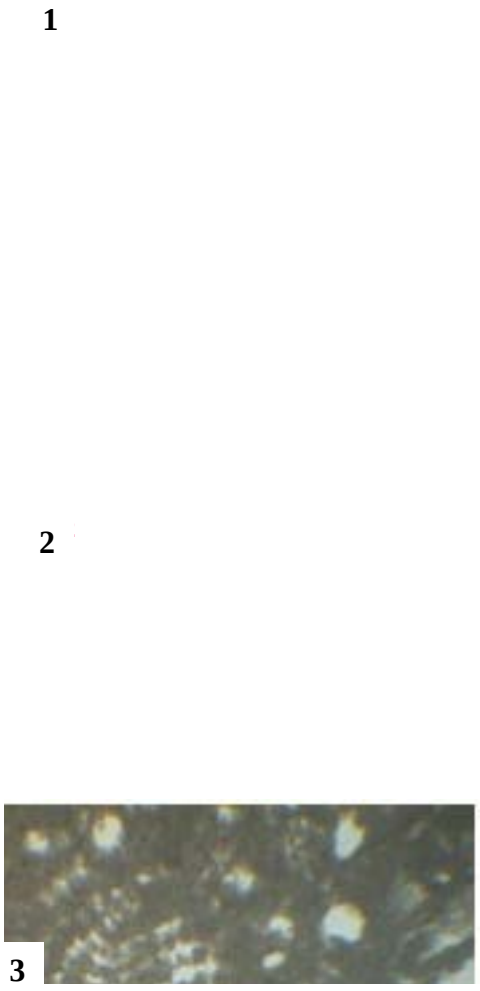

Fig.7: The indentified foraminifera:
1. *Lituonella* sp., X10
2. *Rhapydionina urensis* HENSON, X6.3
3. *Peneroplis* sp., X6.3

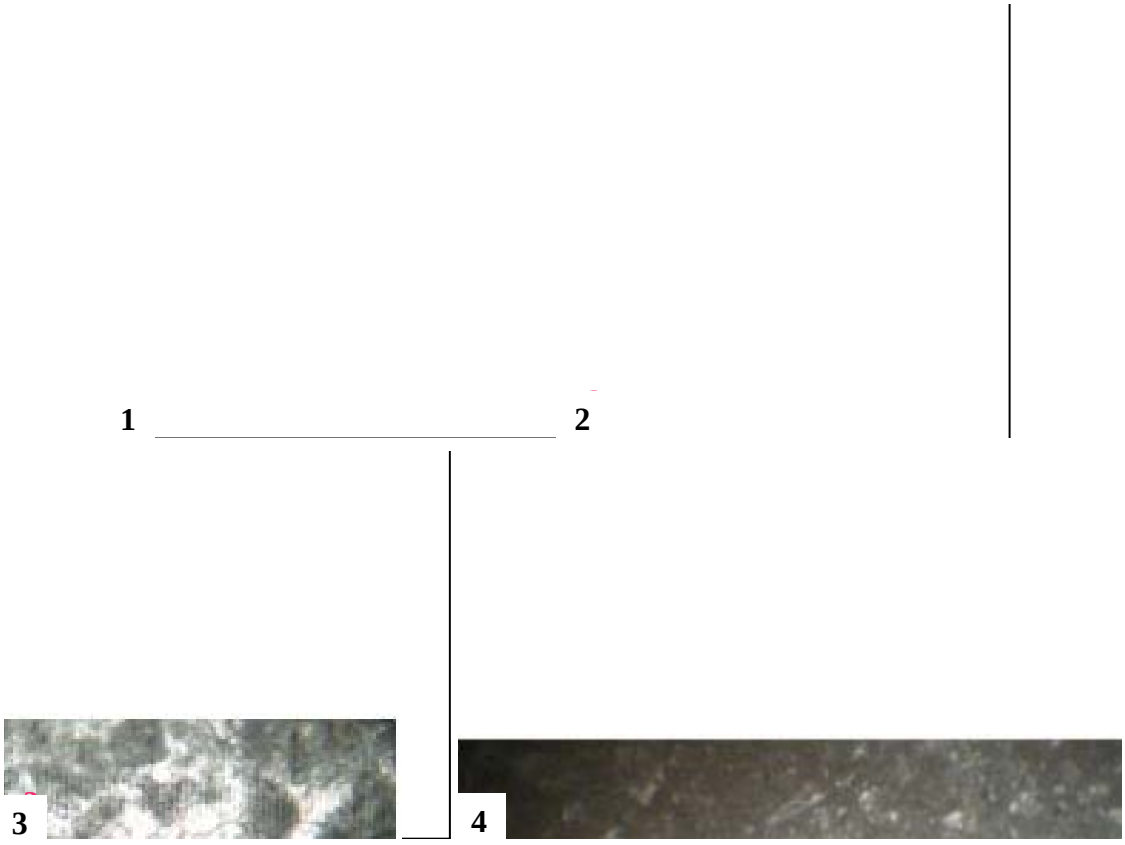

Fig.8: The indentified foraminifera:
1. *Coskinolina* sp., X5
2. *Bigenerina* sp., X10
3. *Elphidium* sp., X10
4. Algae, X4

▪ **Age**

According to Said (1950 and 1951), Ejel (1969), Al-Hashimi (1972), Karim (1977), Al-Mutter (1979) and Amer (1980),the *Nummulites gizehensis* FÖRSKAL represents excellent index species of Middle Eocene (Late Lutetian) age; therefore, in this study we indicate Middle Eocene (Late Lutetian) age for the Middle Member of the Dammam Formation; depending on the presence of *Nummulites gizehensis* Zone.

Yousif (1983) and Al-Hashimi and Amer (1985) indicated Late Eocene (Bartonian) age for the Upper Member of the formation; depending on the presence of the assemblage fossils, which are similar to the Miliolids – Peneroplid Assemblage Zone; therefore, in this study we indicate the same age for the Upper Member of the Dammam Formation.

MICROFACIES OF THE DAMMAM FORMATION

The Dammam Formation is widely exposed in the southwestern part of Iraq. It is faunal characterized by vertical changes in lithology and fauna assemblages. Therefore, different facies are encountered throughout the succession of the formation. Dunham (1962) and Embry and Klovan (1971) classifications of calcareous rocks were adopted in this study for purpose of determining the different microfacies and to compare them with the standard microfacies types (SMF) and facies zone (FZ), while their depositional environments are interpreted as categorized by Wilson (1975). The following microfacies were recognized:

▪ **Dolomitic Wackestone – Packstone Facies**

The rocks of this facies are represented by samples No. (2 – 28) (depth interval 3.0 – 41.0 m), they are yellowish white to white, pinkish white, brown to yellowish brown, grayish brown, light brown, pink, pale green – green, and yellowish grey to light grey, medium tough to very tough (Fig.9). The total thickness of this facies is 38.0 m. The identified fossils are *Rhapydionina* sp., *Praerhapydionina* sp., *Peneroplis* sp., *Rotalia* sp., *Elphidium* sp., biomold of *Nummulites* sp. (Fig.10), biomolds of fossils, miliolids, rotallids, algae, gastropoda, echinoids and shell fragments. The main digenetic processes affected this facies are dolomitization, dedolomitization, selective silicification, selective phospharitization, dissolution and porosity. Biomolds, vugs, intercrystalline pores and intraparticles are developed as the result of severe dolomitization and cementation of some pores by granular calcite. This facies is equivalent to the standard microfacies SMF24, which is deposited within the restricted platform and lagoon (restricted circulation shelf and tidal flats FZ8) area.

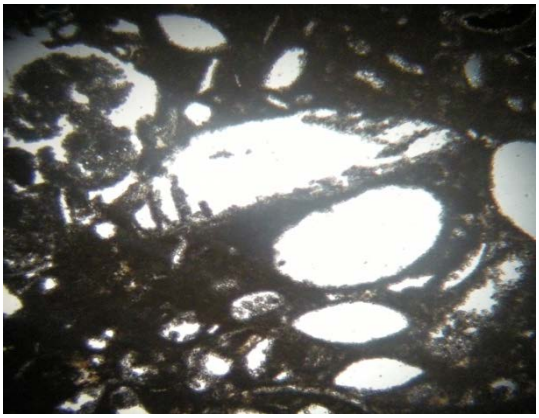

Fig.9: Dolomitic Wackestone – Packstone Facies, X2.5

Fig.10: Biomolds fossils (*Nummulites* sp.) in Dolomitic Wackestone – Packstone Facies, X2.5

▪ **Foraminiferal Dolomitic Packstone Facies**

The rocks of this facies are represented by samples No. (29 – 35) (depth interval 41.0 – 51.0 m), they are white, pale brown, brownish grey, medium tough to tough. The total thickness of this facies is 10.0 m. The identified fossils are *Rhapydionina urensis* HENSON, *Rhapydionina* sp., *Praerhapydionina huberi* HENSON, *Praerhapydionina* sp., *Lituinella* sp., *Nummulites* sp. (recrystallized fragments), *Coskinolina* sp., *Textularia* sp., *Spiroloculina* sp., *Bigenerina* sp., *Bolivina* sp., *Peneroplis* sp., *Rotalia* sp., *Elphidium* sp., biomolds of fossils, rotallids, algae, miliolids, corals, gastropoda, ostracods, echinoids and shell fragments. The main digenetic processes, which have affected this facies are partial dolomitization; affected groundmass and some fossils, recrystallization from fine to medium crystals, dissolution resulting in the formation of pores (biomolds and vugs) and selective cementation of some pores. This facies (Fig.11) is equivalent to the standard microfacies SMF10, which is deposited within the open platform (shelf lagoon open circulation FZ7) area.

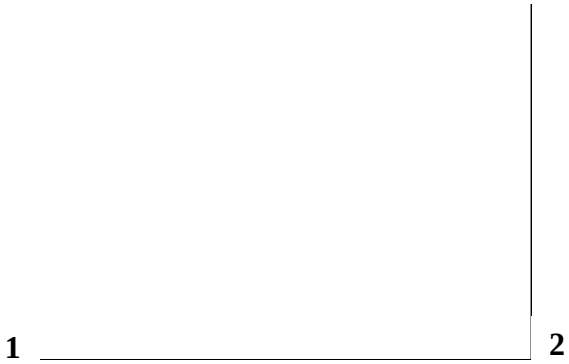

Fig.11: Foraminiferal Dolomitic Packstone Facies, X6.3

▪ **Nummulitic Dolomitic Packstone Floatstone Facies**

The rocks of this facies are represented by samples No. (36 – 66) (depth interval 51.0 – 113.5 m.), they are white, pale brown, pale green, greenish grey, pale grey, medium tough to tough. The total thickness of this facies is 62.5 m. The identified fossils are *Nummulites gizehensis zeitteli* DE LAHARPE, *N. gizehensis* FÖRSKAL, *N. elevata* (AL-HASHIMI AND AMER), *N. bayhariansis* CHECCHIA-RISPOL, *N. striatus* (BRUGUIERE), *N. planulatus* (LAMARCK), *N. murchisoni* (RUTIMEYER), *Nummulites* sp., *Linderina chapmani* HALKYARD, *L. brugesi* SCHLUMBERGER, *Linderina* sp., *Spiroloculina depressa* D'ORBIGNY, *Spiroloculina* sp., *Coskinolina* sp., *Textularia* sp., *Bolivina* sp., *Rotalia* sp., *Alveolina munieri* HOTTINGER, *Alveolina* sp., *Lockhartia alvealata* SILVESTRI, *Lockhartia* sp., *Heterostegina* sp., algae, miliolids, brozyoa, ostracods, echinoids and shell fragments. (Fig.12). The main digenetic processes, which have affected this facies are partial dolomitization, selective dedolomitization, recrystallization, dissolution resulting pores (biomolds, vugs, intraparticles, intercrystalline, veinlets and fracture) and then cemented by calcite. This facies is equivalent to the standard microfacies SMF12, which is deposited within the shelf sands (winnowed edge sands FZ6) area.

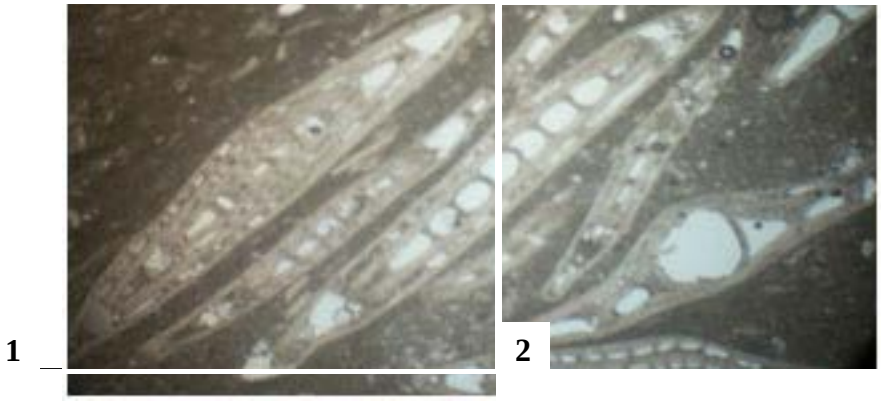

Fig.12: Nummulitic Dolomitic Packstone – Floatstone Facies, X2.5

DEPOSITIONAL ENVIRONMENT OF THE DAMMAM FORMATION

The depositional environment of the Dammam Formation was described by different authors in different localities. Henson (1950); Pokorny (1958) and Al-Hashimi (1973) claimed that the sediments and the associated fauna of Middle Member of the Dammam Formation are deposited in a neretic sub littoral fore reef shoal zone of shallow warm water temperature. Al-Hashimi (1972) claimed that the sediments of the Upper Member of the Dammam Formation are deposited under shallowing or regression, littoral and lagoonal conditions suggested by the high occurrence of miliolids and *Peneroplis* faunal assemblage. Buday (1980) concluded the environment for the formation in the Western and Southern Deserts, to be mostly shallow neretic environment. Amer (1980) recognized that the sediments and the associated fauna of the Middle Member of the Dammam Formation are deposited in a neretic sub littoral fore reef shoal zone of shallow warm water temperature. According to Bonefous and Bismuth (1982), the presences of miliolids and *Peneroplis* sp.are good indication of lagoon (back reef) environment. According Al-Mubarak and Amin (1983) the depositional environment of the Middle Member of the Dammam Formation is shallow marine tropical – subtropical; with depth not more than 100 m, and that of the Upper Member of the Dammam Formation is near shore (Lagoon). In southwest of Busaiya, it is tropical and subtropical marine with depth not more than 20 m (Al-Sharbati and Ma'ala, 1983). In south of Samawa, it is tropical and subtropical marine (Al-Ani and Ma'ala, 1983). Jassim *et al*. (1984) described the environment to be started with shallow marine of inner shelf – shelf depth, followed by well defined warm normal conditions, giving rise to extensive shoals of large nummulites and mollusk fauna. These conditions were of higher salinity, as indicated by abundant miliolids and alveolinids. Al-Hashimi and Amer (1985) suggested typical restricted marine platform (lagoon) facies prevailed over the area of the Dammam Formations deposition, which is characterized by dolomitic limestone and dominant occurrences of miliolids and *Peneroplis* sp.

In this study, to indicate the depositional environment of the Dammam Formation, in Borehole No.1 the model of Hallock and Glenn (1986) (Fig.13) has been applied, using the individuals of foraminifera groups primarily, which are divided in three groups, and then each group was assigned at one of the vertices of the triangle, each group represents the individuals that reside jointly or roughly in one environment or in converged environments. These groups are:

Group I: Planktonics and flat rotaliines: *Globigerina* spp., *Globorotalia* spp., *Globigerapsis* spp., *Bolivina* sp., *Bulimina* sp., textularrids, rotallids.

Group II: Lenticular and subspheroid large rotaliines: *Nummulites* spp., *Rhapydionina* sp., *Lituinella* sp., *Prarerhpydionina* sp., *Coskinolina* sp., *Linderina* spp., *Alveolina* spp. and *Lockhartia* spp.

Group III: Miliolines and smaller rotaliines: *Peneroplis* sp., *Rotalia* sp., *Elphidium* sp., *Textularia* sp., *Bolivina* sp., *Bigenerina* sp., *Spiroloculina* sp., *Heterostegina* sp. and miliolids.

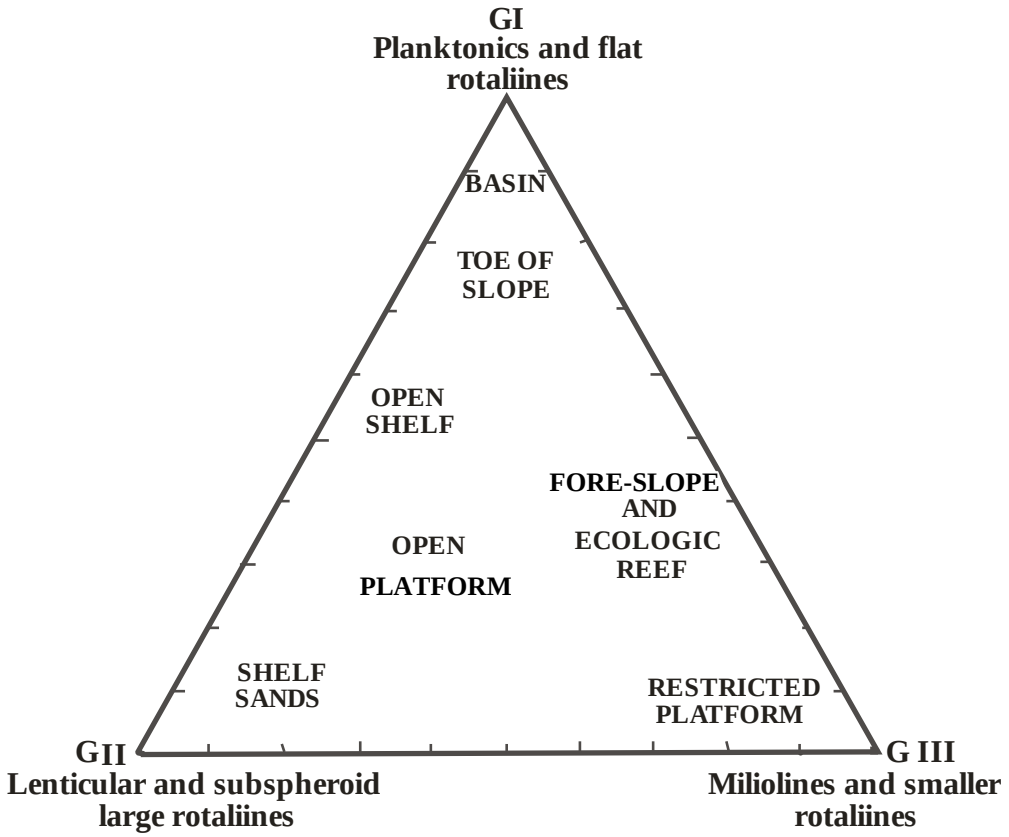

Fig.13: Triangle of environment used by Hallock and Glenn (1986) to determine the depositional environment showing the standard microfacies assumed by Wilson (1975)

The individuals, which belong to each group in the thin section, were counted, and then percentages were calculated for each group (Table 1). After the overthrow of these percentages in the triangle environment, the distribution zones of the foraminifera and the microfacies for the formation were acquired (Fig.14).

When comparing and matching the distribution of the foraminifera and the microfacies of the Dammam Formation (Fig.14) in the studied borehole with the environment triangle (Fig.13), which contains the standard microfacies; supposed by Wilson (1975), it is concluded that the deposition of the Dammam Formation is clearly shelf sand area; extending to shoal – open platform area then continues to restricted platform area.

DISCUSSION

The exposed part of the Dammam Formation (Middle Member), which is penetrated in Borehole No.1 is represented by Nummulitic Dolomitic Packstone – Floatstone Facies; with thickness of 62.5 m (depth interval 51.0 – 113.5 m),it is deposited in the shelf sands (winnowed edge sands) area with effective streams and high energy. Then the upper part of the formation (Upper Member) is represented by Foraminiferal Dolomitic Packstone Facies, with thickness of 10.0 m (depth interval 41.0 – 51.0 m),it is deposited in open platform (shelf lagoon open circulation) area with quieter water power effective and followed upwards by Dolomitic Wackestone – Packstone Facies; with thickness of 38.0 m (depth interval 3.0 – 41.0 m)it is deposited in restricted platform and lagoon (restricted circulation inner shelf and tidal flats) area (Fig.15).

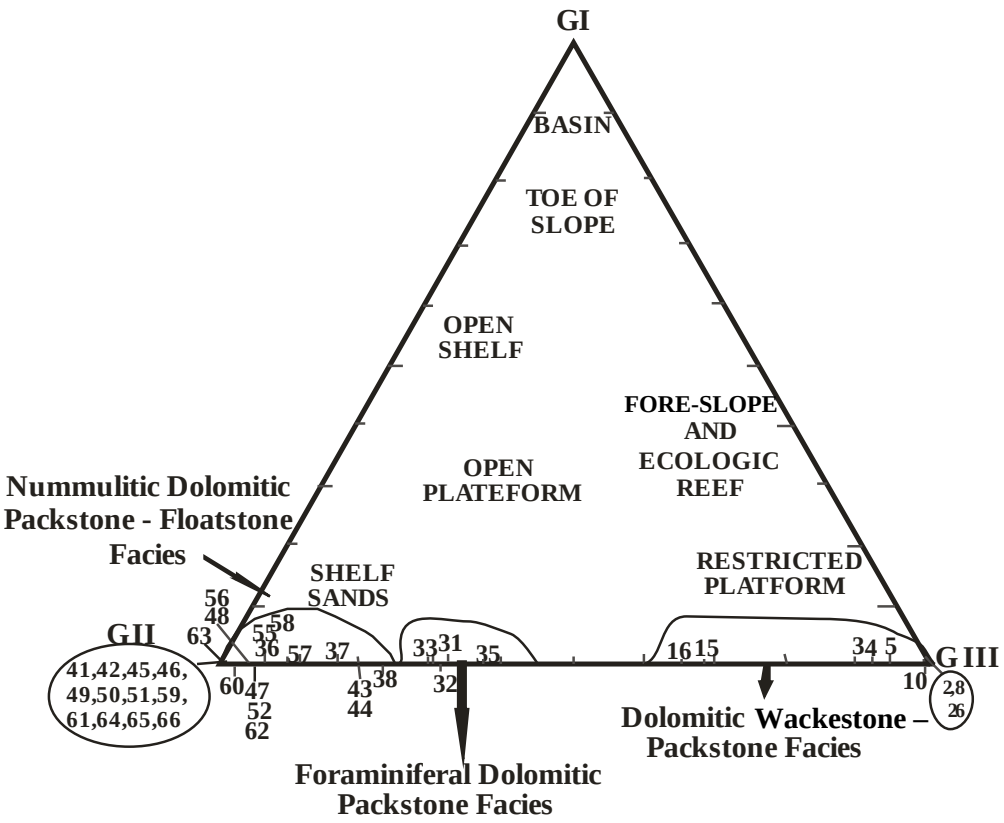

Fig. 14: The distribution of the fossils and microfacies of the Dammam Formation with the triangle of environment (after Willson, 1975)

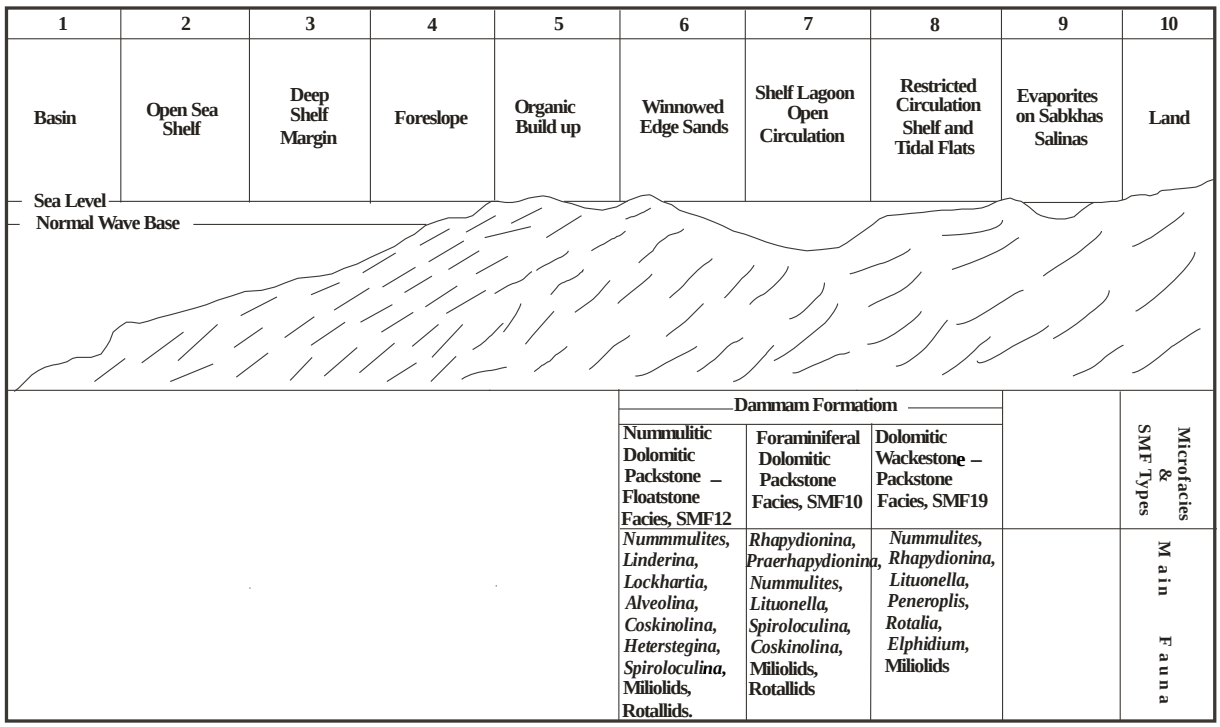

Fig.15: The distribution of fossils and microfacies of the Dammam Formation identified in Borehole No.1, with the extensions of the formation in the depositional basin within the zones and standard microfacies (supposed by Wilson ,1975)

Table 1: The total percentage of the foraminifera groups configured in Borehole No.1

Sample No.	I	II	III	Formation	Sample No.	I	II	III	Formation
	(%)					(%)			
1				Euphrates	38		77	23	Dammam
2			100	Dammam	39				Dammam
3		10	90	Dammam	40				Dammam
4		8	92	Dammam	41		100		Dammam
5		5	95	Dammam	42		100		Dammam
6				Dammam	43		80	20	Dammam
7				Dammam	44		80	20	Dammam
8			100	Dammam	45		100		Dammam
9				Dammam	46		100		Dammam
10		1	99	Dammam	47		95	5	Dammam
11				Dammam	48		96	4	Dammam
12				Dammam	49		100		Dammam
13				Dammam	50		100		Dammam
14				Dammam	51		100		Dammam
15		31	69	Dammam	52		95	5	Dammam
16		35	65	Dammam	53				Dammam
17				Dammam	54				Dammam
18				Dammam	55		93	7	Dammam
19				Dammam	56		96	4	Dammam
20				Dammam	57		88	12	Dammam
21				Dammam	58		93	7	Dammam
22				Dammam	59		100		Dammam
23				Dammam	60		98	2	Dammam
24				Dammam	61		100		Dammam
25				Dammam	62		95	5	Dammam
26			100	Dammam	63		99	1	Dammam
27				Dammam	64		100		Dammam
28				Dammam	65		100		Dammam
29				Dammam	66		100		Dammam
30				Dammam	67				Dammam
31		68	32	Dammam	68				Rus
32		69	31	Dammam	69				Rus
33		71	29	Dammam	70				Rus
34				Dammam	71				Rus
35		63	37	Dammam	72				Rus
36		93	7	Dammam	73				Rus
37		83	17	Dammam	74				Rus

CONCLUSIONS

This study has the following conclusions:

- In Borehole No.1, three rock units were recognized from the studied samples, these are from the oldest to the youngest:
  - Rus Formation (Early Eocene)
  - Dammam Formation (Middle – Late Eocene)
  - Euphrates Formation (Early Miocene)
- Two biozone were recognized, they are from the oldest to the youngest:
  - *Nummulites gizehensis* Zone of Middle Eocene (Late Lutetian) age
  - Miliolids Peneroplid Assemblage Zone of Late Eocene (Bartonian) age
- The first biozone indicates Middle Eocene (Late Lutetian) age for the Middle Member of the Dammam Formation and the second biozone indicates Late Eocene (Bartonian) age for the Upper Member of the formation.
- Three microfacies were recognized in the Dammam Formation from Borehole No.1, these are from top to bottom:
  - Dolomitic Wackestone – Packstone Facies
  - Foraminiferal Dolomitic Packstone Facies
  - Nummulitic Dolomitic Packstone Floatstone Facies
- The triangle of environment was used to infer the depositional environment with distinction facies containing the individuals of different foraminifera to indicate different areas in which the rocks of the Dammam Formation were deposited.
- The beginning of the deposition configuration was in the vicinity of shelf sands area (winnowed edge sands) with Nummulitic Dolomitic Packstone – Floatstone Facies, with thickness of 62.5 m.
- The deposition extended towards open platform area (shelf lagoon open circulation) within Foraminiferal Dolomitic Packstone Facies with thickness of 10.0 m.
- The deposition terminated in the restricted area (restricted circulation shelf and tidal flats) within the Dolomitic Wackestone – Packstone Facies with thickness of 38.0 m.

REFERENCES

Ajar, D.K., Yousif, L.D., Zaini, M.H., Al-Shawi, S.H., Kadhum, M.A.A., Basher, W.P., Al-Kubaysi, K.N., Mohammed, R.A.A., Ali, M.A., Kambar, A.S. and Rehaimah, R.H., 2011. Detailed geological survey of south Samawa region, scale 1: 25 000, first stage. GEOSURV, int. rep. no. 3335.

Al-Ani, M.Q. and Ma'ala, K.A., 1983. Report on the regional geological mapping of the south Samawa area. GEOSURV, int. rep. no. 1348.

Al-Hashimi, H.A.J., 1972. Foraminiferida of the Dammam Formation (Eocene) in Iraq. Unpub. Ph.D. Thesis, University of London, 200pp.

Al-Hashimi, H.A.J., 1973. The sedimentary facies and depositional environment of the Eocene Dammam and Rus Formations. Jour. Geol. Soc. Iraq, Vol.VI, p. 1 – 18.

Al-Hashimi, H.A.J., 1974. Stratigraphy and paleontology of the subsurface rocks of Samawa Area. GEOSURV, int. rep. no. 646.

Al-Hashimi, H.A.J., and Amer, R.M., 1985. Tertiary Microfacies of Iraq. GEOSURV, Baghdad, Iraq, 56pp.

Al-Kubaysi, K.N., 2013. The biostratigraphy, microfacies and depositional environment of the Dammam Formation in borehole No.1, south Samawa area, Southern Desert, Iraq. GEOSURV, int. rep. no. 3446.

Al-Mubarak, M.A. and Amin, R.M., 1983. Report on the regional geological mapping of the eastern part of the Western Desert and western part of the Southern Desert. GEOSURV, int. rep. no. 1380.

Al-Mutter, Sh.S., 1979. Early – Middle Eocene larger foraminifera of the Dammam Formation, Western Desert, Iraq, Jordanian – Saudia Arabian Border, Traibeel Area, Part II. GEOSURV, int. rep. no. 983.

Al-Mutter, Sh.S., 1983. Biostratigraphic study of the south Najaf area. GEOSURV, int. rep. no. 1322.

Al-Mutter, Sh.S., 1984. Biostratigraphic study of the south Salman area. GEOSURV, int. rep. no. 1344.

Al-Sharbati, F. and Ma'ala, K.A., 1983. Report on the regional geological mapping of west of Zubair area. GEOSURV, int. rep. no. 1345.

Amer, R.M., 1980. Biostratigraphic and micropaleontologic study of west Najaf – Nukhaib Area, Western Desert, Iraq. GEOSURV, int. rep. no. 1097.

Bellen, R.C., van, Dunnington, H.V., Wetzel, R. and Morton, D., 1959. Lexique Stratigraphic International. Asie, Fasc.10a, Iraq, Paris, 333pp.

Bonefous, F. and Bismuth, A., 1982. Les facies carbonates de plate forme de I Eocene moyent superieur dans I offshare tunisein nord, oriental etenmer palagiennelimplicatious paleogeographisquses et analysis micropalontologique, Belletin Des Centres, Derechercher Eryploration Production Elf-Aquitaine. Vol.6, No.2, p. 337 – 403

Buday, R.T., 1980. The Regional Geology of Iraq, Vol.1, Stratigraphy and Paleogeography. In: I.I., Kassab and S.Z., Jassim (Eds.). GEOSURV, Baghdad, Iraq, 445pp.

Dunham, R.J., 1962. Classification of Carbonate Rocks According to Depositional Texture. In: W.E., Ham (Ed): Classification of Carbonate Rocks. A symposiam Amer. Ass. Petrol. Geol. Mem.1, p. 108 – 171.

Ejel, J., 1969. Zones stratigraphiqus due paleogenoat probleme de la limite Eocene maye, Eocene supperieur daus la region Danes(Syria). Proceeding of the first International Conference an Planktonic Microfossils. Geneva, Vol.II, p. 175 – 181.

Embry, A.F. and Klovan, J.E., 1971. A Late Devonion reef tract on northeastern Banks Island. N.W.T. Bull. Canadian Petrol. Geol., Vol.19, p. 730 – 781.

Hallock, P. and Glenn, E.C., 1986. Larger foraminifera. A tool for paleoenvironment and analysis of Cenozoic carbonate depositional facies. Palaios, Vol. 1, p. 55 – 64.

Henson, F.R.S., 1950. Some observation on Cretaceous and Tertiary reef formations and associated sediments in the Middle East. Bull, A.A.P.G., Vol.34, No.2, p. 215 – 328.

Jassim, S.Z., Karim, S.A., Basi, M.A., Al-Mubarak, M.A. and Munir, J., 1984. Final report on the regional geological survey of Iraq, Vol.3: Stratigraphy. GEOSURV, int. rep. no. 1447.

Jassim, S.Z. and Goff, J.C., 2006. Geology of Iraq. Dolin, Prague and Moravian Museum, Brno, 341pp.

Karim, S.A., 1977. Paleocene – Eocene biostratigraphy of subsurface section in the Akashat area, Western Desert, Iraq. GEOSURV, int. rep. no. 785.

Mahmood, E., 1983. Biostratigraphic and paleontologic study of Shbicha area, Southern Desert, Iraq. GEOSURV, int. rep. no. 1228.

Muniem, A.A., 1983. Biostratigraphy of Early Eocene – Late Miocene of west Samawa area, Southern Desert, Iraq. GEOSURV, int. rep. no. 1326.

Owen, R.M. and Nasr, S.N., 1958. The Stratigraphy of Kuwait – Basrah area. In: G.L., Weeks (Ed.). Habitat of Oil, a Symposium, A.A.P.G., Tulsa.

Pokorny, V., 1958. Ecology of Living Foraminifera, Principles of Zoological Micropaleontology, Vol.1, 652pp.

Raji, W. and Said, V.V., 1984. Primary study on paleontology of Dammam and Zahra formations in south Samawa area. GEOSURV, int. rep. no. 1387.

Said, R., 1950. *Nummulites gizehensis* as a possible indiciater of Eocene climate. Contributions from the Cushman Foundation for Foraminiferal Research, Vol.1, p. 30 – 31.

Said, R., 1951. Restudy of traces of *Nummulites gizehensis*. Contributions from the Cushman Foundation for Foraminiferal Research, Vol.1, p. 11 – 131.

Sissakian, V.K. and Fouad, S.F., 2012. Geological Map of Iraq, 4th edit., scale 1: 1000 000. GEOSURV, Baghdad, Iraq.

Yousif, W., 1981. Biostratigraphy and paleoecology of south Nukhaib area. GEOSURV, int. rep. no. 1269.

Yousif, W., 1983. Micropaleontology and biostratigraphic study of borehole No.7, Abu Rudham (Hydrogeological Explorations Project, Blocks 1, 2, 3). GEOSURV, int. rep. no. 1388.

Wilson, J.L., 1975. Carbonate Facies in Geologic History. Spring Verlag, Berlin, Heidelberg, New York, 471pp.

About the author

Miss. Kifah N. Al-Kubaysi graduated from University of Al-Mustansiriyah in 1979 with Higher Diploma degree in Geology; in 2001 she got B.Sc. degree and M.Sc. in 2007 from University of Baghdad. She joined the State Establishment of Phosphate in 1979, and then joined GEOSURV in 1985, where currently she is working in the Paleontological Laboratory. She has 8 documented reports in GEOSURV's library and 5 published articles in different geological aspects. Her major field of interest is paleontology.
e-mail: akifahnoore@yahoo.com
Mailing address: Iraq Geological Survey, P.O. Box 986, Baghdad, Iraq