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Biostratigraphy of Euphrates, Dhiban, and Jeribe formations in Ajil oil field, Salah Al-Deen Governorate, central Iraq

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Abstract

The studied succession (Lower Miocene-Early Middle Miocene) In central Iraq is distinguished by a wide range of fossils, mostly benthic foraminifera, and other fossils including bivalves, gastropods, echinoids fragments, red algae and coral are also presented. Index fossils of benthic foraminifera have been used for the purpose of determining the age of the Euphrates and Jeribe formations, because of their young age, wide geographical distribution and abundance in the selected wells.

The present study involves four selected wells of Ajil oil field and in terms of the biostratigraphy of the Euphrates, Dhiban, and Jeribe formations depending on benthic foraminifera and other associated fossils. Some of these fossils have a short vertical distribution, while others have long vertical distribution. There are two biozones determined. First, in Euphrates Formation "*Ammonia beccarii-Miogypsina globulina*" (Assemlage zone) Second in Jeribe Formation "*Borelis melo curdica*" (range zone). Dhiban Formation include only small pieces of distorted fossils and dominated by anhydrite, therefore it lacks the biostratigraphic zonation.

Keywords: Biostratigraphy, Biozone, Ail oil field, Benthic foraminifera.

الطباقية الحياتية لتكوينات الفرات والذبان والجريبي في حقل عجيل النفطي، محافظة صلاح الدين، وسط العراق

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الخلاصة

التتابع المدروس (المايوسين الاسفل–المايوسين المتوسط المبكر) في وسط العراق تميز بمدى واسع من المتحجرات معظمها من الفورامنيفرا القاعية والمتحجرات الكبيرة التي تشمل ثنائية الاصطداف وبطنيات القدم وشوكيات الجلد والطحالب الحمراء والمرجان. تم الاعتماد على المتحجرات الدالة للفورامنيفرا القاعية لغرض تعيين عمر تكوينات الفرات والجريبي بسبب عمرها الحديث وتوزيعها الجغرافي الواسع ووفرتها في الابار المختارة.

الدرراسة الحالية شملت اربعة ابار لحقل عجيل النفطي وتم دراسة الطباقية الحياتية لتكوينات الفرات والذبان والجريبي معتمدة على الفورامنيفرا القاعية وتجمعات المتحجرات الاخرى. بعض هذه المتحجرات لها توزيع عمودي قصير بينما الاخرى لها توزيع عمودي طويل. ووفقا لذلك هنالك نطاقين تم تحديدهم الاول في تكوين الفرات (Assemlage zone) *"Ammonia beccarii–Miogypsina globulina"* والثاني في تكوين الجريبي(range zone) *"Borelis melo curdica"*

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اما في تكوين الذبان تم ملاحظة قطع صغيرة من المتجحرات المتكسرة مع وجود الانهايدرايت الشائع بصورة رئيسية في هذا التكوين وعليه لم يتم تمييز الانطقة الحياتية.

Introduction:

The Early-Mid Miocene succession in the Low Folded Zone of the Zagros Fold Belt with transition toward northern part of the Mesopotamian Foredeep Basin is represented by a complete sedimentary cycle of the Euphrates, Dhiban, and Jeribe formations. Ajil Oil field is located about 30 km to the North East of Tikrit city, Norther Iraq. The average elevation of the field area is 150-170 m above Mean Sea Level. Four boreholes have been studied, Table-1 shows the Geographic coordinates and thickness of the selected formations at the study area. These wells are: AJ-4, AJ-6, AJ-11, and AJ-12 (Figure-1). Structurally, this field is part of many fields of structurally oriented NW-SE within northern part of adjacent to the Low Folded Zone of the Zagros Fold Belt. Geographically within Salah Al-Deen Governorates in the east of Tigris river between the cities of Tiqrit and Beiji [1].

The Early-Mid Miocene Sequence can be divided into two second order sequences, each with shallow water carbonates passing up into evaporates. They are the Early Miocene and Mid Miocene sequences. The formations previously included in the Early-Mid Miocene Sequence including the Asmari, Euphrates, Serikagni, Dhiban, Kaihur Gypsum, Ghar, Jeribe and Lower Fars formations. [2] claimed that Jeribe Formation is equivalent to the basal limestone members of the Lower Fars (Fatha) Formation marked by conglomeratic limestones at the base Figure-2.

The age of the Euphrates Formation is late Early Miocene (Burdigalian), proved by the presence of *Miogypsina globulina* and *Miogypsina intermedia* [3]. *Miogypsina globulina* appears to be restricted to the Early Miocene (early-mid Burdigalian); M. *intermedia* to the Early-Mid Miocene (Burdigalian-early Langlhan). [4] argued that only *pre-Orbulina* beds are presented (pre-Middle Miocene) [5]. Lower Miocene limestones in Syria were referred to the Euphrates Formation by [6]. The formation is equivalent to part of the Asmari Limestone of SE Iran. The Euphrates Formation passes laterally into continental clastics in Saudi Arabia, represented by the Hadrukh Formation [7].

Table 1- Geographic coordinates and thickness of the selected formations at the study area

Well No.	Location(UTM)	Formation	Thickness (M)	Drilling year	Total depth (M)	Formation depth (m)
AJ- 4	N: 3 861 592.4 E: 394 407.3	Euphrates	105	1981	1171.5	968-1073
		Dhiban	22			946-968
		Jeribe	39			907-946
AJ- 6	N: 3 861 500 E: 385 400	Euphrates	96	1982	1626	1081-1177
		Dhiban	33.5			1047.5-1081
		Jeribe	27			1020.5-1047.5
AJ- 11	N: 3 863 401.4 E: 398 401.8	Euphrates	76	1984	1210	1091-1201
		Dhiban	17			1074-1091
		Jeribe	35			1039-1074
AJ- 12	N: 3 858 116.5 E: 390 817.5	Euphrates	116	1985	3761	1134-1250
		Dhiban	15			1119-1134
		Jeribe	45			1074-1119

The Dhiban Formation was defined [8] from the type area near Dhiban village in the Sinjar area of the Foothill Zone of NW Iraq. The formation comprises 72 m of gypsum, thin beds of marl and brecciated recrystallized limestone. Salt occurs in well Injana-5 [9]. Between Mosul and Qaiyarah the anhydrites are replaced by "chemical" limestones [8] due to bacterial reduction and sulphur formation. [10] recorded sandstone in well Khleisia-l. The age of the Dhiban Formation has been defined on the basis of stratigraphic relationships with other formations. The Dhiban overlies the Serikagni Formation, interfingers with the Euphrates Formation and is overlain by the Jeribe Formation. Therefore, its age has been established as Early Miocene. The Dhiban Formation occurs in NE Syria [6]. The Kalhur Gypsum of SW Iran (sometimes recorded in Iraq) is equivalent to the Dhiban Formation [5].

The Jeribe Limestone was defined by Bellen in 1957 [8] from the type locality near Jaddala village in the Sinjar anticline, and assumed to be of Early Miocene age. However, the formation was later included within the Middle Miocene sequence. A Middle Miocene age is indicated by the presence of the Orbulina datum near the base of the Jeribe Formation [4]. [8] suggested that the Jeribe Formation was deposited in lagoonal (back reef) and reef environments. Back reef and reef facies are predominant. The conspicuous index fossil *Borelis melo curdica* "Karim and Prazak, 1973" in [5] and *Orbulina* occur in the lower part of the formation. In addition to the fossil list provided by Bellen et al. (1959), [4] provided a fossil list which supports a Middle Miocene age.

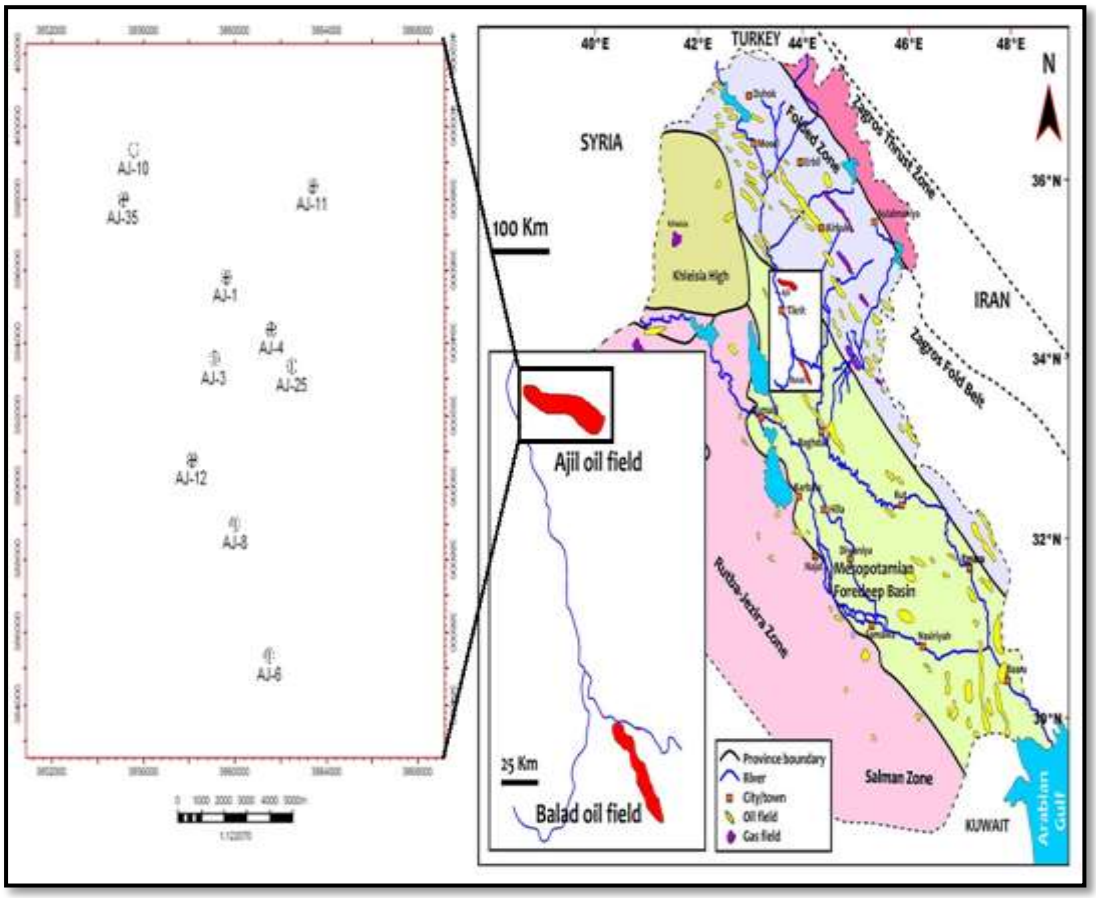


Figure 1- Location Map of the study area (Ajil oil field) [11].

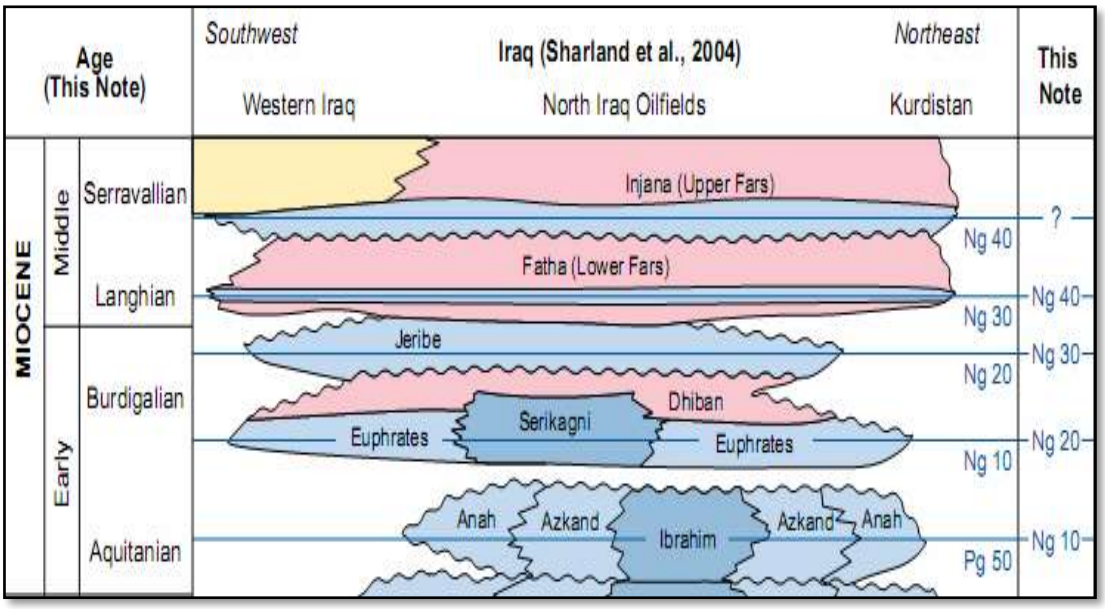


Figure 2- Stratigraphic correlation of Miocene formations. Megasequence Ap11 [12]

Material and methods:

The biostratigraphic study of benthic foraminifera is based on 450 thin sections of studied succession. All thin sections are housed in the N.O.C stores. Biostratigraphic study is depending on the examination of thin sections. Classification was done according to the concepts of Loeblich and Tappan [13]. All the images were taken at the N.O.C, Micropaleontology Lab.

Biostratigraphy of Euphrates Formation

This Formation is located at depth (1091m - 1201 m) in well No AJ-11, the thickness is 110m consists of dolomitic limestone, anhydritic dolomitic limestone, and anhydritic limestone. The limestone unites contain benthic foraminifera that have been used to determine the lower boundary between the carbonate Euphrates and underlying Serikakni formations. The upper boundary, it was determined based on the presence of the anhydrite layer.

The following benthic foraminifera are identified from the sediments of Euphrates Formation (Figure-3):

Austrotrillina asmariensis Adams, *Austrotrillina howchini* (Schlumberger) *Borelis melo curdica* Reichel, *Borelis melo melo* (Fichtel and Moll), *Dendritina rangi* D'orbigny, *Peneroplis evolutus* Henson, *Peneroplis farsensis* Henson, *Prearhapydionina delicate* Henson, *Quinquiloculina* sp. *spiroloculina* sp., *Triloculina tricarinata* D'orbigny.

In addition, to the following fossils were recognized: - coral, gastropoda, ostracoda, ostrea, pelecypoda (bivalves), red algae, shell fragments.

Biostratigraphy of Dhiban Formation

This Formation is located at depth (1074m - 1091m) in well No AJ-11, the thickness is 18m.The formation was identified on the basis of high ratio of anhydrite. Wherever layers of carbonate rock were found on a high-grade anhydrite. The following benthic foraminifera are identified from the sediments of Dhiban Formation but it's were very rare (Fig.3):

Dendritina rangi D'orbigny, *Quinquilucuilina* sp. *Austrotrillina howchini* (Schlumberger).

The top surface of this formation is a conformable surface with Jeribe Formation, its lower surface is also a conformable surface with the Euphrates Formation that follows it [5], (Figure-3).

Biostratigraphy of Jeribe Formation

This formation is located at depths (1039m - 1074 m) in well No AJ-11, the thickness is 35 m, and it consists of anhydritic marly limestone, limestone, marl bed, anhydritic limestone, and anhydric dolomitic limestone.

The upper surface of this formation is a conformable surface with Fatha Formation, and the lower surface is also a conformable with the underlying Dhiban Formation [8].

The diagenesis effects have been noticed within the study area for example dolomitization, cementation, stylolite, and dissolution.

The following microfauna are identified in the Jeribe Formation (Figure-3). These include the following foraminifera:

Austrotrillina asmariensis Adams, *Austrotrillina howchini* (Schlumberger), *Borelis melo curdica* Reichel, *Borelis melo melo* (Fichtel and Moll), *Dendritina rangi* D'orbigny, *Peneroplis evolutus* Henson, *Peneroplis farsensis* Henson, *Prearhapydionina delicate* Henson, *pyrgo sp*. *Quinquiloculina* sp., *Rotalia viennoti* Greig, *Spiroloculina* sp.

Other fossils include echinodemata, gastropoda, pelecypoda (bivalves), red algea, shell fragments, fossils that were identified in this formation.

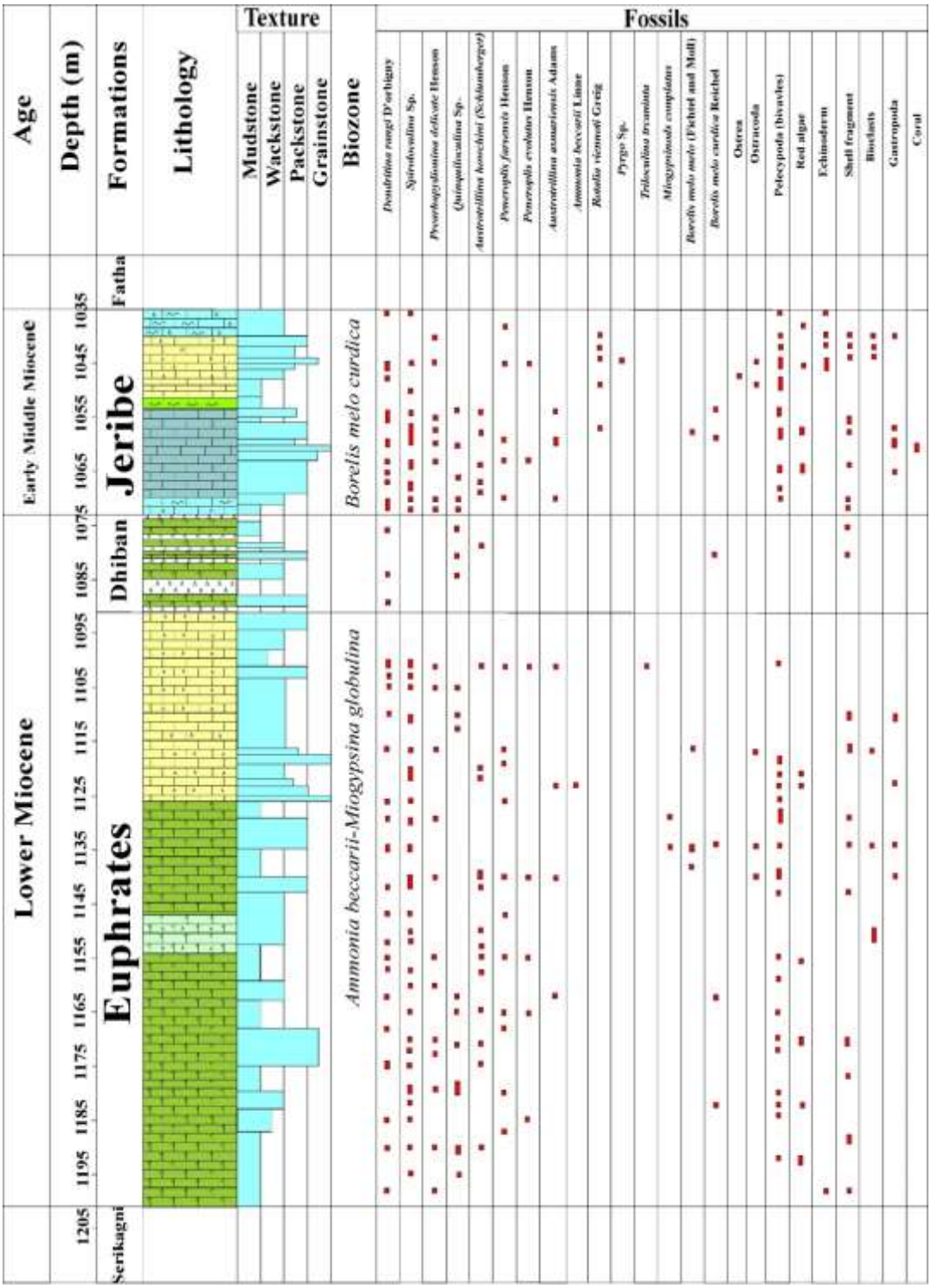


Figure 3- Biostratigraphy of studied formations at AJ-11.

The presence and vertical distribution of fossils in the studied wells

Miliolid

Euphrates and Jeribe formations are characterized by a widespread distribution of miliolids within the studied wells. The species which have been diagnosed include *spiroloculina* plate (Plt.1-A and B), *Quinquilucuilina* (Plt.1-C and D), and *Austrotillina howchine* schlumberger (Plt.1-E and F), are the most common in all studied succession, but *Austrotillina asmariensis* Adam is less common plate (2. A). while *Pyrgo* is rare (Plt.2-B), *Trilloculina* is observed only in the upper part of Euphrates Formation (Plt.2-C).

Rotaliidae

Rotaliidae has been diagnosed in the Euphrates and Jeribe formations with less common species such as *Ammonia beccarii* (Linne) (Plt.2-D) in the upper and middle parts of Jeribe Formation and in the upper and lower parts in the Euphrates Formation but it was very rare. While *Rotaliaveinnoti* Greig (Plt.2-E), is diagnosed in the Jeribe Formation and in the upper part of Euphrates Formation.

Soritidae

Four species of Sotaliidae were diagnosed. These are *praehyodionina delicate* Henson (Plt.2-F), *Dendritina rangi* D'obigny (Plt.3-A), which are very common in the Jeribe and Euphrates Formation, *Peneroplis.* sp. (Plt.3-B), is very rare and observed only in (Wells No. AJ-4 and Aj-12), *Peneroplis farsensis* Henson plate (3.C), is common in the studied formations, while *Peneroplis evolute* Henson (Plt.3-D), is less common.

Alveolinidae

This family (Alveolinidae) is represented by *Borelis melo melo* (Plt.3-E), this index fossil is very important because it indicates the Miocene age. It's exists in Euphrates and Jeribe formations and with less common. *Borelis melo var curdica* (Plt.3-F), is very important, and it is considered as an index fossil that exists in the Jeribe Formation and indicates a middle Miocene age.

Miogypsindae

This family includes *Miogypsina globulina* (Michelotti) (Plt.4-A). These fossils are less common and seen in the Euphrates Formation and is very important that indicates the age of Miocene.

Victoriellidae (Victorillinae)

It includes Victoriella (Plt.4-B), and it's very rare and seen in the Euphrates Formation.

Bolivinellidae

This family represented by Bolivina, it was diagnosed in the Ephrates Formation and was very rare (Plt.4-C).

Favreina asmaricus, Ostrea.

These fossils Favreina asmaricus (Plt.4-D) and Ostrea (Plt.4-E) were also identified in the studied formations with very few percentages.

As for other fossils such as bioclasts (Plt.4-F), corals (Plt.5-A and B), echinoderm as plated (Plt.5-C and D), enchinodem as spine (Plt.5-E), gastropoda (Plt.5-F), pelecypoda (bivalves) (Plt.6-A and B), red algea (Plt.6-C), and shell fragments (Plt.6-D), are scattered differently in all studied wells.

Biozone

The biozones in this study of Euphrates and Jeribe formations are composed of two Biozones. The thickness, appearance, and disappearance of these biozones varies among the four described wells (AJ-4, AJ-6, AJ-11, and AJ-12). As for the Dhiban Formation, we cannot distinguish any fossils except bioclasts, because the anhydrite is predominant in this formation. The description and discussion of the biozones are manifested below: -

***Borelis melo curdica* (range zone)**

Occurrence: Jeribe Formation.

Definition: The lower limit of this zone is set with accordance of the first appearance of this species and its upper limit coincides with disappearance of the species. This zone occurs within all four described wells of the study.

Thickness: The thickness of the zone is 23m in AJ-4, 11m in AJ-6, 6m in AJ-11 and 23m in AJ-12.

Age: The age of this zone was determined depending on the occurrence of this species within sediments belonging to Middle Miocene age in Iraq and in neighboring countries. Some of these occurrences were recorded by number of researchers as:

[14], the *Borelis melo curdica* is equivalent to *Borelis melo curdica- Meandropsina iraqnica* zone for eastrn south of Iraq wells, and it's the same zone suggested by [15] for Asmai Formation in Iran. [16],

where this zone is equivalent to *Neooalveolina melo* zone for middle Miocene rocks in Eypet. [17], also it is equivalent to *Boreli smelo* zone for middle Miocene in Palestine.

Remax:

Austrotrillina asmariensis Adams, *Austrotrillina howchini* (Schlumberger), *Borelis melo curdica* Reichel, *Borelis melo melo* (Fichtel and Moll), *Dendritina rangi* D'orbigny, *Peneroplis evolutus* Henson, *Peneroplis farsensis* Henson, *Prearhapydionina delicate* Henson, *pyrgo sp*. *Quinquiloculina* sp., *Rotalia viennoti* Greig, *Spiroloculina* sp.

In addition to the following fossils: - Bioclasts, Coral, Gastropoda, Ooids, Ostracoda, Ostrea, Pelecypoda (bivalves), Shell fragments.

***Ammonia beccarii-Miogypsina globulina* (Assemblage zone)**

Occurrence: Euphrates Formation

Definition: This zone was determined according to the first appearance of this species as a lower limit and its disappearance as the upper limit. The zone occurs within all four described wells of the study.

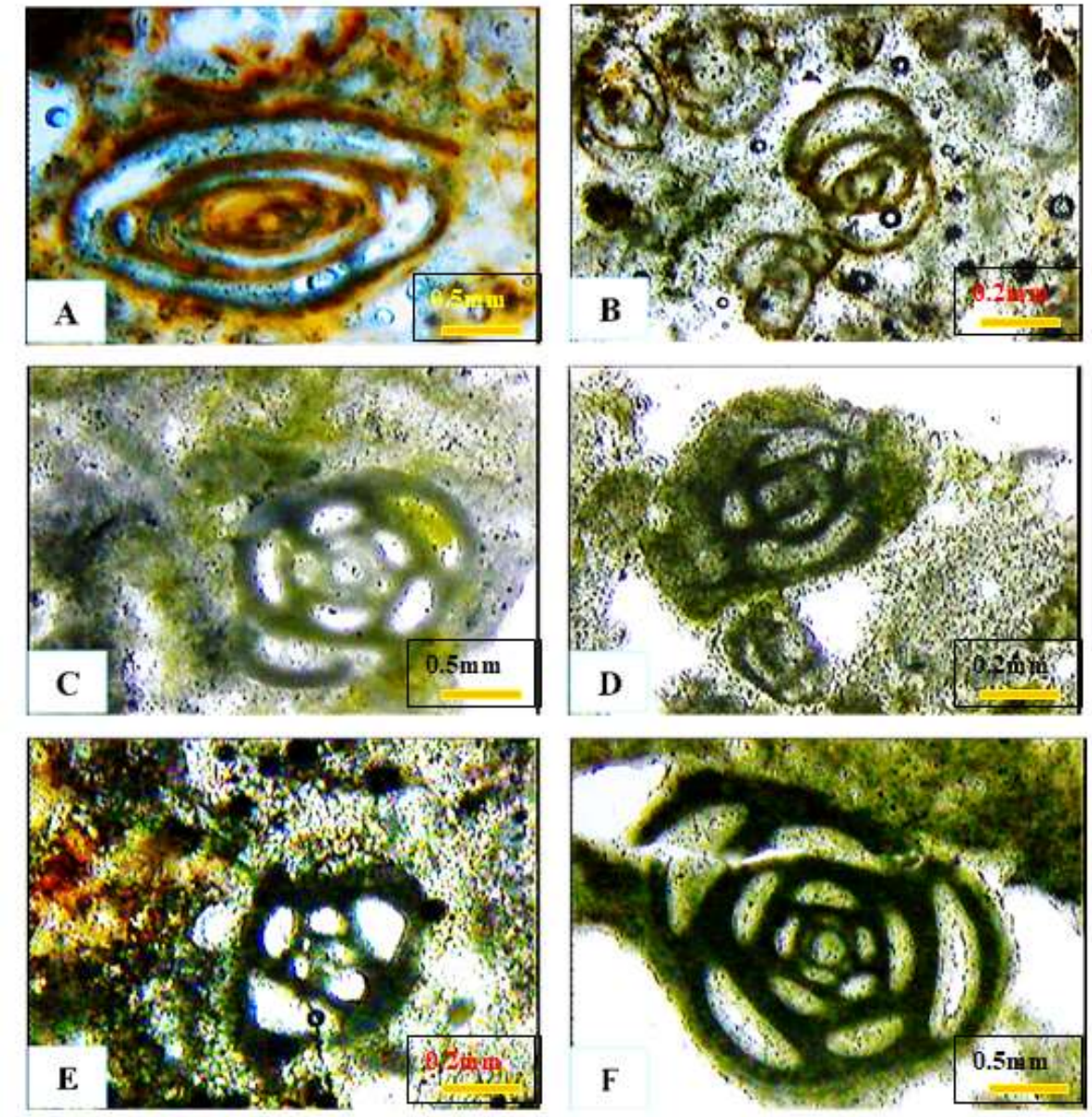
Thickness: The thickness of the zone is 57m in AJ-4, 3m in AJ-6, 6m in AJ-11 and 13m in AJ-12.

Age: The age of this zone was determined depending on the occurrence of this species within sediments belonging to lower Miocene age in Iraq and in neighboring countries. Where this zone is equivalent to *Ammonia beccarrii- mogypsina globula* zone was suggested by [18]. For lower Miocene rocks in north eastern Iraq and which includes the following species *Peneroplis* sp., miolilids. These are the same species in the current study, so this zone is representing lower Miocene. Also this zone is equivalent to the zone which suggested by [19] belonging to lower and middle Miocene rocks of Euphrates Formation at upper Euphrates valley. The *Miogypsina globulina* which mentioned in this study specially in this zone represents a fossils index in the lower Miocene [3] in western desert from Iraq.

Remax: *Ammonia beccarii* Linne, *Austrotrillina asmariensis* Adams, *Austrotrillina howchini* (Schlumberger), *Bolivina* sp., *Borelis melo curdica* Reichel, *Dendritina rangi* D'orbigny, *Favreina asmaricus*, *peneroplis* sp., *Peneroplis evolutus* Henson, *Peneroplis farsensis* Henson, *Prearhapydionina delicate* Henson, *Quinquiloculina* sp., *Spiroloculina* sp.

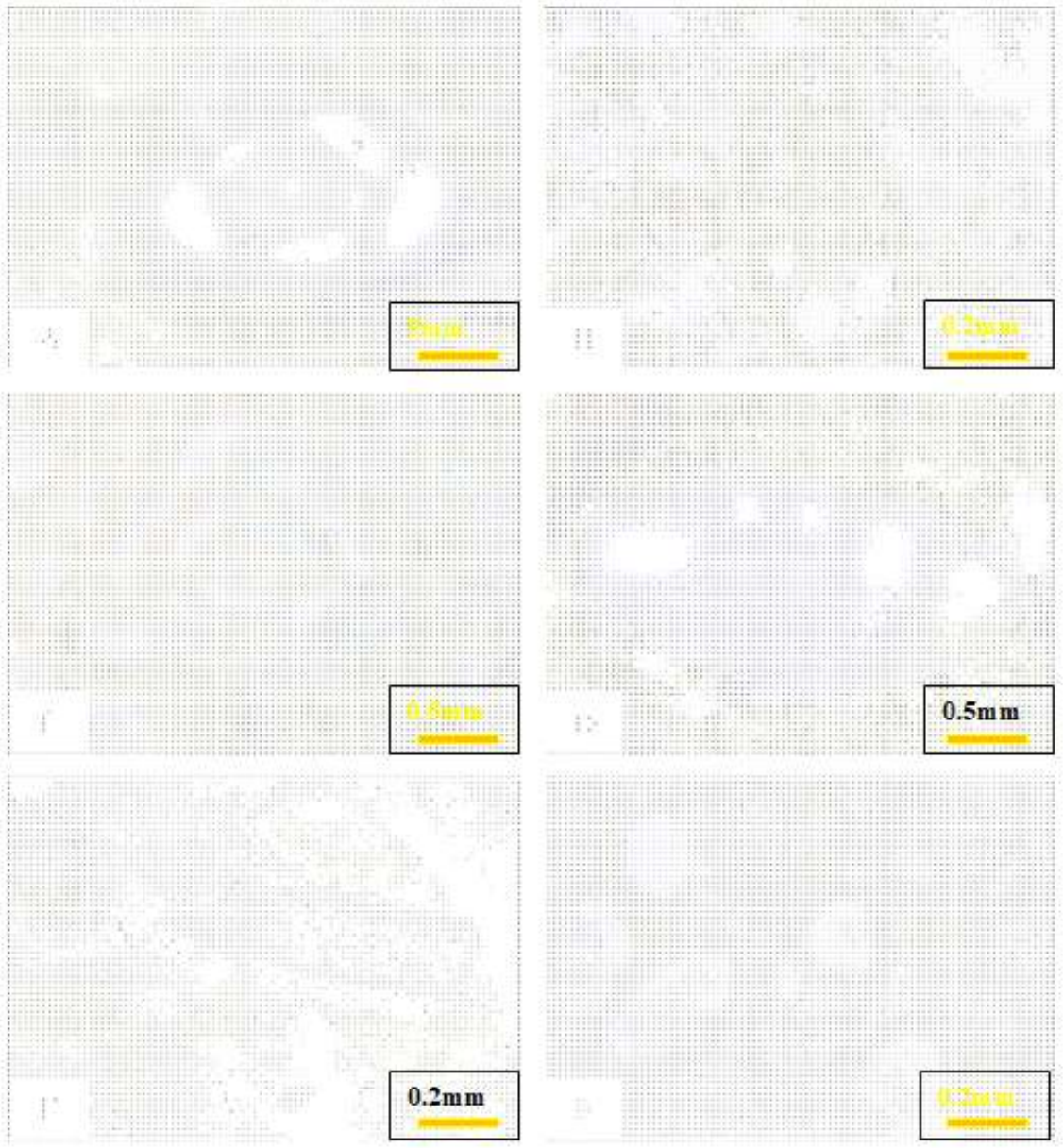
In addition to the following fossils: - Bioclasts, Coral, Gastropoda, Ooids, Ostracoda, Ostrea, Pelecypoda (bivalves), and Shell fragments.

Plate 1



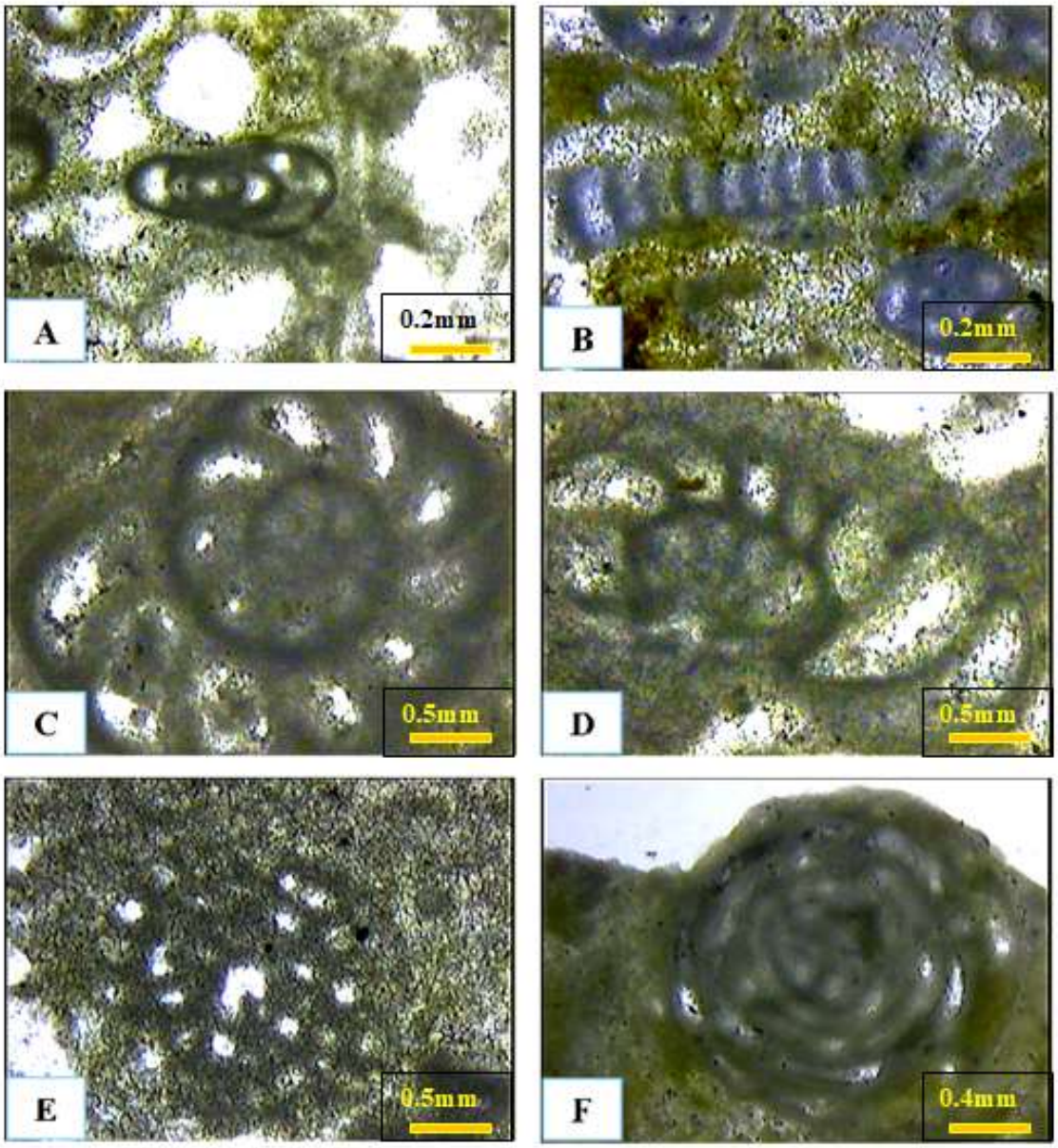
1. *Spiroloculina*sp (Euphrates Formation) (AJ-6, 1088 m).
2. *Spiroloculina*sp (Jeribe Formation) (AJ-4, 911 m).
3. *Quinquilucuilina* sp (Jeribe Formation) (AJ-11, 1045 m).
4. *Quinquilucuilina* sp (Jeribe Formation) (AJ-12, 1117 m).
5. *Austrotillina howchine* schlumberger sp (Euphrates Formation) (AJ-12, 1212 m).
6. *Austrotillina howchine* schlumberger sp (Jeribe Formation) (AJ-11, 1064 m).

Plate 2



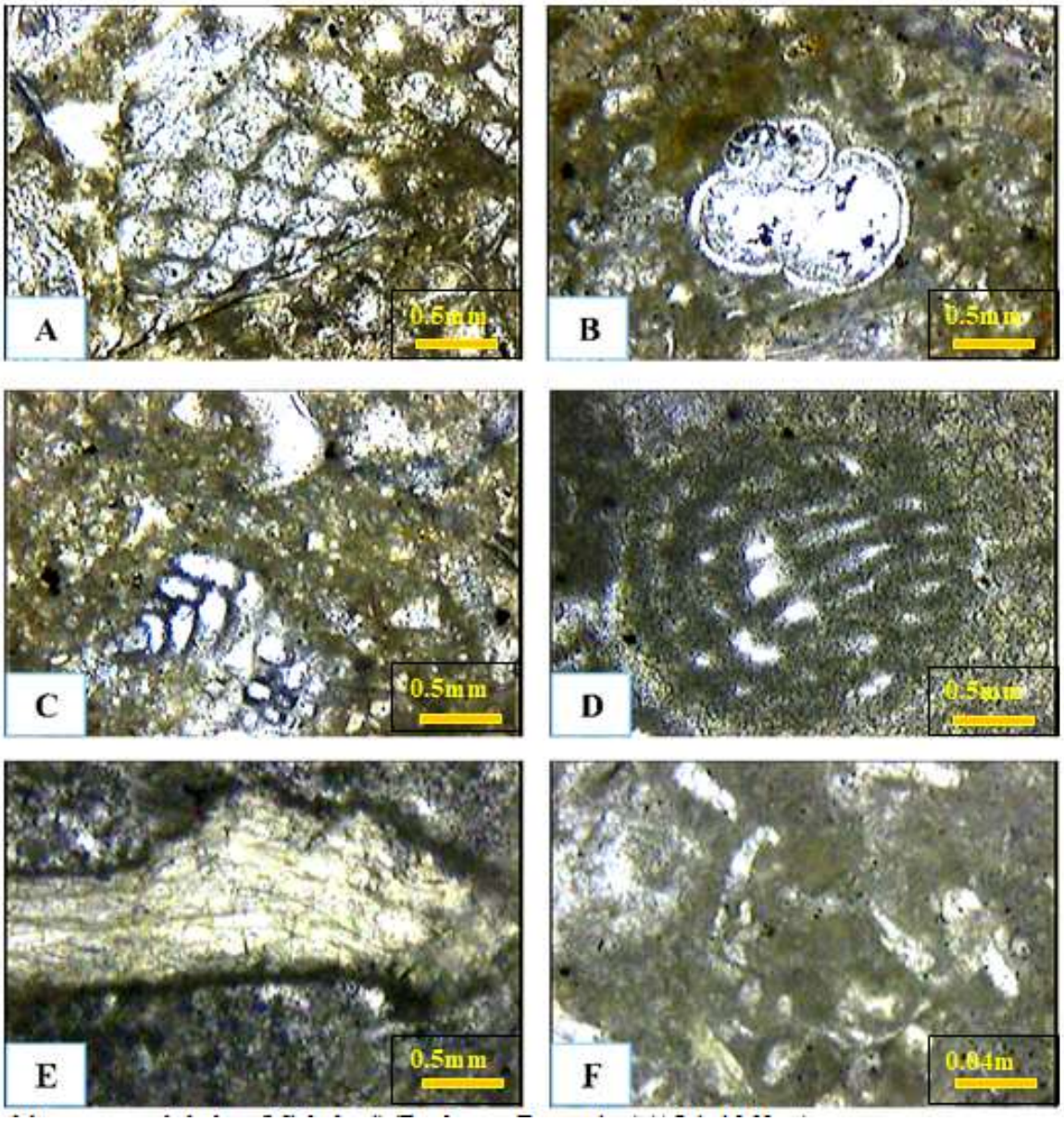
1. *Austrotillina asmariensis* Adam (Euphrates Formation) (AJ-12, 1173 m).
2. *Pyrgo*sp (Euphrates Formation) (AJ-6, 1115 m).
3. *Trilloculina* sp (Euphrates Formation) (AJ-6, 1088 m).
4. *Ammonia beccarii* (Linne) (Jeribe Formation) (AJ-12, 1118 m).
5. *Rotalia veinnoti* Greig (Jeribe Formation) (AJ-11, 1044 m).
6. *Praehyodionina delicate* Henson (Jeribe Formation) (AJ-12, 1116 m).

Plate 3



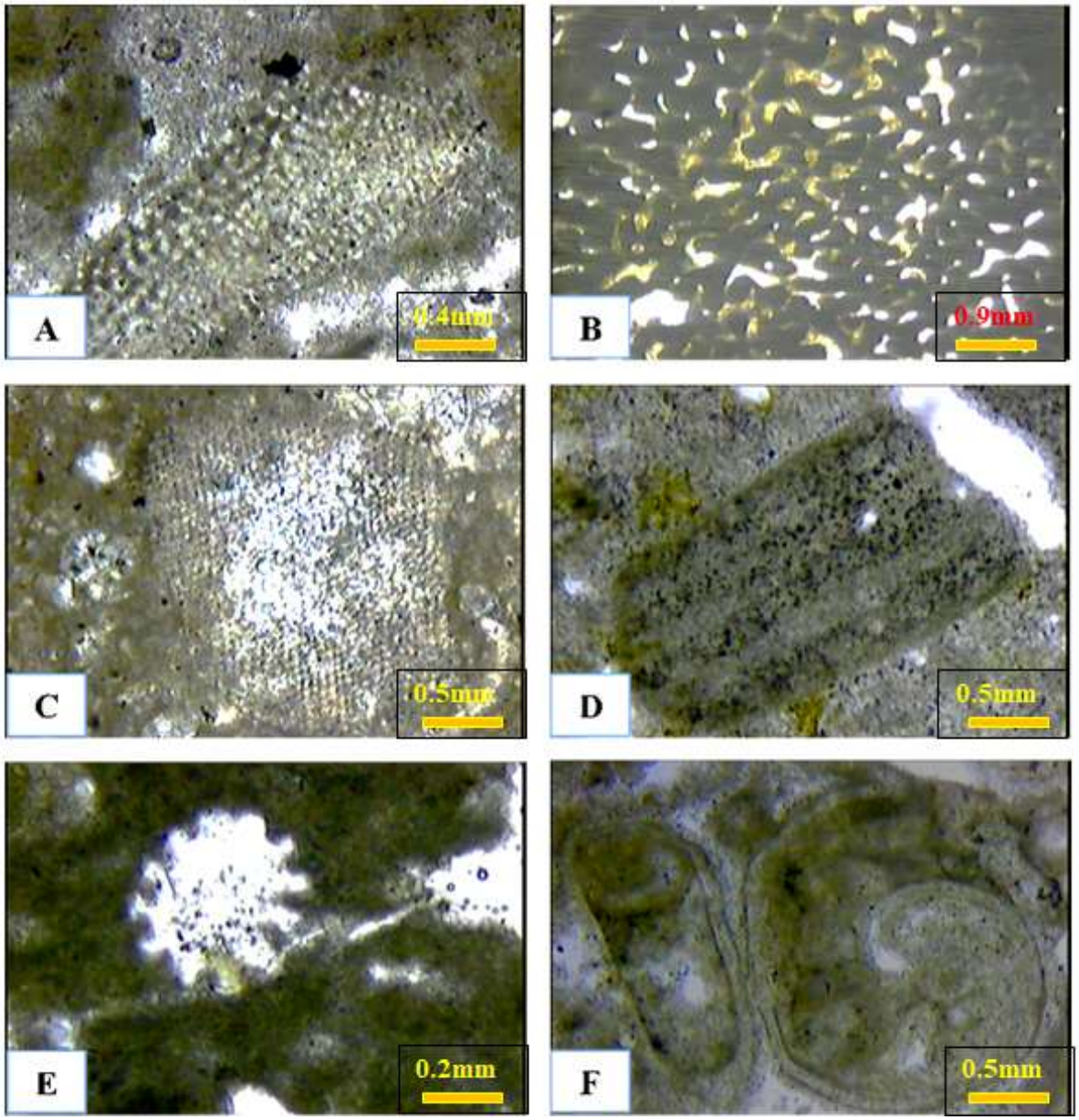
1. *Dendritina rangi* D'obigny (Jeribe Formation) (AJ-12, 1116 m).
2. *Peneroplis.* sp. (Jeribe Formation) (AJ-12, 1118 m).
3. *Peneroplis farsensis* Henson (Euphrates Formation) (AJ-12, 1134 m).
4. *Peneroplis evolute* Henson (Euphrates Formation) (AJ-6, 1114 m).
5. *Borelis melo melo* (Fitchel&Moll) (Jeribe Formation) (AJ-12, 932 m).
6. *Borelis melo var curdica* Reichel (Jeribe Formation) (AJ-12, 1118 m).

Plate 4



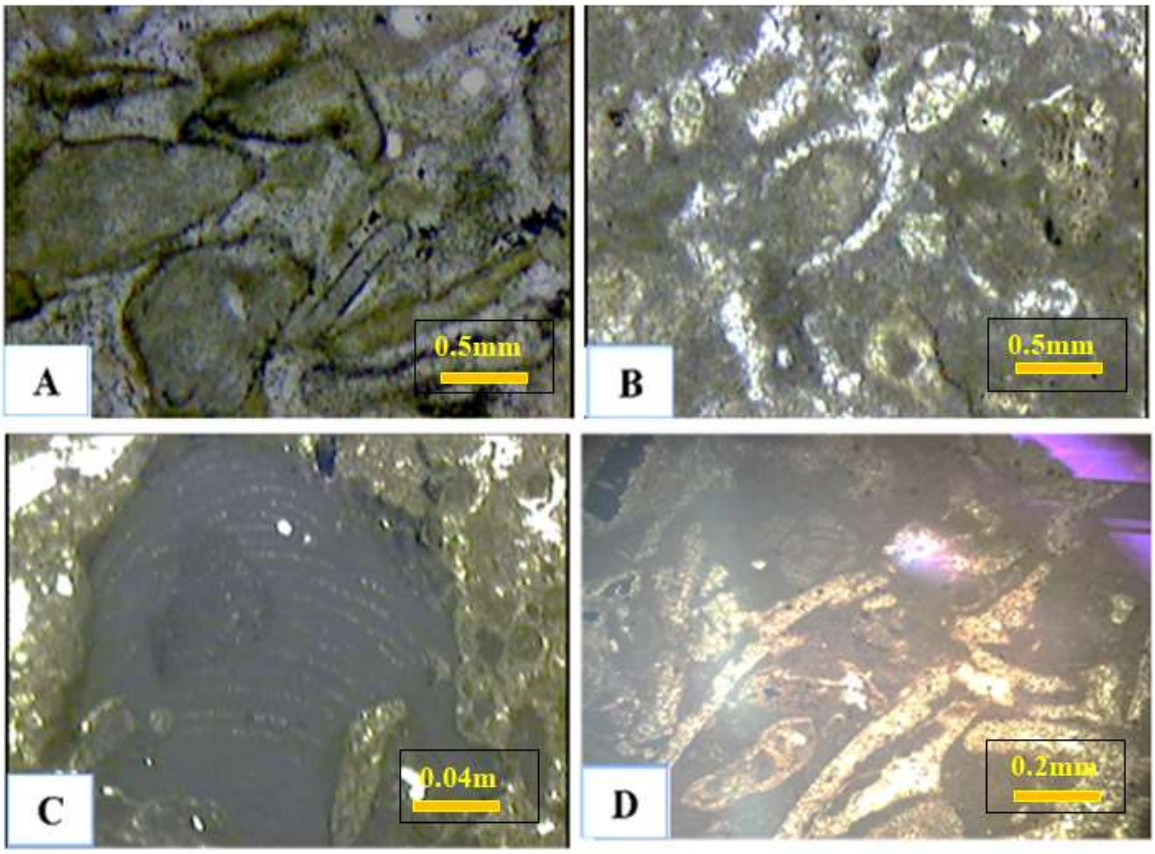
1. *Miogypsina globulina* (Michelotti) (Euphrates Formation) (AJ-4, 1063 m).
2. Victoriella (Euphrates Formation) (AJ-4, 1063 m).
3. Bolivina (Euphrates Formation) (AJ-4, 1063 m).
4. *Favreina asmaricus* (Euphrates Formation) (AJ-12, 1144 m).
5. Ostrae (Jeribe Formation) (AJ-11, 1047 m).
6. Bioclastic fragments (Euphrates Formation) (AJ-4, 1064 m).

Plate 5



1. Coral fragments (Jeribe Formation) (AJ-11, 1050 m).
2. Coral fragments (Jeribe Formation) (AJ-11, 1065 m).
3. Echinoid plate (Euphrates Formation) (AJ-4, 1063 m).
4. Echinoid spine (Jeribe Formation) (AJ-6, 1033 m).
5. Echinoid plate (Jeribe Formation) (AJ-11, 140 m).
6. Gastropoda (Euphrates Formation) (AJ-11, 1100 m).

Plate 6



1. Pelecypoda (Euphrates Formation) (AJ-11, 1123 m).
2. Pelecypoda (Jeribe Formation) (AJ-11, 1040 m).
3. Red algae (*Lihophyllum)* (Euphrates Formation) (AJ-11, 1130 m).
4. Shell fragment (Euphrates Formation) (AJ-4, 1057 m).

Discussion and Results

Two biozones of Euphrates and Jeribe formations are distinguished depending on the presence of benthonic foraminifera.

Arrangement of Biozones from older to younger are:

Ammonia beccarii-Miogypsina globulina (Assemlage zone)

Borelis melo curdica (range zone)

Index fossils of benthic foraminifera have been used for the purpose of determining the age of the Euphrates and Jeribe formations, because of their young age, wide geographical distribution and abundance in the selected wells. Most important of these are *Miogypsina globulina* (Michelotti) and *Borelis melo var curdica*.

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