Benthic Foraminiferal biostratigraphy of the Euphrates Formation (Early Lower Miocene-Middle Miocene) in selected sections, Western Iraq

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Abstract
Studies of three surface sections of the Euphrates Formation in its type locality Western Iraq, yielded a rich benthic foraminifera. Tabulation of the results showed more or less similar content which are previously studied except for the presence for the first time of *Triloculina trigonula* Lamark, *Triloculina tricarinata* D'orbigny in the lower parts and *Spirolina* cf. *cylindracea* Lamark in the upper parts. In addition two Biozone established in the studies sections, the lower *Ammonia beccarii* zone and upper *Ammonia beccarii-Borelis melo curdica* zone.

Keywords: Benthic Foraminiferal, Biostratigraphy, Euphrate Formation, West Iraq, Iraq.

الطباقية الحياتية للفورامنيفيرا القاعية لتكوين الفرات (المايوسين الأسفل المبكر – المايوسين الأوسط) في مقاطع مختارة، غرب العراق

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الخلاصة
اثبت دراسة المقاطع الثلاثة لتكوين الفرات في منطقة المثال غرب العراق، عن وفرة عالية من الفورامنفيرا القاعية. دلت جدولة هذه المعلومات ان التجمعات هي مشابهة تقريبا لما سبق ان تم تحديده في دراسات سابقة للتكوين عدى تواجد الأنواع الآتية *Triloculina trigonula* Lamark, *Triloculina tricarinata* D'orbigny and *Spirolina* cf. *cylindracea* Lamark في هذه المقاطع، اضافه إلى تثبيت نطاقين حياتيين هما:
lower *Ammonia beccarii* zone and upper *Ammonia beccarii–Borelis melo curdica* zone.

كلمات مفتاحية: الفورامنفيرا القاعية، الطباقية الحياتية، تكوين الفرات،غرب العراق، العراق.

Aim of the study

The aim of this study is elucidation of the benthic foraminiferal biostratigraphy of the Euphrates Formation in its type area, close zonation of the unit and throwing further light on the contradiction regarding its age.

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The study area

Generally, the area under investigation is a part of the stable shelf that bounds Syria and Jordan countries from the west. The location selected in this study in the type location, western Iraq, where extending from the town of Al-Baghdadi to Wadi Smendan, west of the old Anah town, it well represented at deep cut Wadies. The exposed limestone rocks in this area belong to the Lower–early Middle Miocene in age (figures- 1).

Figure.1- Location map of the studied area.

The lower contact of this unit was considered to be the first appearance of the calcitic conglomerate layer which varies in thickness from section to another (figures- 2); it overlies "Lower" Oligocene in section no.1, while it overlies the "Upper" Oligocene rocks in sections no.2 and section no.3 [1].

As well as, the upper contact is variable from section to section; it is the contact with the overlying alternate succession of marl and gypsum in (section no.1), the alternation of green marl with clastic limestones of section no.2 (possibly part of what [2] called "Kherish Beds", or overlain by green marl with chalky limestone in section no.3.

Previous studies

The Euphrates Formation exposed along the upper Euphrates valley, in both side of the Euphrates river, were several geological studies with different aim have been made in the investigated area of them: Bellen et al., [3] studied the type section in wadi Fuhaimi, 32km southeast of old Anah and assigned it to "Lower" Miocene in age [4] studied the depositional environment of the formation. According to the researches of [5, 6] it seems that both subspecies *Borelis melo melo* and *Borelis melo curdica* often occurs together in the Euphrates Formation.

Several geological studies indicated the lithological characterizes of this formation in the western desert, and divided it from lower to upper into: three units [7- 9] five units [10] and six units [11]. Later, the upper parts of these units is announced as a new formation and is called Nfayil Formation [12]. More recent studies of the Euphrates Formation have been conducted on biostratigraphic criteria, microfacies and depositional environments [13,14].

Sampling and techniques

Three stratigraphic sections were chosen, approximately forty-five surface samples collected in the field, where all standard criteria were observed in sampling. The laboratory work included making one hundred twenty-five thin sections of the limestones samples, 2-3 thin sections of each sample taking at right angles wherever that is possible, further six samples, especially near lower and upper contacts, were treated for fossils residue. Subsequent works, description of the lithology, identification of the fossils to determined the biozones and age of the formation.

Section no.1

This section lies 66 km. NW of Ramadi city, on the left side into main paved road, in Al-Baghdadi area. The section was measured in detail at 33° 52' 36" N and 42° 30' 16" E, total thickness about (36)m. It is possible to distinguish from bottom upwards the following lithological sequence. The lower part consist of a massive layer of calcitic conglomerates comparison of about (8) m thickness, overlain by well bedded calcitic limestone and dolomitic limestone which grades in to dolomitic rocks in the middle part, overlain by light grey, fossiliferous limestone, contains bands with pores, followed by well bedded of marly limestone in the upper most part (figure - 2)**.**

Figure 2- Showing the basal conglomerates in the Lower unit of the Euphrates Formation at section no. 1.

Section no.2

This section is at 31 km. distance from section no.1 to the left side of the main road on the Hadetha town. The section was measured in detail at 34° 07' 53" N and 42° 21' 27" E, with a total thickness is (33.40) m, included basal conglomerates layer of about (5) m thickness, which is overlain by well bedded limestone, dolomitic limestone, fossils are very abundant and chiefly represented by peneroplids, then beds of dolomite with only shadows of fossils, the upper part of this section contain white to grey chalky limestone, which alternates mainly with horizontal bands of marly limestone. In fact, this band is more observable in the middle and in the upper part.

The main features that are observed in the field, showing the horizons of bands from pores in which are sometimes contain finely crystalline calcite in the lower and upper parts, may be due to burrowing, or due to the effect of dissolution process (figure - 3). As well as, another features such as cavernous nature that appearance in the lower part.

Figure3- Showing the numerous pores (may be due to burrowing or dissolution) and the cavernous nature of the upper unit of the Euphrates Formation at section no.2.

[15]where recorded a total thickness is (25)m., after one year, [16] restudied the section, identified a *Borelis melo curdica* from the upper beds, and hence suspected it to be Jeribe limestone without any other information.

Section no.3

This section lies 54 km. of section no.1 in the direction of NW, on the new road to Rawah town, The section was measured in detail at 34° 26' 19" N and 41° 54' 16" E, with a total thickness (23.60)m. It is possible to distinguish from bottom upwards the following lithological sequence, the lower part consist of a massive layer of calcitic conglomerates of about (3.60) m thickness 'some time change to red claystone' which is in both case, overlain by well bedded limestone, dolomitic limestone in the middle part, and hence burrowed chalky limestones, overlain by alternate green marl with chalky limestone in the upper most part.

Figures- 4, 5, 6. Lists the fossils as identified from the sampled section of this study.

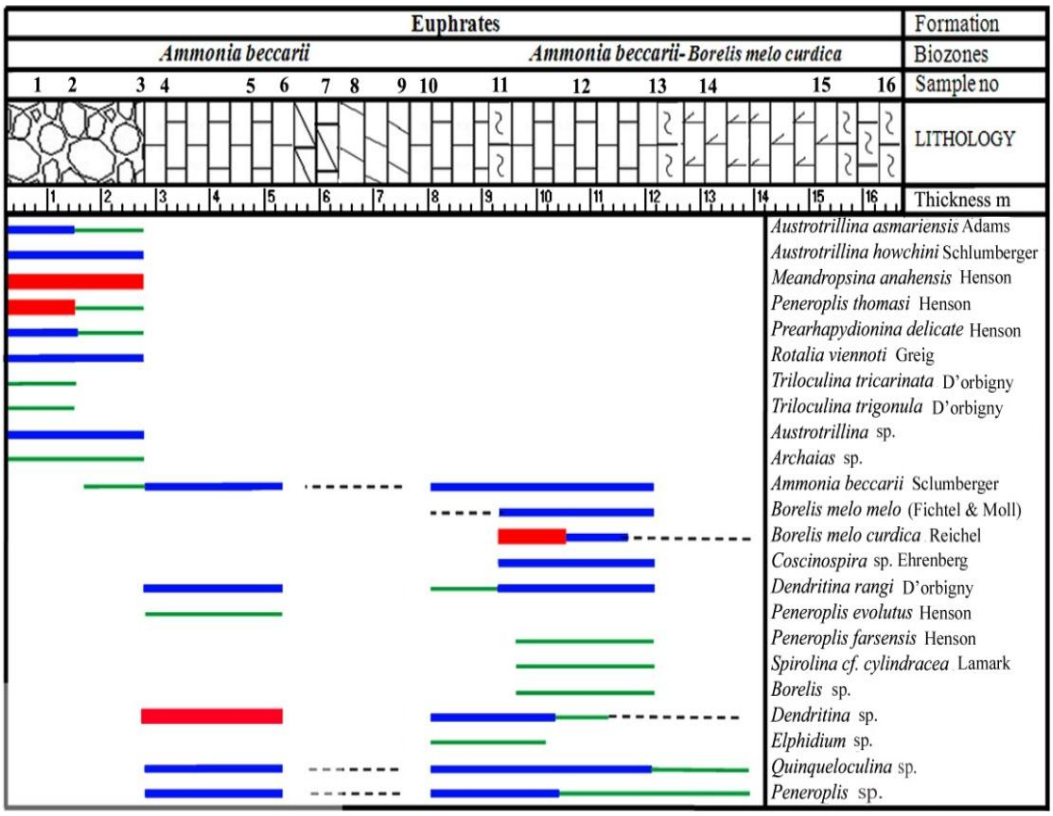

Figure 4- Vertical distribution of the benthic foraminifera of the Euphrates Formation at section no1.

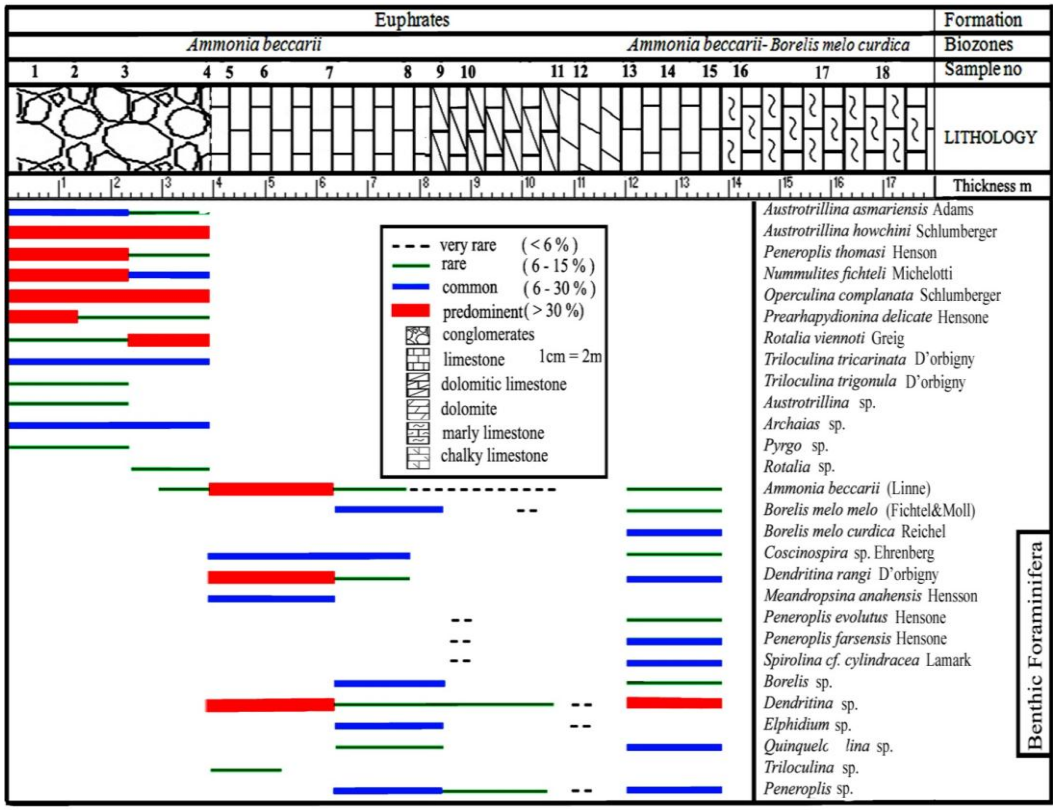

Figure 5- Vertical distribution of the benthic foraminifera of the Euphrates Formation at section no.2

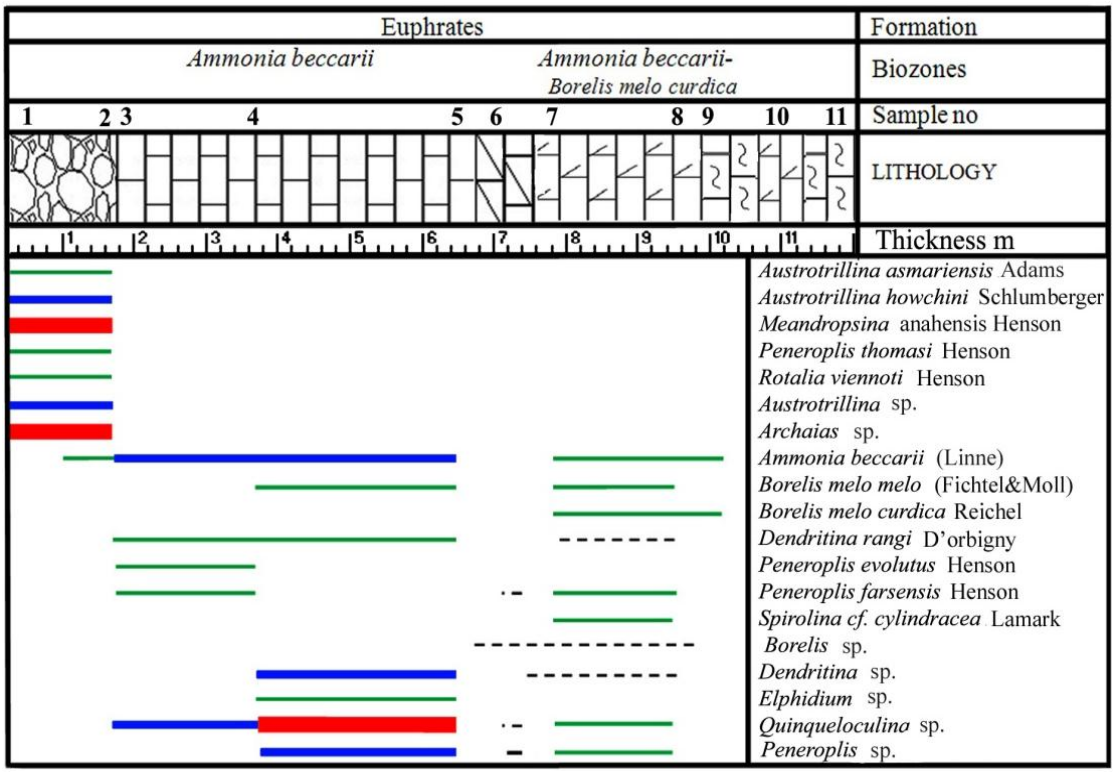

Figure.6- Vertical distribution of the benthic foraminifera of the Euphrates Formation at section no.

Biostratigraphic Zones

This report is a useful reference for recognition of biozones in the studies sections. Based on the distribution of the benthic foraminifera, and from the data presented in figures- 4, 5 and 6, two benthic foraminifera biozones are recognized in this study belong to the Lower-early Middle Miocene in age.

Ammonia beccarii zone

Ammonia beccarii-Borelis melo curdica zone

1- ***Ammonia beccarii* zone** its lower limit is determined by the first appearance of *Ammonia beccarii*, while its upper limit is marked by appearance of *Borelis melo curdica*. It is partial range zone.
This zone is omnipresent in all sections as following:

Table 1- Comparative total thicknesses with samples number of this zone in the studied sections.

Section (no)	Thickness (m)	Sample (no)
1	15	4-11
2	12	3-9
3	5	2-5

The association includes the following important fossils:
Dendritina rangi, *Meandropsina anahensis*, *Borelis melo* spp., , *Borelis* sp., *Dendritina*, *Elphidium* sp., *Coscinospira* sp., *Peneroplis* sp., and *Triloculina* sp.,

2-***Borelis melo curdica-Ammonia beccarii* zone**

The lower limit is the first appearance of *Borelis melo curdica* with continuous presence of *Ammonia beccarii*. It is an assemblage-rang zone. This zone is omnipresent in all sections as following:

Table 2- Comparative total thicknesses with samples number of this zone in the studied sections.

Section (no)	Thickness(m)	Sample (no)
1	4	13-15
2	8	10-13
3	5	7-9

The important associated microfossils are:
Borelis melo melo, *Spirolina* cf. *cylindracea*, *Peneroplis farsensis*, *Peneroplis evolutus*, *Peneroplis* sp., and *Quinqueloculina* sp.

Comparison and Correlation

As it noticed, the lower biozone *Ammonia beccarii* zone included the conglomerate layer which is considered a part of this sedimentary cycle of this unit. This layer contains apparently reworked fauna in the conglomerates particles; which consist of: *Austrotrillina asmariensis*, *Austrotrillina howchini, Nummulites fichteli, Operculina complanata, Peneroplis thomasi, Prearhapydionina delicate, Rotalia viennoti, Triloculina tricarinata, Triloculina trigonula, Archaias* sp., *Austrotrillina* sp., *Rotalia* sp., and *Pyrgo* sp. This assemblage had been described from the Oligocene rocks of Iraq [3, 17, 18]. As well as, [19-21] and [1], identified a similar listing fauna from the conglomerate layer in Kan Al-Baghdadi area. While the above is true of the fragments of the conglomerate layer, its fine interfragmental cement contains *Ammonia beccarii*.

This mixing explains the reworked of the fragments, but in situ deposition of part of the conglomerate layer during the early stages of "Lower" Miocene cycle. The upper part of *Ammonia beccarii* biozone is seemingly equivalent to *Ammonia beccarii globula* zone which was proposed by [22] for the lower Miocene rocks in northeast Iraq, and the same biozone suggested by [13] in center and north Iraq Middle Miocene in age.

Comparison with the studied sections by [13,22,23] and [24] indicates that the upper part of this biozone is probably of the same age as indicated by the aforesaid authors in their respective area i.e. late Lower Miocene. It follows that the lower part, must be of an earlier age.

As far as *Ammonia beccarii-Borelis melo curdica* assemblage-range zone, it is thought that it is equivalent Neoalveolina (*Borelis*) *melo* zone, probably early Middle Miocene, Langhian in Egypt [25], *Borelis melo* zone of Israel 'Unit 4' Ziqlag formation [26], *Borelis melo* curdica-*Ammonia beccarii globula* zone of northeast Iraq [27] and equivalent *Ammonia beccarii -Borelis melo melo-Borelis melo curdica* Partial concurrent-rang zone in the center and north Iraq, Middle Miocene in age [13]. While [28], reported the associated occurrence of *Borelis melo curdica* with *Dendritina rangi* D'orbigny and *Peneroplis farsensis* Henson from the Qom formation (Central Iran) which refer to the early Burdigalian in age.

Furthermore, As indicated above, This assemblage zone is recognized in the upper part of the Asmari Formation and is marked by the first appearance of *Borelis melo melo* and *Borelis melo curdica* [29] and *Borelis melo* group-*Meandropsina iranica* biozone of [30] and indicates a Burdigalian in age.

Moreover, the distribution of foraminiferal genus *Borelis* de Montfort [31] regarded that association of *Borelis melo melo* and *Borelis melo curdica* in the Indo-Pacific Province represented Early-Middle, Burdigalian- Langhian ?Serravallian; while in the Mediterranean Province in least Early-Middle Miocene, "middle" Burdigalian Langhian,? Serravallian in age. In all of these studies, their biozone were assigned to Early Middle Miocene in age.

Further comparison of the listings of the fossils and previous studied carried on this stratigraphic unit, whether in its type locality or elsewhere in Iraq, we may add that this study contributes some additions which are as follow:

Triloculina trigonula Lamark, *Triloculina tricarinata* D'orbigny, *Spirolina* cf. *cylindracea* Lamark. The identification of this species is for the first time in rocks of this unit in Iraq.

Plate (1 and 2) show some fossils recorded of the Euphrates Formation.

CONCLUSIONS

1- Based on the distribution of the larger benthic foraminifera, two foraminiferal assemblage biozones have been recorded from three stratigraphic surface sections of the Euphrates Formation, in its type

locality extending from the town of Al-Baghdadi to old Anah town, it is proposed that the unit is divided into lower: *Ammonia beccarii* range zone and upper *Ammonia beccarii - Borelis melo curdica* assemblage-range zone.

2- The fragments of the conglomerates layer, its fine interfragmental cement contains *Ammonia beccarii* in the lower parts of all sections, Early Lower Miocene in age.

3- *Ammonia beccarii* and *Borelis melo* are distinguishable nearly at the middle parts of all sections.

4- *Borelis melo* range at least throughout the Miocene, while *Borelis curdica* is restricted to the late early to Middle Miocene.

5- Both subspecies occurs in both the Indo-Pacific and Mediterranean provinces in the latest Early-early Middle Miocene points to marine (re) connection between the two provinces at this time.

6- Further the list of fossils should be amended to include *Triloculina trigonula* Lamark, *Triloculina tricarinata* D'orbigny in the lower parts and *Spirolina* cf. *cylindracea* Lamark in the upper parts.

The foremost interesting points revealed by this biostratigraphic study is that the conglomeratic layer is part of sedimentary cycle which is initiated at the early lower Miocene.

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Plates

Plate.1, Photomicrographs of Euphrates microfauna

1.Austrotrillina asmariensis Adams. Section no.1,sample no.1, x60.
2.Austrotrillina howchini (Schlumberger). Section no. 1,Sample no.3, x60.
3.Peneroplis thomasi Henson. section no.2 Sample no.2, x50.
4.Nummulites fichteli Michelotti. Section no.1,Sample no.2, x20.
5.Operculina complanata Schlumberger. section no.1, Sample no.3, x50.
6.Prearhapydionina delicate Henson. Section no.1, Sample no.2, x40.
7.Rotalia viennoti Greig. Section no.1, Sample no.3, x40.
8.Triloculina tricarinata D'orbigny. Section no.1, Sample no.1, x40.
9.Triloculina trigonula Lamark. Section no.1, Sample no.2, x40.
10.Triloculina tricarinata D'orbigny and Triloculina trigonula Lamark. Section no.1 Sample no.1, x40

Plate.2, Photomicrographs of Euphrates microfauna

1.Borelis melo curdica Reichel. Section no. 2,Sample no.10, x60
2.Dendritina rangi D'orbigny. Section no.2,Sample no.11, x30
3.Spirolina cf. cylindracea Lamark. Section no.3, Sample no.9, x 40
4.Mandropsina anahensis Henson. Section no.3,Sample no.2, x40
5.Pyrgo sp. Section no.1,Sample no.1, x38
6.Peneroplis farsensis Henson. Section no.2 Sample no.12, x44
7. Spirolina cf. cylindracea Lamark. Section no.2, Sample no.10, x40

8. Ammonia beccarii Linne. Section no.1, Sample no.6, x40
9. Borelis melo melo (Fichtel and Moll). Sample no.2, x30
10. Peneroplis evolutus Henson. Section no.3 Sample no.3, x44

plate.1

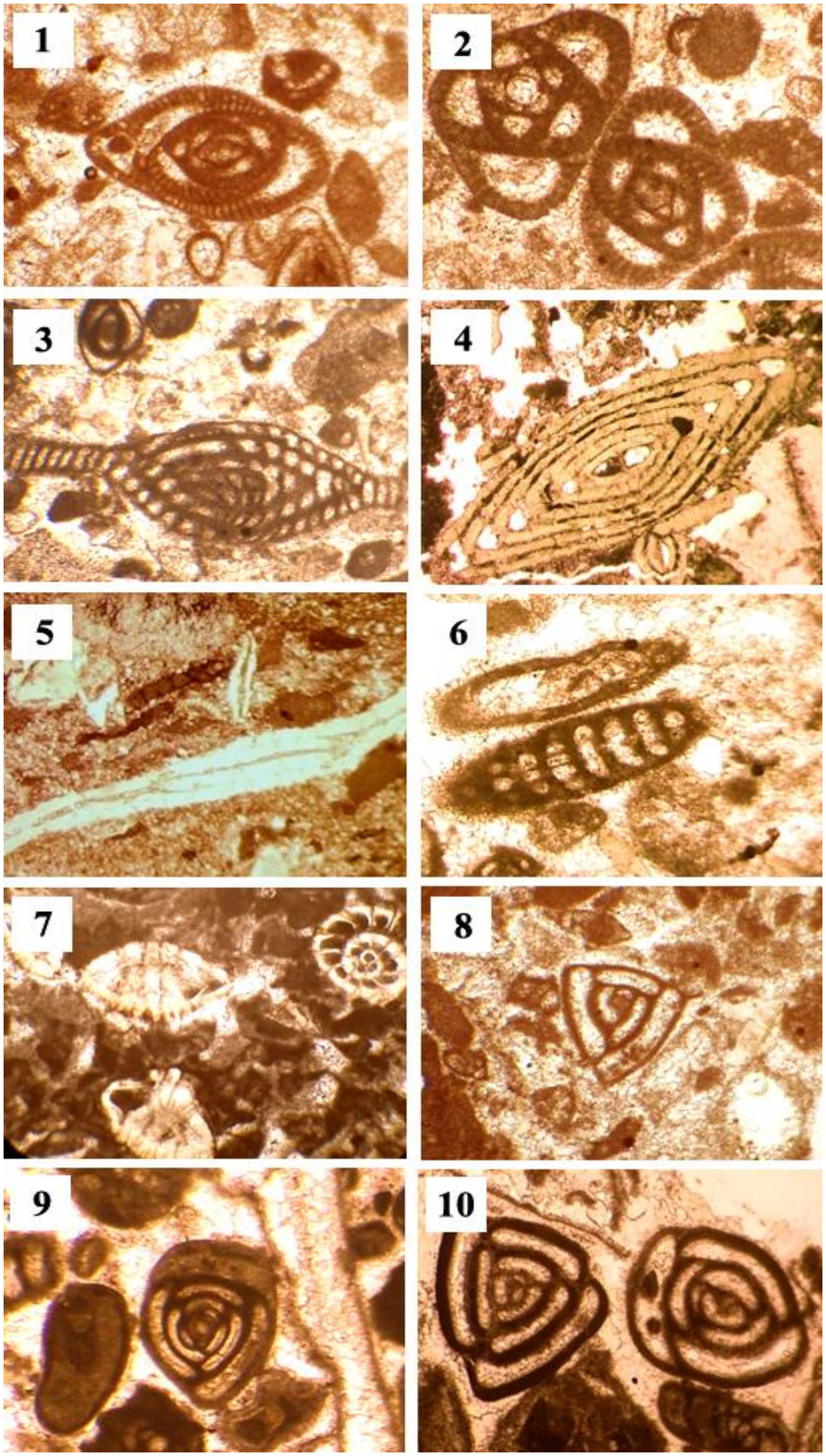

Plate 2