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Biostratigraphy of Yamama Formation at Luhais and Rifaee oilfields, Southern Iraq

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Abstract

Yamama Formation is the most important and widespread Lower Cretaceous Formation in Iraq. Yamama Formation in the Luhais well-12 and Rifaee well-1 are composed of dolomitized in some places and foraminifera and algae bearing limestone, 19 genera and species of foraminifera, 10 genera and species of algae. Two biozones were distinguished *Pseudochrysalidina arabica* Range zone and *Pseudocyclammina lituus* Range zone. The age of the formation was determined as Berriasian – Valanginian according to these biozones of Foraminifera. In this study, bryozoa, Gastropoda and Pelecypoda are recorded but less than Foraminifera.

Keywords: Yamama, Cretaceous, Berriassian, Valanginian, Foraminifera.

ألطباقيه الحياتيه لتكوين اليمامة في حقلي لحيس ورفاعي النفطيين, جنوبي العراق

لؤي سمير شاكر ,فرح علاءالدين خزعل*

قسم علم الأرض، كلية العلوم، جامعة بغداد، بغداد، العراق

الخلاصة

يعتبر تكوين اليمامة من اهم تكاوين العصر الطباشيري الاسفل في العراق, تم دراسة هذا التكوين في حقل لحيس, بئر-12 وحقل رفاعي, بئر -1, جنوبي العراق. تم تحديد نطاقيين حياتيين *Pseudochrysalidina arabica* Range zone و*Pseudocyclammina lituus* Range zone بالاعتماد على هذه الانطقه الحياتيه من الفورامنيفرا تم تحديد عمر تكوين اليمامة (برياسيان-فالانجينيان).

1. Introduction

The Cretaceous of the Arabian Plate hosts the most prolific hydrocarbon systems and good oil potential rocks in Iraq. The main oil reservoirs are of the Cretaceous age. The deposits are suitable for reserve, especially in the lower and middle Cretaceous Formations in southern Iraq [1, 2, 3 and 4].

The Mesopotamian Zone witnessed repeated open marine incursions leading to the deposition of alternating shallow-water carbonates and outer shelf marls. Sedimentation began with the transgressive Sulaiy and Yamama Formations and ended with the deposition of the Ratawi Formation during a highstand, as shown in Figure 1 [5]. The Yamama Formation in southern Iraq comprises outer shelf argillaceous limestones and oolitic, pelloidal, pelletal and pseudo-

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oolitic shoal limestones. Oolitic reservoir units are present in several NW-SE trending depocentres [5].

The Yamama Formation was deposited during the Lower Cretaceous period within the main retrogressive depositional cycle (Berriasian - Aptian) south of Iraq. This cycle is represented from shore to deep basin by the Zubair, Ratawi, Yamama, Shuiaba, and Sulaiy Formations [6]. It has attracted many researchers' attention because of its good oil potentiality [4, 7, 8, 9 and 10].

The current research aims to investigate the micropaleontological to provide a biostratigraphic scheme of the Yamama Formation in Luhais-12 (Lu-12) and Rifaee-1 (Ri-1), southern Iraq (Figure 2).

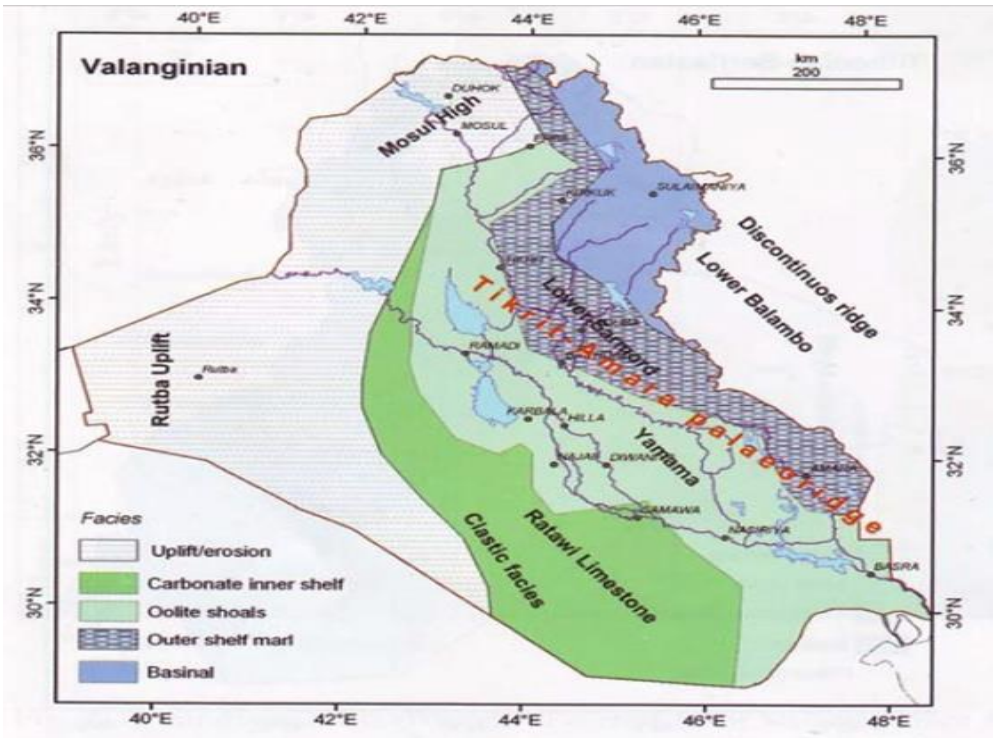

Figure 1-Paleogeography of the Yamama Formation [5].

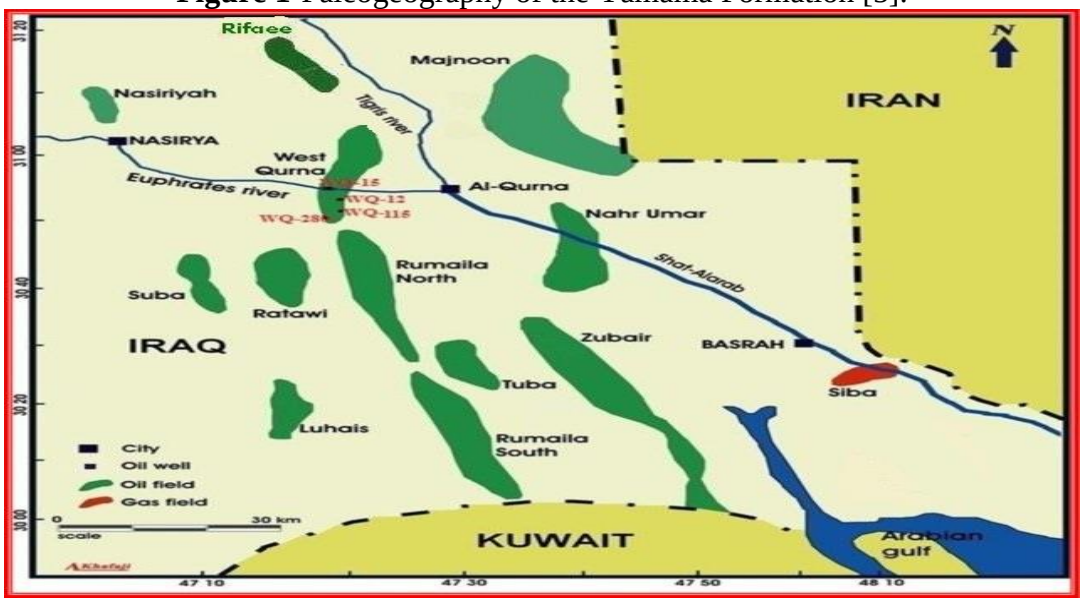

Figure 2- Luhais and Rifaee oil fields [5,9].

2. MATERIALS AND METHODS

This study was based on subsurface data provided by South of the oil company. Two wells were selected at the Luhais field structure: Lu-12 and the Rifaee field structure: Ri-2. The row data were collected from the final geological reports of the studied wells, which contain the identified plugs and thin sections .

The Luhais oil field is located within the southern desert, about 90 km SW of Basrah, which lies about 50 km SW of the North Rumaila oil field. The Rifaee oil field is located within the Missan governorate about 25 km to the south of Amara city (Figures 2 and 3).

Slides were studied by polarized microscope for the biostratigraphic description depending on benthonic foraminifera and other associated fossils. A total slide of more than 165 cores and cuttings were described and interpreted, together with several hundred thin sections previously. These slides have been studied with the aid of a binocular microscope to determine the fossils content and then estimate the age of formation.

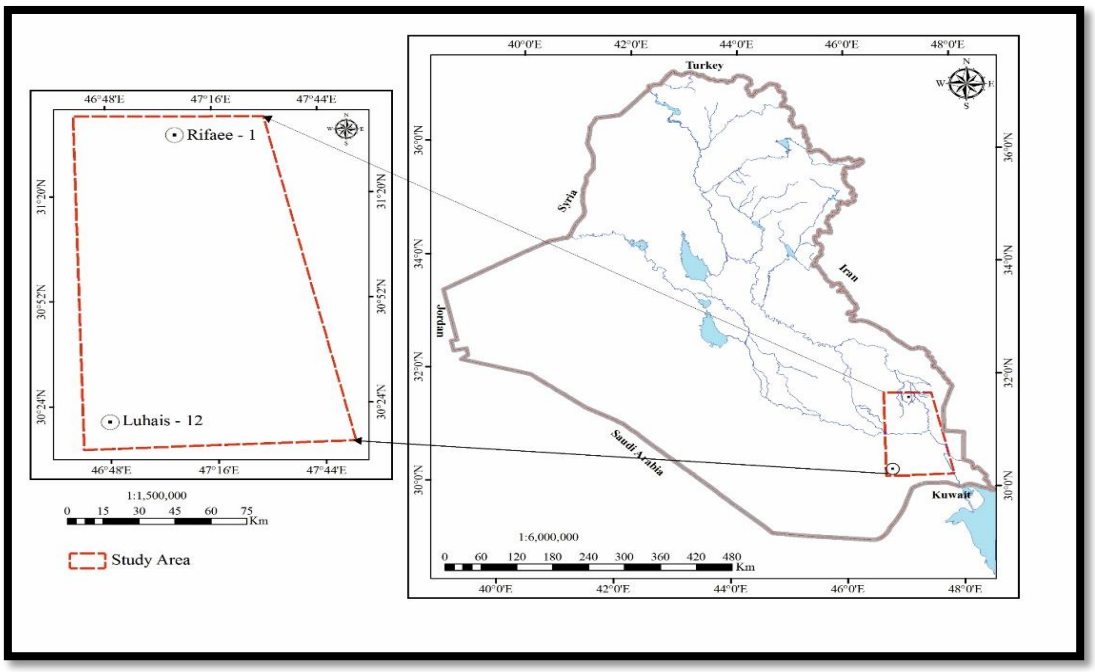

Figure 3- Location map of the study area.

3. Stratigraphy and Geological setting

The first description of the Yamama formation is in Saudi Arabia from outcrops. It belongs to the late Berriasian - Aptian cycle, which is represented from shore to deep basin by the Zubair, Ratawi, Garagu-Yamama, Shuaiba, Sarmord and lower Balambo formations. The formation usually conformably overlies the Ratawi. Towards the west of the Salman zone, the Yamama and Ratawi Formations are absent [6]. The formation is underlain conformably by the Sulaiy Formation and grades upward into the Ratawi Formation [11].

The thickness of the Yamama Formation is up to 400m in the Euphrates area near Najaf and up to 360 m thick in SE Iraq [5]. In the study area, the thickness of the formation is shown in Table 1.

Table 1-Thickness with top and bottom depth of the Yamama Formation in oil fields

Well Names	Top (m)	Bottom (m)	Thickness(m)
LU-12	3608.8	3770.2	161.4
RF-1	4230	4430	200

The equivalents of the Yamama Formation extend in Iraqi territory and are widespread in

Saudi Arabia, Qatar and Kuwait, depending on facies and age. Two variant of the Yamama Formation (described initially as separate formations) is the Garagu and Zangura formations. The Garagu Formation comprises oolitic sandy limestone with marl and sandstone within its upper and lower parts and organic detrital limestone in the middle [12]. To the eastward, the Yamama Formation grades into the Lower Sarmord Formation, then into the upper part of Chia Gara and Lower Balambo Formations. The Lower Sarmord Formation includes the basinal marly sediments of the Tithonian–Berriasian age (Figure-4).

The Chia Gara Formation is of Tithonian–Berriasian age and is formed of thin-bedded limestone and calcareous shale of deepwater type only; the most upper part of the formation is equivalent in age to the lower part of the Yamama Formation [5].

The Balambo Formation comprises the bathyal sediments of the entire Cretaceous of Iraq; the Lower Balambo Formation includes the Valanginian– Albian deposits and embraces deep–water sediments with pelagic fauna. It is composed of thin-bedded, blue, ammonite–bearing limestone with intercalations of olive–green marls and dark blue shale [6]. In Iran, the equivalent of Yamama is the Fahliyan Formation, and Minagish Formation is the equivalent of the Yamama Formation in Kuwait [5].

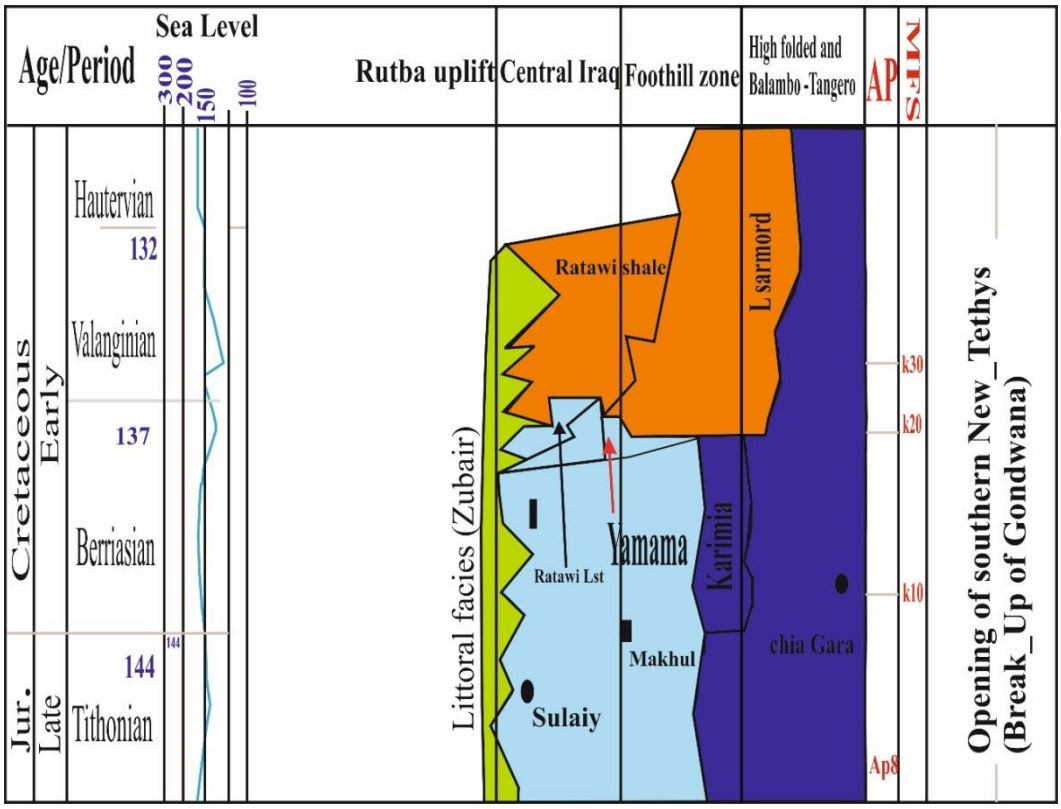

Figure 4-Chronostratigraphy of Yamama Formation and equivalent formations within Tithonian-Hauterivian sequence [5].

4. BIOSTRATIGRAPHY AND BIOZONE

Biostratigraphy intends to subdivide strata based on their biotic content and to make fine and finer orderings of what are considered sequential events in the geologic record [13].

The present study of the Yamama Formation is carried out at two selected wells (Lu-12 and Ri-1) from Luhais and Rifaee oil fields, respectively. The biostratigraphy of the formation depends on benthonic foraminifera and other associated fossils.

- **Microfossils of the Yamama Formation in Luhais-12 well**

The following microfauna are identified in the sediment of Yamama Formation at well Lu-12.these include the following benthic foraminifera (Figure-6):

Glomospira sp., *Lenticulina* sp., *Mayncina bulgarica* Schlumberger (Pl.1-H), *Mayncina termieri* Hottinger (Pl.1- F&G) , *Nautiloculina oolithica* Mohler, *Nezzazata* sp. (Pl.1- I), *Pseudochrysalidina* sp. (Pl.1-B), *Pseudochrysalidina arabica* Henson (Pl.1-A), *Pseudocyclammina lituus* Yokoyama(Pl.1- K&L), *Quinqueloculina* sp. (Pl.1-E(b)), *Istriloculina ellipitica* (Pl.1- C), *Textularia* sp. (Pl.1- D), *Trocholina cf. chouberti* Hottinger(Pl.1- J), *Valvulina* sp.,

In addition to the following red and green Algae: *Acicularia elongata* Carozzi (Pl.2-E), *Actinoporella podolica* Alth(Pl.2-C), *Cylindroporella* sp., *Lithocodium aggregate* Elliot (Pl.2 -F), *Permocalculus* sp., *Permocalculus ampullaceous* Elliot, *Permocalculus inopinatus* Elliot (Pl.2-D), *Permocalculus irenae* Elliot, *Salpingoporella annulata* Elliot.

And associated Fossils: Bryozoa, Gastropoda (Pl.2-I), Ostracoda, Pelecypoda (Pl.2-G).

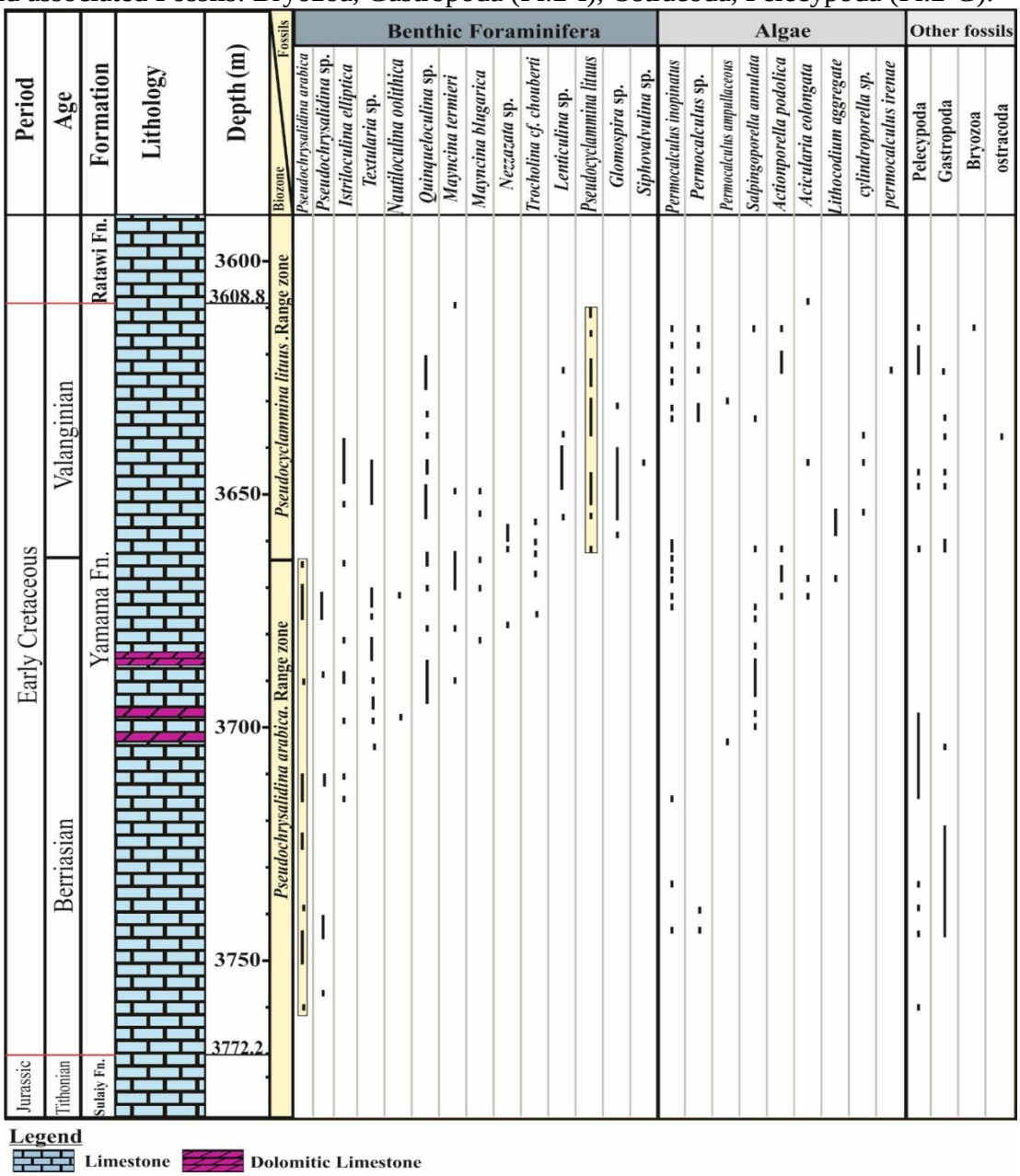

Figure 5-Biostratigraphy of Yamama Formation at well Lu-12.

- **Microfossils of Yamama Formation at Rifaee-1**

The following microfauna are identified in the sediment of Yamama Formation at well Ri-1.these include the following benthic foraminifera (Figure-7):

Charentia cuvillieri Neumann (Pl.2-B) , *Pseudochrysalidina* sp. , *Everticyclammina eccentrica*, *Lenticulina* sp., *Mayncina termieri* Hottinger, *Nautiloculina bronnimani* Mohler, *Nautiloculina oolithica* Mohler, *Pseudocyclammina lituus* Yokoama, *Pseudotextularia salvensis* Charollias, ronniaman, Et zeninetti, *Quinqueloculina* sp. (Pl.1-E(b)), *Textularia* sp., *Trocholina* sp. (Pl.2-A).

In addition to the following red and green Algae: *Acicularia elongata* Carozzi, *Actinoporella podolica* Alth, *Cylindroporella* sp., *Cylindroporella sugdeni, Lithocodium aggregate* Elliot, *Permocalculus* sp., *Permocalculus inopinatus* Elliot, *Permocalculus irenae* Elliot, *Salpingoporella annulata* Elliot.

And associated Fossils: Gastropoda (Pl.2-H), Pelecypoda.

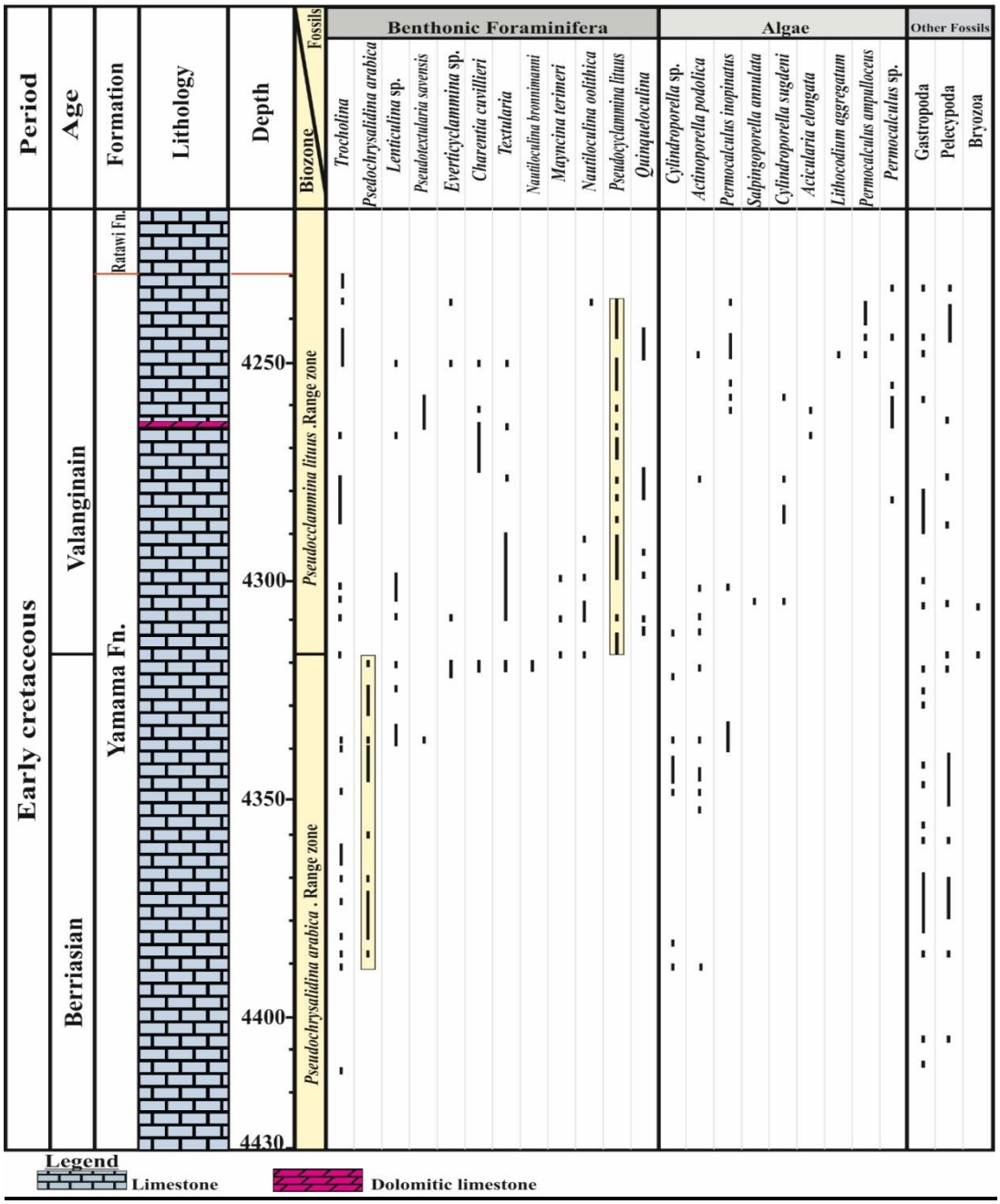

Figure 6-Biostratigraphy of Yamama Formation at well Ri-1

- **Biozones of Yamama Formation**

Through the biostratigraphic study of the Yamama Formation, depending on the presence of benthonic foraminifera and algae, two biozones are distinguished as shown below:

***1. Pseudochrysalidina arabica.* Range zone:**

Definition: This zone is identified depending on the first appearance of *Pseudochrysalidina arabica*.

The upper limit of the zone was determined by the disappearance of this species and the appearance of *pseudocyclammina lituus*.

Occurrence: This zone occurs within two described wells of the study, Luhais-12 and Rifaee-1.

Age: The age of this range zone is Berriasian.

Thickness: The thickness of the zone is 95 m at Luhais well, and 65 m at Rifaee well.

Assemblages: The fossils assemblages of this zone are Foraminifera: *Charentia cuvillieri* Neumann,

Everticyclammina sp., *Istriloculina elliptica*, *Lenticulina* sp., *Mayncina bulgarica* Schlumberger,

Mayncina termieri Hottinger, *Nautiloculina oolithica* Mohler, *Nezzazata* sp., *Quinqueloculina* sp., *Textularia* sp., *Pseuodchrysalidina* sp., *Pseudochrysalidina arabica* Henson, *Pseudotextularia salvensis* Charollias, ronniaman, Et zeninetti, *Textularia* sp., *Trocholina* sp., *Trocholina cf. chouberti* Hottinger.

Algae: *Acicularia elongata* Carozzi, *Actinoporella podolica* Alth, *Cylindroporella* sp., *Lithocodium aggregate* Elliot, *Permocalculus ampullaceous* Elliot, *Permocalculus* sp., *Permocalculus inopinatus* Elliot, *Salpingoporella annulata* Elliot.

And associated Fossils: Gastropoda and Pelecypoda.

Remarks and correlation: Bellen *et al.* [14] recorded the age of the Yamama Formation in Iraq

Berriasian-Valanginian based on fossils content, also Buday [6] assumed Yamama Formation equivalent to Zangura Formation based on fossils content, and it is age Berriasian-Valanginian.

Pseudochrysalidina arabica zone is reported as (Berriasian-Valanginian) in the SW of Iran [15]. It is reported as Berriasian-Valanginian by Abyat *et al.* [16, 17, and 18]. Rostami *et al* [19 and 20]

recorded the age of *Pseudochrysalidina arabica* as (Berriasian).

***2. Pseudocyclammina lituus.* Range Zone:**

Definition: This zone is identified depending on the first appearance of *pseudocyclammina lituus*. The disappearance of this species determined the upper limit of the zone.

Occurrence: This zone occurs within two described wells of the study, Luhais-12 and Rifaee-1.

Age: The age of this range zone is Valanginian.

Thickness: The thickness of the zone is 51 m at Luhais well, and 79 m at Rifaee well.

Assemblages: The fossils assemblage of this zone are Foraminifera: *Charentia cuvillieri* Neumann, *Everticyclammina* sp., *Glomospira* sp., *Istriloculina elliptica*, *Lenticulina* sp., *Mayncina bulgarica* Schlumberger, *Mayncina termieri* Hottinger, *Nautiloculina oolithica* Mohler, *Nezzazata* sp., *Pseudocyclammina lituus* Yokoyama, *Pseudotextularia salvensis* Charollias, ronniaman, Et zeninetti, *Quinqueloculina* sp., *Siphovavulina* sp., *Textularia* sp., *Trocholina* sp., *Trocholina cf. chouberti*

Hottinger.

Algae: *Acicularia elongata* Carozzi, *Actinoporella podolica* Alth, *Cylindroporella* sp., *Lithocodium aggregate* Elliot, *Permocalculus ampullaceous* Elliot, *Permocalculus* sp.,

Permocalculus inopinatus Elliot, *Permocalculus irenae* Elliot, *Salpingoporella annulata* Elliot.

And associated Fossils: Bryozoa, Gastropoda, Ostracoda, Pelecypoda.

Remarks and correlation: This biozone was described by several authors like Al-Shahwan [21] in the southern part of Iraq as *Pseudocyclammina lituus-Trocholina elongata, Alpina-Nautiloculina oolithica* assemblage zone (Berriasian- late Hautervian), Wynd [22] in SW of Iran and Gollestaneh [23] South of Iran as *Pseudocyclammina lituus-Dokhania arabica* and Gollestaneh [23] described as *Pseudocyclammina lituus-Trochlina*(Berriasian-Hautervian), Shakib [15]described as (Hautervian), Abyat *et al.* [16, 17 and 18] in South West of Iran described as (Valanginian-Hautervian). Pirbalouti and Abyat [24] are also described as (Valanginian-Hautervian). Al-Hassani and Al-Dulaimi [25] in the southern part of Iraq described this zone as (Valanginian); in this study, this zone was described as Valanginian.

Plate 1

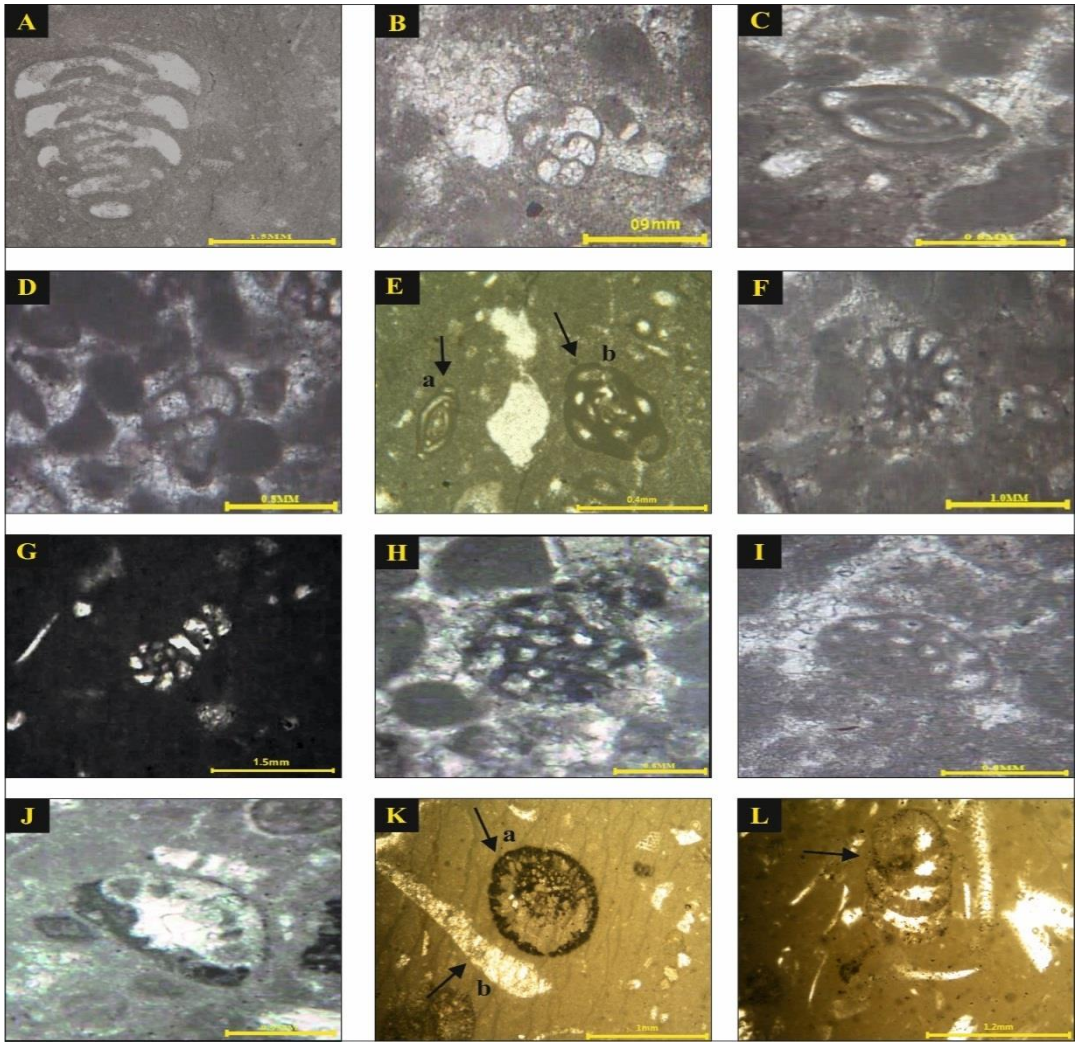

Plate 1: Benthic Foraminifera and Algae of the Yamama Formation:

A- *Pseudochrysalidina Arabica* Henson, Lu-12well, depth 3670m.
B- *Pseudochrysalidina* sp., Lu-12 well, depth 3602m.
C- *Istriloculina elliptica*, Lu-12 well, depth 3960m.
D- *Textularia* sp., Lu-12 well, depth 3650m.
E- (a) *Istriloculina elliptica*, (b) *Quinqueloculina* sp., Lu-12 well, depth 3645m.
F- *Mayncina termieri* Hottinger, Lu-12 well, depth 3665m.
G- *Mayncina termieri* Hottinger, Lu-12 well, depth 3608.8m.
H- *Mayncina bulgarica* Schlumberger, Lu-12 well, depth 3681m.

I- *Nezzazata* sp., Lu-12 well, depth 3660m.
J- *Trocholina cf. chouberti* Hottinger, Lu-12 well, depth 3663m.
K- (a)*Pseudocyclammina lituus* Yokoyama, (b) Permocalculus algae, Lu-12 well, depth 3632m
L- *Pseudocyclammina lituus* Yokoyama, Lu-12 well, depth 3622m.

Plate 2

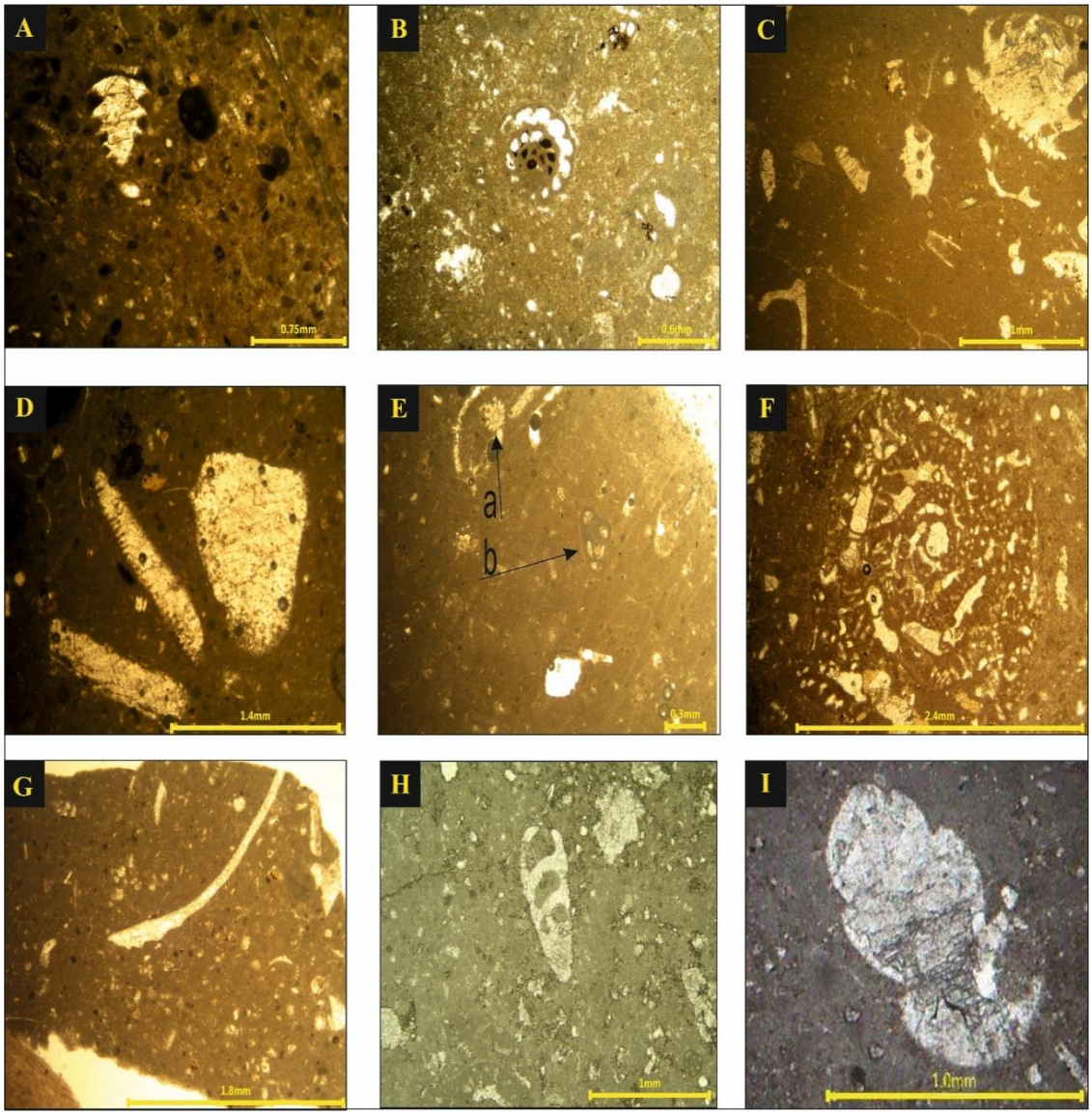

Plate 2: Benthic Foraminifera and Algae of Yamama Formation:
A- *Trocholina* sp., Ri-1 well, depth 4348m.
B- *Charentia cuvillieri* Neumann, Ri-1 well, depth 4270m.
C- *Actinoporella podolica* (Alth), Lu-12 well, depth-3621m.
D- *Permocalculus inopinatus* (Elliot), Lu-12 well, depth- 3618m.
E- *(a) Acicularia elongata* Carozzi, Lu-12 well, depth 4263m, (b) *Glomospira*, Lu-12 well, Depth 3643m.
F- *Lithocodium aggregate (*Elliot), Lu-12 well, depth- 3655m.
G- Pelecypoda, Lu-12 well, depth
H- Gastropoda, Ri-1 well, depth 4285m.
I- Gastropoda, Lu-12 Well, depth- 3662m.

5. Conclusions

The present study includes biostratigraphy and microfacies analysis of the Yamama Formation in two oil fields: Luhais well -12 and Rifaee well - 1 . the main conclusions are:

1. The microbiostratigraphical studies led to identifying 19 genera and species of Foraminifera and ten genera and species of Algae they are: Foraminifera: *Charentia cuvillieri* Neumann, *Everticyclammina* sp., *Glomospira* sp., *Istriloculina elliptica*, *Lenticulina* sp., *Mayncina bulgarica* Schlumerger, *Mayncina termieri* Hottinger, *Nautiloculina bronnimani* Mohler, *Nautiloculina oolithica* Mohler, *Nezzazata* sp., *Pseudochrysalidina* sp., *Pseudochrysalidina arabica* Henson, *Pseudocyclammina lituus* Yokoyama, *Pseudotextularia salvensis* Charollias, ronniaman, Et zeninetti, *Quinqueloculina* sp., *Siphovavulina* sp., *Textularia* sp., *Trocholina* sp., *Trocholina cf. chouberti* Hottinger ,.
Algae: *Acicularia elongata* Carozzi, *Actinoporella podolica* Alth, *Cylindroporella* sp., *Cylindroporella sugdeni*, *Lithocodium aggregate* Elliot, *Permocalculus* sp., *Permocalculus ampullaceous* Elliot, *Permocalculus inopinatus* Elliot, *Permocalculus irenae* Elliot, *Salpingoporella annulata* Elliot .
And associated Fossils: Bryozoa, Gastropoda, Ostracoda and Pelecypoda.

2. Two biozones were distinguished in Yamama Formation depending on benthic foraminifera. These zones are:

a. *Pseudochrysalidina arabica*. Range zone (Berriasian age).
b. *Pseudocyclammina lituus*. Range Zone (Valanginian age).

3. The age of the Formation was determined as Berriasian –Valanginian according to foraminifera biozones.

References

[1] M. Al-Dabbas, J. Al-Jassim, and S. Al-Jumaily, "Depositional environments and porosity distribution in regressive limestone reservoirs of the mishrif formation, Southern Iraq," *Arab. J. Geosci.*, vol. 3, no. 1, pp. 67–78, 2010, doi: 10.1007/s12517-009-0057-x.

[2] M. A. Al-Dabbas, J. A. Jassim, and A. I. Qaradaghi, "Sedimentological and depositional environment studies of the mauddud formation, central and southern Iraq," *Arab. J. Geosci.*, vol. 5, no. 2, pp. 297–312, 2012, doi: 10.1007/s12517-010-0256-5.

[3] M. A. Al-Dabbas, J. A. Al-Jassim, and A. I. Qaradaghi, "Siliciclastic deposit of the Nahr Umr Formation, sedimentological and depositional environment studies, central and southern Iraq," *Arab. J. Geosci.*, vol. 6, no. 12, pp. 4771–4783, 2013, doi: 10.1007/s12517-012-0747-7.

[4] A. J. Al-Khafaji, F. M. Al Najm, R. N. Al Ibrahim, and F. N. Sadooni, "Geochemical investigation of Yamama crude oils and their inferred source rocks in the Mesopotamian Basin, Southern Iraq," *Pet. Sci. Technol.*, vol. 37, no. 18, pp. 2025–2033, 2019, doi: 10.1080/10916466.2019.1578801.

[5] S. Z. Jassim and J. C. Goff, *Geology of Iraq*. DOLIN, sro, distributed by Geological Society of London, 2006.

[6] T. Buday, *The regional geology of Iraq: stratigraphy and paleogeography*, vol. 1. State Organization, 1980.

[7] H. A. Chafeet, "Yamama Reservoir Characterization in the West Qurna Oil Field , Southern Iraq Yamama Reservoir Characterization in the West Qurna Oil Field , Southern Iraq," *Iraqi J. Sci.*, Vol. 57, No.2A, pp: 938-947, 2020.

[8] A. M. Handhal, "The spatial analysis of Yamama Formation heterogeneity in south of Iraq," *Iraqi J. Sci.*, vol. 57, no. 3A, pp. 1783–1794, 2016.

[9] [9] Th. K. Al-Ameri1, M S. A. Jafar², and J Pitman, "Hydrocarbon Generation Modeling of the Basrah Oil Fields, Southern Iraq, oral presentation," *AAPG Annual Convention and Exhibition, Houston, Texas*, Vol. 20116. 2011.

[10] A. M. Handhal, F. M. Al-Najm, and H. A. Chafeet, "Determination of flow units of Yamama formation in the West Qurna oil field, Southern Iraq," *Iraqi J. Sci.*, vol. 59, no. 4 A, pp. 1878–1898, 2018, doi: 10.24996/IJS.2018.59.4A.13.

[11] F. N. Sadooni, "Stratigraphic sequence, microfacies, and petroleum prospects of the Yamama Formation, Lower Cretaceous, southern Iraq," *Am. Assoc. Pet. Geol. Bull.*, vol. 77, no. 11, pp. 1971–1988, 1993.

[12] A. A. M. Aqrawi, A.D. Horbury, J.C. Goff and F.N. Sadooni, *The Petroleum Geology of Iraq* .State oil, 2010.

[13] B. U. Haq, and A. Boersma, *Introduction to marine micropaleontology*, Elsevier, 1998.

[14] R. C. V. Bellen, H. V. Dunnington, R. Wetzel, and D. M. Morton., *Lexique Stratigraphique International*, Asia, Iraq. Int. Geol.Congr. Comm. Stratig, 1959.

[15] S. S. Shakib, Paleoenvironmental and biostratigraphic significance of foraminiferal associations from the Early Cretaceous sediments of southwest Iran, In: Simmons, M.D. (Ed.), Micropalaeontology and Hydrocarbon Exploration in the Middle East, British Micropalaeontological Society Publication Series, Chapman & Hall, London, 1994.

[16] A. Abyat, D. Baghbani, M. Afghah, N. K. Ghadimvand, and A. Feghi, "Microbiostratigraphy and lithostratigraphy of Fahliyan and Gadvan Formations in Kuh-e-Surmeh (Zagros Basin, Southwest Iran)," *Adv. Environ. Biol.*, vol. 6, no. 12, pp. 3078–3086, 2012.

[17] A. Abyat, D. Baghbani, M. Afghah and Kohansal Ghadimvand N, "Microfacies, depositional environment and sequence stratigraphy of the Fahliyan and Gadvan Formations, Kuh-e-Surmeh section (Zagros Basin, Southwest Iran).," *Adv. Environ. Biol.*, vol. 35, no. 1, pp. 82–89, 2014.

[18] A. Abyat, D. Baghbani, M. Afghah, N. K. Ghadimvand, and S. Afsari, "Neocomian – Barremian foraminifers and algae from Coastal Fars," *Arab. J. Geosci.*, 2016, doi: 10.1007/s12517-015-2128-5.

[19] L. Rostami *et al.*, "Benthic foraminiferal and calcareous algal biostratigraphy of the Fahliyan Formation in oil well X1, Dorood Oilfield, Persian Gulf," *Geopersia*, vol. 8, no. 2, pp. 319–329, 2018, doi: 10.22059/GEOPE.2018.256557.648385.

[20] L. Rostami *et al.*, "Neocomian Fahliyan formation carbonates in the oil well X2 (Dorood oil field, Persian Gulf): Biostratigraphic data from benthic foraminifera and algae," *Iran. J. Earth Sci.*, vol. 11, no. 3, pp. 173–182, 2019.

[21] M. F. Al-Shahwan, Biostratigraphy and microfacies of Yamama Formation in selected wells, southern Iraq, M.S. Thesis, University of Baghdad, Iraq, 1993.

[22] J.G. Wynd, Biofacies of the Iranian Oil Consortium Agreement Area: Iranian Oil Operating Companies, Geological and Exploration Division Report 1082, 1965.

[23] A. Gollesstaneh, Micropalaeontological study of the Upper Jurassic and Lower Cretaceous of Southern Iran. Ph.D. Thesis, University College London, 1965.

[24] B. A. Pirbalouti, and A. Abyat, "Early Cretaceous benthic foraminiferal biozonation of the Fahliyan and Gadvan Formations in the Assaluyeh and Halegan stratigraphic sections, Zagros Basin, Southwest of Iran," *Carbonates and Evaporites*, doi: 10.1007/s13146-017-0376-z.

[25] M. Al-Hassani and S. Al-Dulaimi, "Biostratigraphy of Yamama Formation in Faihaa Oil Field, Southern Iraq," *Iraqi J. Sci.*, vol. 62, no. 5, pp. 1570–1586, 2021, doi: 10.24996/ijs.2021.62.5.20.