 Iraqi Journal of Science, 2023, Vol. 64, No. 2, pp: 730-749
DOI: 10.24996/ijs.2023.64.2.21

ISSN: 0067-2904

Facies Architecture And Depositional Marine Systems of the Yamama Formation in Selected Wells, Southern Iraq

Shatha A. Mohsin*[1], Abbas H. Mohammed[2], Fahad M. Alnajm[2]

[1]*Basrah Oil Company, Ministry of Oil, Basrah, Iraq*

[2]*Department of geology, college of science, university of Basrah, Iraq*

Received: 24/3/2022 Accepted: 30/8/2022 Published: 28/2/2023

Abstract

The Yamama Formation is characterized by a wide geographic extension of southern Iraq. Microfacies analysis of this formation was studied in six wells distributed in six fields: Fayhaa, Sindbad, Siba, Zubair, Ratawi and West Qurna. This research aims to determine paleoenvironments by diagnosing biofacies and lithofacies. Miscellaneous marine fauna of foraminifera and calcareous algae, mainly green algae (dasycladacean.) and skeletal bioclasts from gastropods, pelecypods, bryozoans, sponge spicules, and echinoderms were found. Petrographic studies and well logs interpretations led to the identification of five main Microfacies (Mudstone, Wackestone, Packestone, Grainestone and Rudstone and twelve submicrofacies (Foraminiferal-Lime mudstone submicrofacies, Argillaceous Lime Mudstone submicrofacies, Planktonic foraminiferal – Lime Wackestone submicrofacies, piculites/ Calcisphers – Lime Wackstone submicrofacies, Benthonic Foraminiferal -Lime wackestone/packestone submicrofacies, Algal (desycladecan) Lime wackestone submicrofacies, Algal-Lime packestone submicrofacies, Bioclastic/ Algal-Lime packestone submicrofacies, Algal/ Foraminiferal- Algal -Lime packstone submicrofacies, Peloidal poorly sorted grainstone with bioclasts submicrofacies, Intraclastic grainstone submicrofacies, Pesudo oolitic-*Lithocodium aggregatum* grainstone submicrofacies and finally Peloidal-intraclastic, and bioclastic grainstone submicrofacies). Microfacies are deposited in the lagoon, shoal, rudist biostrome and open marine gradient to middle and outer ramp environments. Vertical changes in microfacies with depth were reflected by lateral changes in marine depositional systems and the thickness of the formation. Shoal environments' microfacies are characterized by high thickness, while low thickness characterizes the open marine microfacies. The Yamama Formation was deposited on the low-angle homoclinic carbonate ramp, mainly in the inner and middle ramp, with outer ramp conditions in some parts of the formation.

*Email: shathageo791@gmail.com

Keywords: Microfacies, depositional environments, Yamama Formation, Ramp setting, Southern Iraq

البناء السحني وأنظمة الترسيب البحرية لتكوين اليمامة في ابار مختارة جنوب العراق

شذى عباس محسن*[1] ، عباس حميد محمد[2]، فهد منصور النجم [2]

[1]وزارة النفط، شركة نفط البصرة، البصرة، العراق

[2]كلية العلوم، جامعة البصرة، البصرة، العراق

الخلاصة

يتميز تكوين اليمامة بامتداد جغرافي واسع في جنوب العراق ،درس التحليل السحني في ستة ابار توزعت على ستة حقول نفطية هي الفيحاء,السندباد,السيبة,الزبير ,الرطاوي بالإضافة الى غرب القرنة. يهدف هذا البحث الى تشخيص السحنات الحياتية والصخارية وإمكانية استخدامها في تحديد البيئات الترسيبية القديمة . كشفت هذه الدراسة عن وجود مستحاثات بحرية متنوعة تمثلت بالمنخربات والطحالب الكلسية وخاصة الطحالب الخضراء التي تعود الى عائلة الدسيكلاديسيا والتي تترافق مع مكسرات حياتية هيكلية أخرى من بطنيات القدم واالفتات الاحيائي العائد للحزازيات واشواك الاسفنجيات وشوكيات الجلد. وفقًا للتشخيص البتروغرافي والتفسيرات الجسية، تم تحديد خمس من السحنات الدقيقة الرئيسية وهي سحنة الحجر الجيري الطيني والواكي والمرصوص والحبيبي بالإضافة الحجرالجيري الشعابي و اثنتا عشر سحنة ثانويةهي : سحنة الحجرالجيري الطيني الحاوي على المنخربات الثانوية - سحنة الحجر الجيري المتطين الثانوية- سحنة الحجر الجيري الواكي الحاوي على المنخربات الطافية الثانوية- سحنة الحجر الجيري الواكي الحاوي على الكريات الكلسية والاشواك الاسفنجية الثانوية - سحنة الحجر الجيري الواكي \المرصوص الحاوية على المنخربات القاعية الثانوية- سحنة الحجر الجيري الواكي الحاوي على الطحالب الكلسية عائلة الديسيكلادسيا الثانوية- سحنة الحجر الجيري المرصوص الحاوي على الطحالب الكلسية- سحنة الحجر الجيري الحبيبي الحاوي على دمالق جيدة الفرز ومكسرات حياتية- سحنة الحجر الجيري الحبيبي الحاوية على القطع الصخرية – سحنة الحجر الجيري الحبيبي الحاوية على السرئيات الكاذبة ومستحاثات من القشريات واخيرا سحنة الحجر الجيري الحبيبي الحاوية على الدمالق والقطع الصخرية ومكسرات حياتية - ترسبت هذه السحنات الدقيقة في بيئة اللاغون و وبيئة الحواجز البحرية الضحلة ، وبيئة شعاب الرودست، وتتدرج في بيئة البحر المفتوح من بيئات المنحدرات الوسطى الى الخارجية. تتغير السحنات الدقيقة عموديا مع العمق والتي انعكست على تغير النظام الترسيبي البحري جانبياو انعكست أيضا على التغير في سمك التكوين ,تتميز السحنات الدقيقة في البيئات الضحلة بالسماكة العالية والسماكة المنخفضة للبيئات البحرية المفتوحة. ترسب تكوين اليمامة في منحدر كربونايتي متجانس بزاوية منخفضة ، وفي الغالب في المنحدر الداخلي والمتوسط ، مع حدوث ظروف منحدر خارجي في بعض أجزاء التكوين.

1-Introduction

The Yamama Formation originally was defined from a surface section in the Saudi Arabia as a fragmental limestone [1] that was deposited during the Early Cretaceous belonging to the Thamama Group.

The Yamama Formation was characterized by an alternative of oolitic shoal and a deep inner shelf. Subtle structural highs probably control association facies within a carbonate ramp setting [2] (Figure 1)

The Yamama and Ratawi succession represent source rocks which range from being very good source rocks for the Sulaiy Formation and good source rocks for the Yamama and Ratawi succession [3, 4, 5]. The Yamama-Sulaiy succession is deposited in a shallow ramp dipping gently towards the east [6,7]. The Yamama Formation included five depositional environments: Mid-ramp and Inner- ramp (open and restricted marine, shoal and lagoon [8,9,10]. It was deposited during the Berriasian- Valanginan[11,12,13].

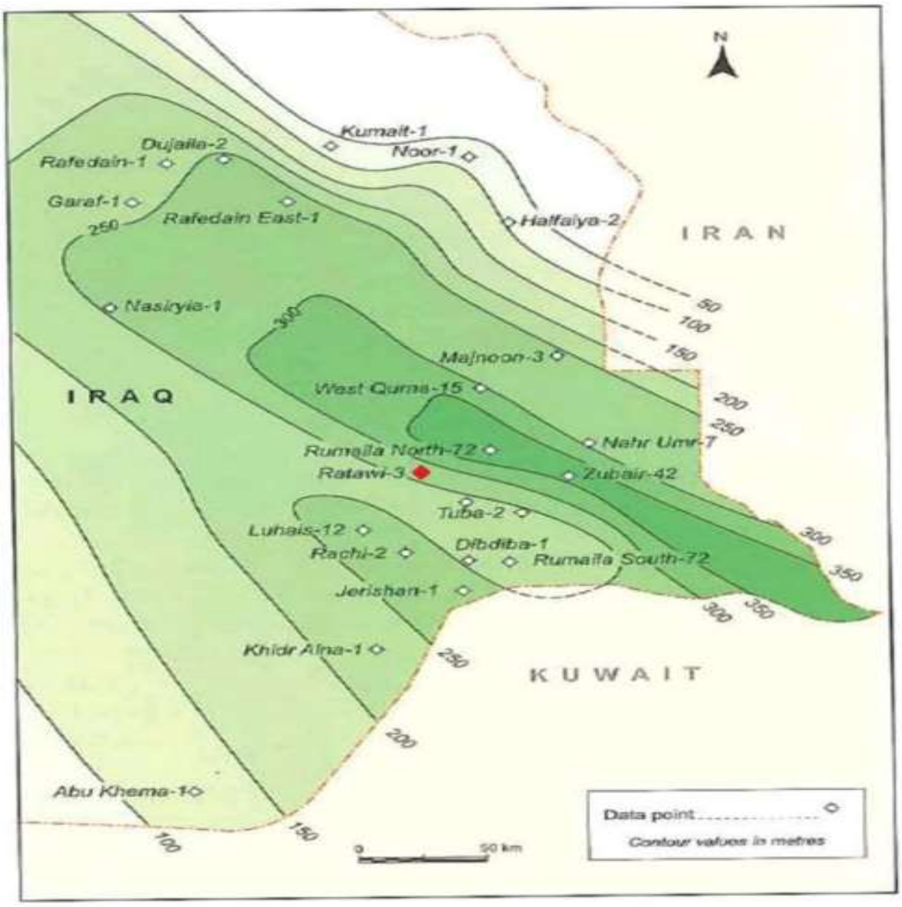


Figure 1: Isopach map of the Yamama Formation [2]

The studied area includes selected wells in several fields (Fayhaa, Sindbad, Siba, Zubair, Ratawi and West-Qurna) that are distributed in the South of Iraq. The targeted wells are Fh-2, Snd-3, Sb-6, Rt-5, Zb-47, WQ-203, Table 1, (Figure 2)

Table 1: Coordinates of wells study

Field name	Well No:	Easting	Northing
Siba	Sb-06	2216000	33687000
Sindbad	Snd-03	786740	3390730
Fayhaa	Fh-02	215502	3432609
Ratawi	Rt-05	700000	3392200
West Qurna	WQ-203	714500	3434750
Zubair	Zb-47	758523	3361470

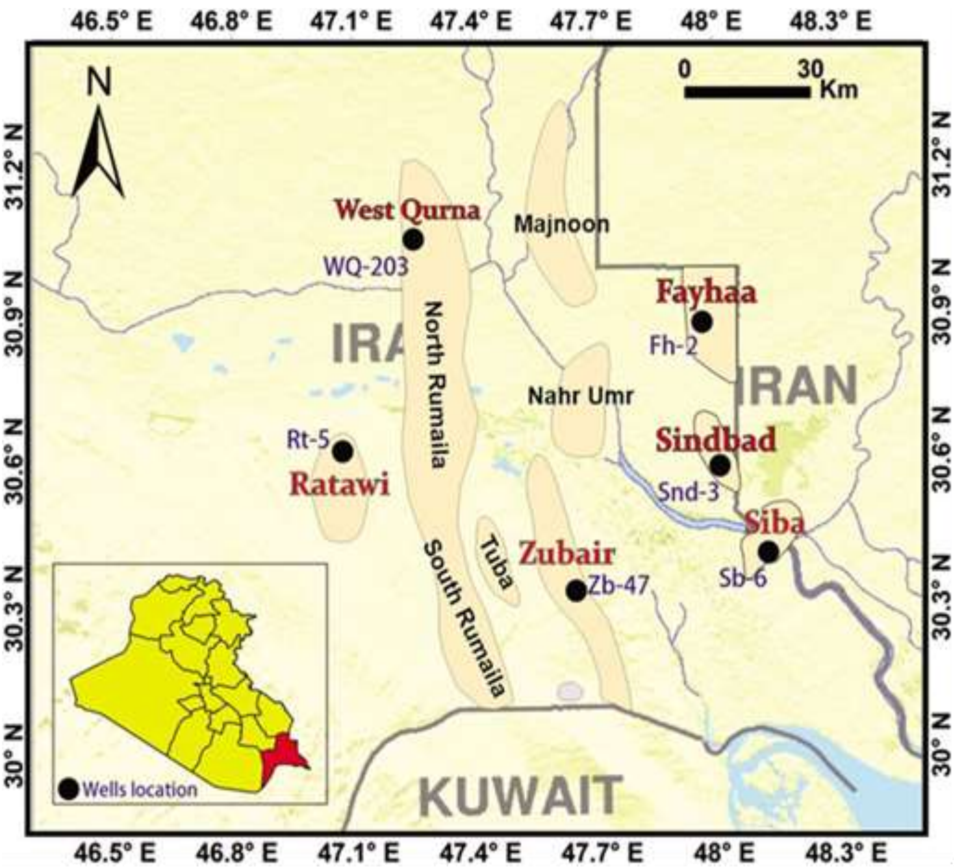


Figure 2: Location map of study area modified from [14]

The current study aims to

1- focusing on microfacies analysis and diagnosis of fossils. This step is significant and very useful in biostratigraphy

2-determine the depositional environment of the Yamama Formation depending on the paleontological and petrographic analysis.

2. Materials and Methods

Two stages of work were done to achieve the goals of this study. These are: -

2-1. Field Work

This step depends on core descriptions for all features, textures, colour variations, and bioturbation.

2-2. Laboratory work:

A-Workshop

This stage included thin sections that were prepared and approved by the Basrah Oil Company. One hundred thirty-seven (137) Thin sections of Fayhaa-02 were made in the central laboratories of the Iraqi Geological Survey.

B-Microscopic examination

This stage included paleontological and petrographic study for all thin sections by Binocular Microscope (Table 2).

c-Well logs analysis

Because of data loss in several well-studied areas (Spontaneous Potential, Gamma Ray, Density, Sonic, Neutron, and Resistivity log), the logs were mostly used to complete the petrographic interpretation results.

Table 2: Number of thin sections completed in the wells studied

Field name	Well No:	Number of thin sections
Siba	Sb-06	26
Sindbad	Snd-03	17
Fayhaa	Fh-02	137
Ratawi	Rt-05	110
West Qurna	WQ-203	75
Zubair	Zb-47	44
Total		409

3. Stratigraphy and Tectonic Framework

The type section of Yamama Formation outcrops in Saudi Arabia is described as fragmental limestone units [1]. Limestone and dolomitic were the main lithology of this formation and overlay Sulaiy Formations [2, 15, 16, 17]. The cycle top was represented by inner ramp facies that transitioned into minor peloidal facies, and wackestone / packstone coral/ Stromatoporoid bioclastic were deposited on the middle ramp [2].

The study area is located in the southern part of Iraq within the Mesopotamian Zone on the basis of the longitudinal tectonic classification of Iraq [18].

Tectonic events affected the Cretaceous period in Iraq, starting with the opening of NeoTethys during the Triassic. In the Lower Cretaceous, extensional forces caused rifting and tectonic movements in Turkey, and north of the Arabian plate. These tectonic movements started at the beginning of the Early Cretaceous and formed the Yamama basin in the Berriasiain -Valanginian. The Arabian plate was influenced by tectonism, which caused rifting around the margins during cretaceous tectonic history [19].

4. Results

4.1. Microfacies Types

Include both lithofacies analysis (identification of the depositional texture of rocks and composition of the particles) and biofacies analysis (recognition of fossil associations). Microfacies types of Yamama were classified depending on [20] its modification by [21].
Five main types of microfacies and twelve sub-microfacies are determined

4.1.1. mudstone Microfacies: This microfacies is divided into two sub-microfacies

4.1.1.1. Foraminiferal-mudstone submicrofacies

This facies offers rare fossils, including small miliolids and shell fragments. The background material is micrite Plate -1- A-. This sub-microfacies is matching to RMF 16 according to [22,23].

4.1.1.2. **Argillaceous Lime Mudstone submicrofacies**

The argillaceous lime mudstone is mainly involved f dark silty shale and higher components of clay minerals; the lime mudstone microfacies transfer into terrigenous lime mudstone, including fine grains of sand in silt size. This microfacies indicate an open-restricted lagoon Environment and shallow open marine [9]. This sub-microfacies is matching to the RMF 16, which is FZ3 based on [22,23]. Plate-1,Figure B and it is found in the middle part of the formation and some places of the formation.

4.1.2. Wackestone Microfacies: It is divided into four submicrofacies

4.1.2.1. Planktonic foraminiferal – Lime Wackestone submicrofacies

This microfacies is identified by containing planktonic foraminifera *Hedbergella* sp and occurs in the Fh-2 well, at a depth of 4122.90 m in the middle part of the formation. This microfacies is similar to the RMF 3, deposited in FZ3 according to [22,23].

4.1.2.2.Spiculites/Calcisphers – Lime Wackstone submicrofacies

This microfacies contains abundant sponge spicules and oligostigena biofacies in different directions (longitudinal or, transverse section) and a rare number of echinoderms. Sponge spicules indicate that deposition occurred in a deep marine and below storm base wave, correlated with [22]. These sub-microfacies are similar to the RMF 3, which is deposited in FZ3 according to [22,23]. Plate- 1 -C-.

4.1.2.3. Benthonic Foraminiferal -Lime wackestone/packstone submicrofacies

Benthic foraminifera are the common skeletal grains of this microfacies, including *Pseudocyclammina lituus*, *Pseudocyclammina* sp.YOKOYAMA, *Chrysalidina intracretacea*,, Sinni, *Chrysalidina gradata* ,*Trocholina alpina* LEUPOLD, *Trocholina elongata* LEUPOLD, *Trocholina altispira* LEUPOLD, *Trocholina conica* LEUPOLD *Rotalia skourensis, Septatrocolina*. It also includes, bivalve bioclasts and echinoderms, with peloids in the background. This submicrofacies is matc hed to the RMF 13, deposited in FZ4 based on [22,23], which was deposited in a shallow marine, back-reef environment. Plate-1-D-.

4.1.2.4. Algal(desycladecan)Lime wacke submicrofacies

This facies is dependent on [23], which is recognized by algae such as *Salpingoporella carpathica* Dragstan,*Salpingoporella muehlbergi, Salpingoporella hasi, Dissocladella undulate*, miliolid, *Textularia* sp., gastropod, rudist and bivalve debris. This sub-microfacies is similar to the RMF 17, which is deposited in FZ8 according to [22, 23]. Plate-2-A-.

4.1.3. Packstone Microfacies: It is divided into two submicrofacies

4.1.3.1. Bioclastic/Algal- Lime packstone submicrofacies

This microfacies is represented by the sediments that transport particles from the shelf margin. Bioclastic of benthic foraminifera, algal Dasycladaceae family such as *Salpingoporella carpathica* Dragstan, *Pianella dinarica* Praturlon & Radoicic,*Cylindroporella sugdeni* Elliott, *Arabicodium texana* Elliott, *Acicularia* sp. endoi Praturlon, *Heteroporella* sp., Cros & Lemoine Ott, ,*Terqumella* sp. Munier-Chalmas ex. Morellet and Morellet, *Carpathoporella occidentalis* Dragastan and rudist are increasing in number and they are an indicator of high energy. This microfacies is similar to the RMF 20, which was deposited in FZ8 according to [22,23]. Plate -2- B-.

4.1.3.2. Algal/Foraminiferal -Algal -Lime packstone submicrofacies

This submicrofacies is characterized by common fossils (such as *Everticyclammina kelleri* HENSON, *Chrysalidina intracretacea,,* Sinni, *Chrysalidina gradata ,Trocholina alpina* LEUPOLD, *Trocholina elongata* LEUPOLD, *Trocholina altispira* LEUPOLD, *Trocholina conica* LEUPOLD *Rotalia skourensis,Salpingoporella Carpathica ,* RADOICIC, *Salpingoporella hasi* Conrad, *Pianella dinaric* Praturlon & Radoicic,*Clypina* sp. Carozzi,, *Mastropora* sp. Cros & Lemoine, *Cyllindroporella sugdeni* ELLIOTT, *Permocalculus irenae* ELLIOTT, *Neomeris cretacea* STEINMANN. It is preserved in molds that are filled with calcite cement.This microfacies is similar to the RMF 16. submicrofacies is recognized in a lagoon which include bioclast of various skeletal grains such as (milliolids), calcareous green algae, gastropods and bivalves bioclasts reveal the lagoon environment [24], Plate -2- C&D-

4.1.4. Grainstone Microfacies: It is divided into four submicrofacies

4.1.4.1. Peloidal poorly sorted grainstone with bioclasts submicrofacies

The common particles of this facies are the peloids and intraclasts. The bioclastic contain smaller and larger foraminifera, echinoids, and coral. This microfacies is similar to the RMF 26. Plate -2- B-. Algae, echinoids and rare coral. Another similar submicrofacies is recognized in West Qurna and Gharaf oil fields by [25,26], (Plate 3A).

4.1.4.2. Intraclastic grainstone submicrofacies

This facies is characterized by intraclasts and peloid particles with benthic foraminifera and bioclasts such as echinoids and bivalve. This microfacies is similar to the RMF 24. Plate-3- B-

4.1.4.3. Oolitic-*Lithocodium aggregatum* grainstone submicrofacies

The dominant components of this facies are *Lithocodium aggregatum* and ooids. Plate-3- C-

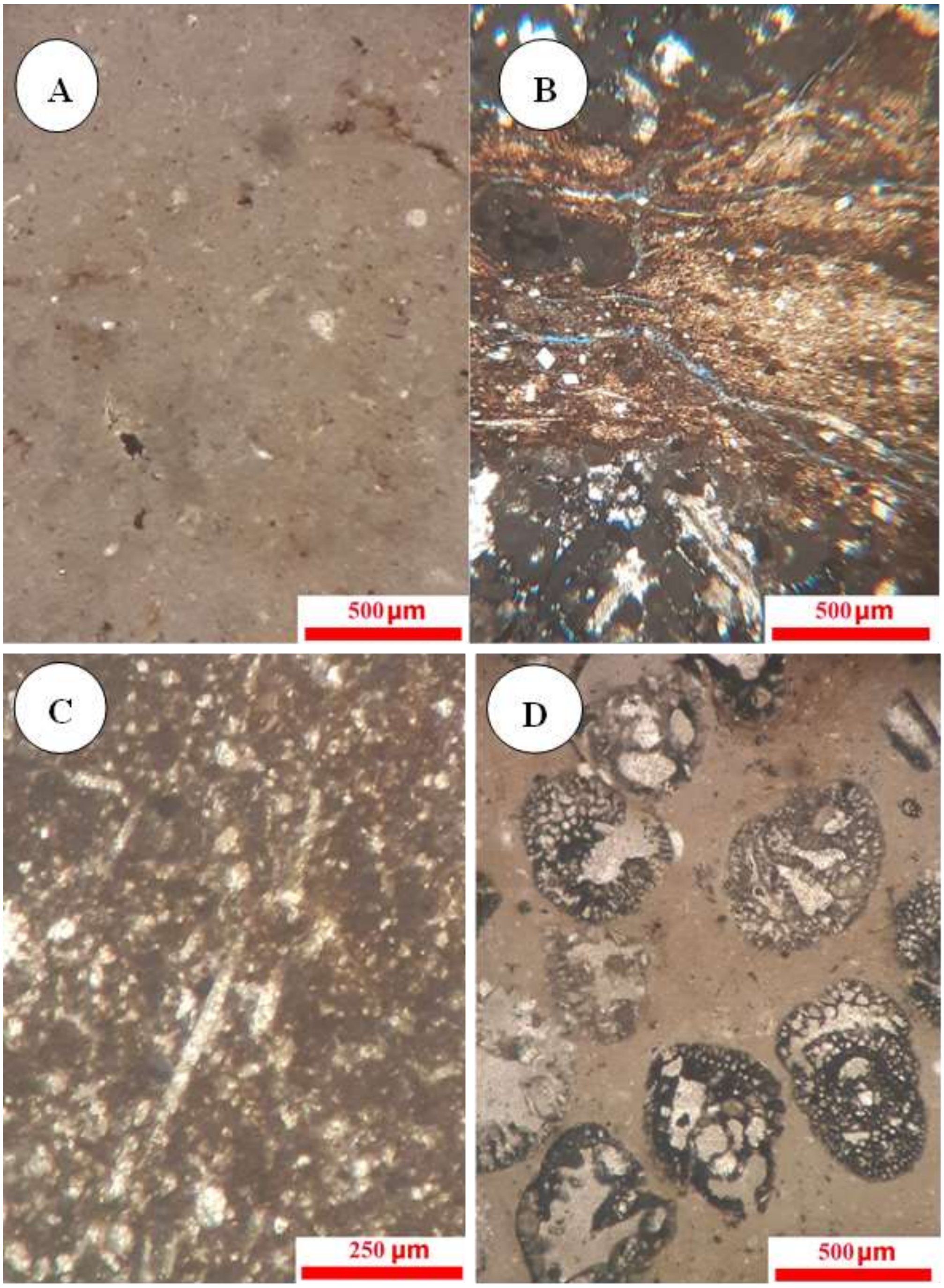
4.1.4.4. Peloidal-intraclastic-, bioclastic grainstone submicrofacies

The dominant of this facies are the peloids and intraclasts. The bioclasts include larger and smaller benthic foraminifera.

4.1.5. Rudstone Microfacies

This microfacies was matched to the RMF 15, deposited in FZ6 according to [22,23], indicating a slope depositional environment.

\



Pate 1: A. Lime Mudstone Microfacies, Rt-05, depth (3857)m., B. Argillaceous lime mudstone, Zb47, depth (3995.60) m., C. Bioclastic - Calcisphers, limeWackestone, Rt-05, depth (3848.75) m., D. *Everticyclamina kelleri*-Lime Packstone, Rt-05, depth (3850.50)m.

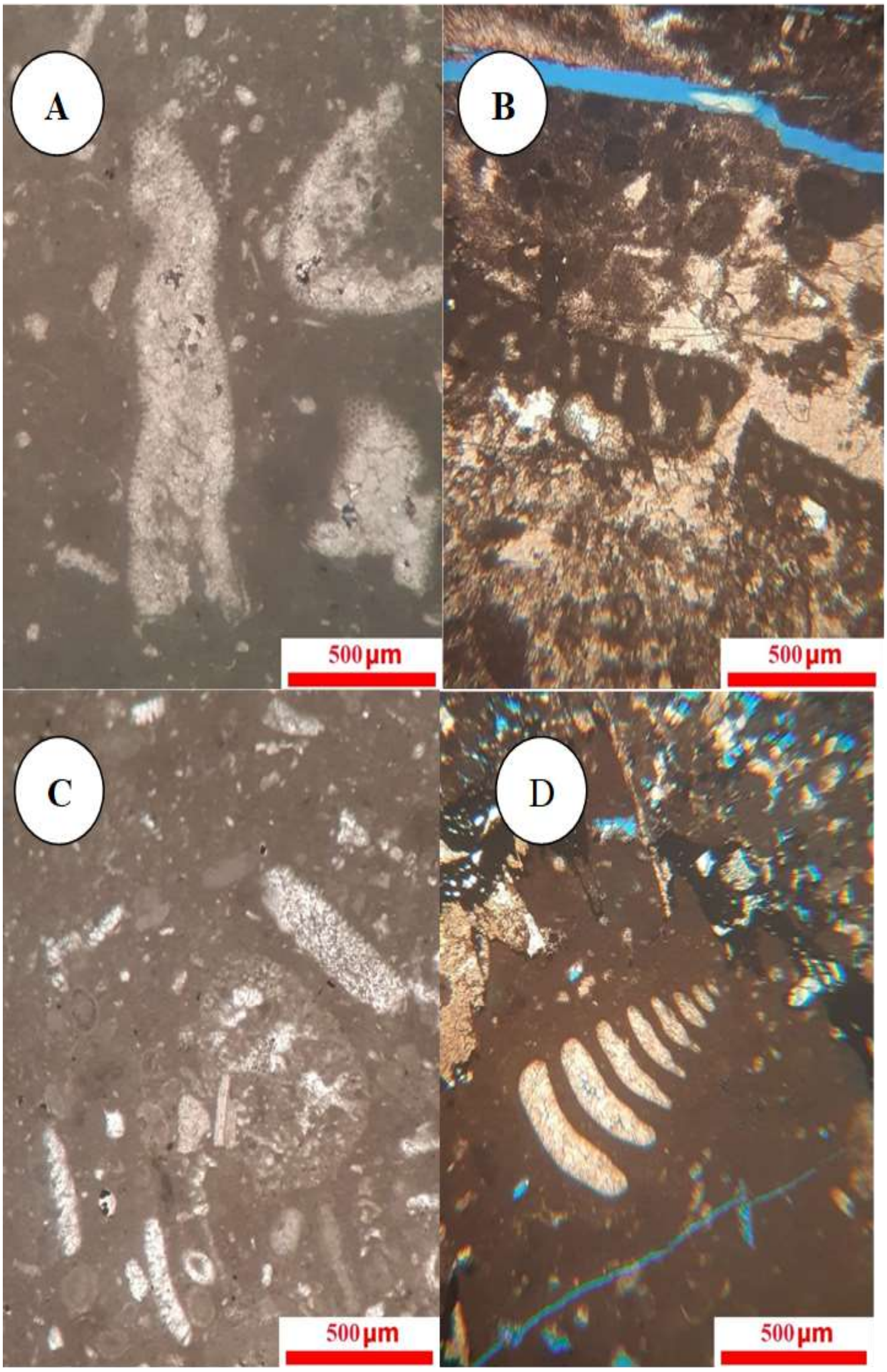


Plate 2: A. Bioclastic of algal Dasycladaceae lime Wackestone, Rt-05, Depth (3850) m., B *Lithocodium aggregatum* Rudstone, WQ-203, depth, (4026.98) m. C. Bioclastic-Algal(dasycladecean) – Foraminiferal (*Psedocyclamina litus*) poloidal, lime wackestone, Rt-05, depth (3848.75) m., D. *Pseudolituonella* sp., lime wackestone, WQ-203, depth (399.97)m.

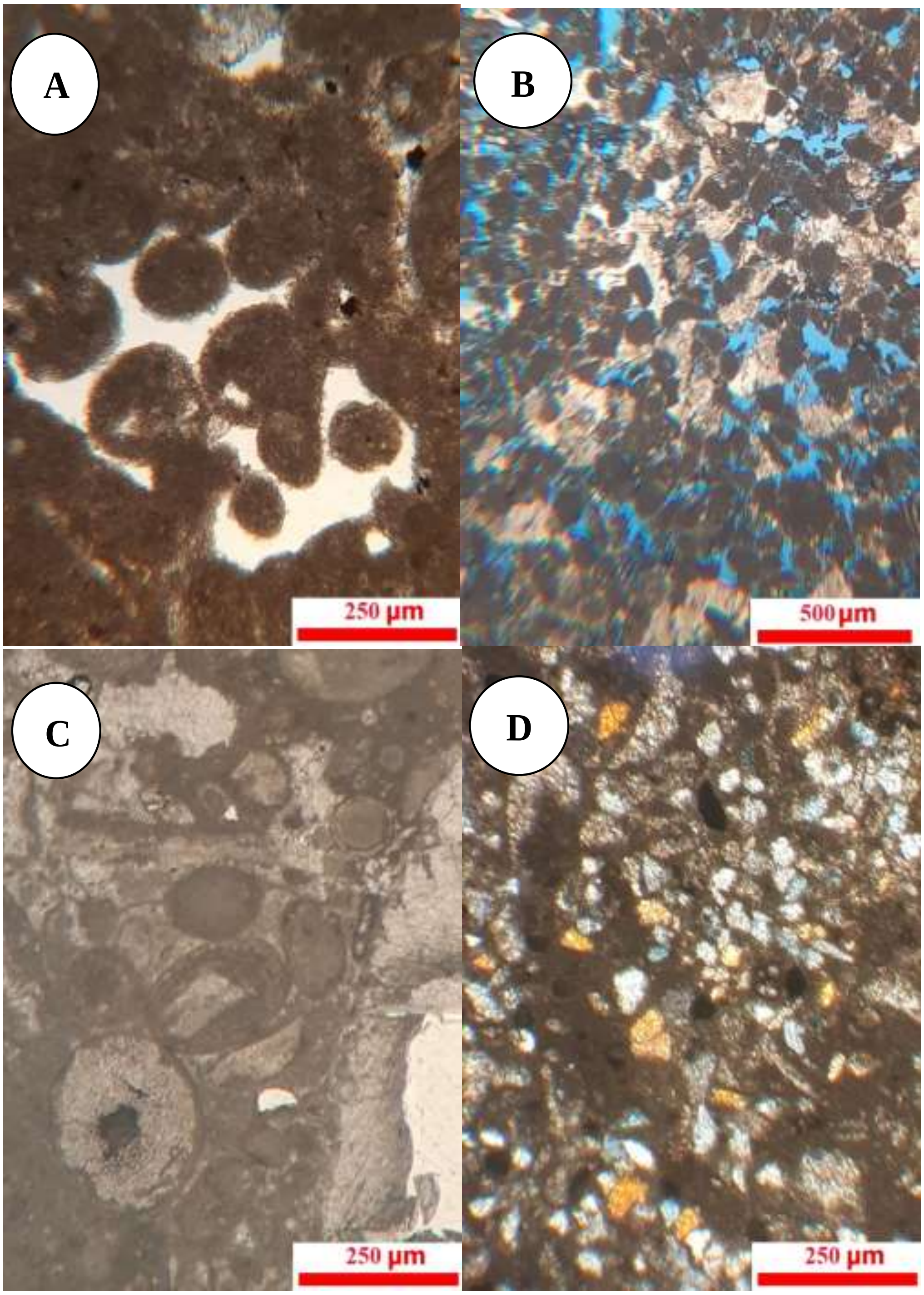


Plate 3: A. Peloidal grainstone, Fh-02, depth 4067.40m., B.Intraclast with Echinoids grianstone, WQ-203, depth(4036.5) m., C. Pseudo oolitic-Algae- grainstone, Rt-05, depth (3854.5) m., D. Fine grains of sand, Snd-03, Depth(4064) m

4.2. Depositional Marine Systems of the Yamama Formation

Microfacies analysis showed that the Yamama Formation in the studied wells was deposited in a carbonate ramp, where many microfacies are identified. (Figures 3-4-5-6-7-8). These are:

4.2.1. Outer Ramp Association facies

The deposition in (100–200) m represents this association facies, which includes bioclast of spicules wackestone, Echinoderm wackestone- mudstone.

The outer ramp in the Yamama Formation represents a shallow open marine depositional environment.

The sponge spicules are common, with much mud supported and associated with pyritization and a low-energy depositional environment [27]. This appeared in Fh-02, Sb-06, and Rt-05.

This indicates that the basin's deepest parts have a large presence of lime mud and a low amount of bioclastics such as spicules and thin-shelled bivalves. The outer ramp is found in a below-normal storm base wave and identified by lime mudstone and storm reworking. Some levels of argillaceous limestone contain organic matter [28, 29, and 30].

4.2.2. Middle Ramp facies association

A variety of sub environments representing the middle ramp comprise baches, barrier bars, stand polains, and shoals, and may also comprise a variety of reef Formations by high-energy wave oscillations which agitate the waters regularly [30]. In mid-ramp environments, a large percentage of micrite indicates a law-energy environment, and deposition can occur between storm wave base and fair-weather wave base50-100m[23].

4.2.3. Inner Ramp facies association

This facies is represented by shallow open marine depositional environments with better water circulation (0-50) m, protecting the depositional environments with restricted water circulation, sand shoals and banks characterized by oolitic and bioclastic grainstones to packstones, which are deposited in lagoonal shoals and pertidal environments [23].
These environments are contained within the Yamama Formation.:

A. Shoal

The shoal facies contains peloid-packstone/grainstone, intraclast-grainstone, ooid–peloid grainstone, ooid grainstone, bioclast–intraclast grainstone, and peloid–intraclast grainstone. The common grain-supported texture, concentric structures of ooids, good roundness, and sorting of this facies indicates high energy conditions [22]. The Yamama Formation in Sindbad -03, Plate-3- D- contains silt-sized quartz grains and shale. These deposits form the main lithological components of the Yamama barrier units YB-1 and YB-2 [4].

B. Open marine

Open-marine facies include bioclastic wackestone, bioclastic sponge spicule wackestone, Foraminiferal packstone and bioclastic echinoderms wackestone. The skeletal fragment consists of sponge spicules with the debris of Echinodermata, Algae, benthic Foraminifera, Miliolids, and shell fragments.

Open marine facies are found at separate depths or inter-bedded with restricted marine facies [23]. This microfacies are comparable to RMF7, RMF13, RMF16, RMF12 respectively [22,23].

C. Lagoon

Microfacies were recognized in the lagoon sub-environment: bioclast– peloid packstone, bioclast wackestone/packstone. Large percentages of mud and the presence of numerous diverse skeletal grains such as milliolids, *Nummolculina* IRK sp., Gorbatchik, Okay & Altner, *Triloculina* sp., Neagu, *Austrotrillina* sp., Neagu *Pyrgo* sp. Defrance, *Moesiloculina* Neagu, *Quinqueloculina* sp., Istriloc [24].

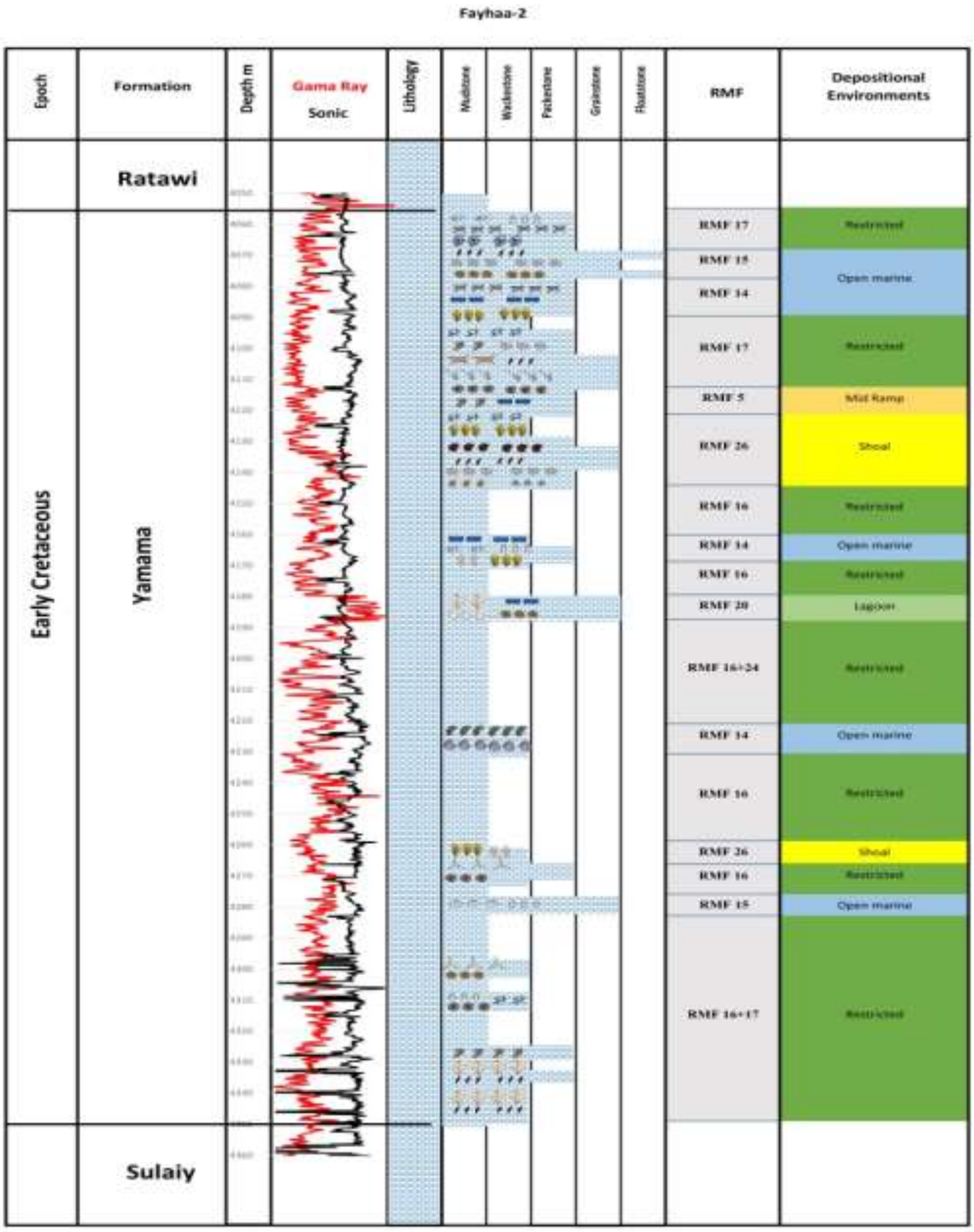


Figure 3: Facies architecture and environments in the Yamama Formation, Fayhaa-02

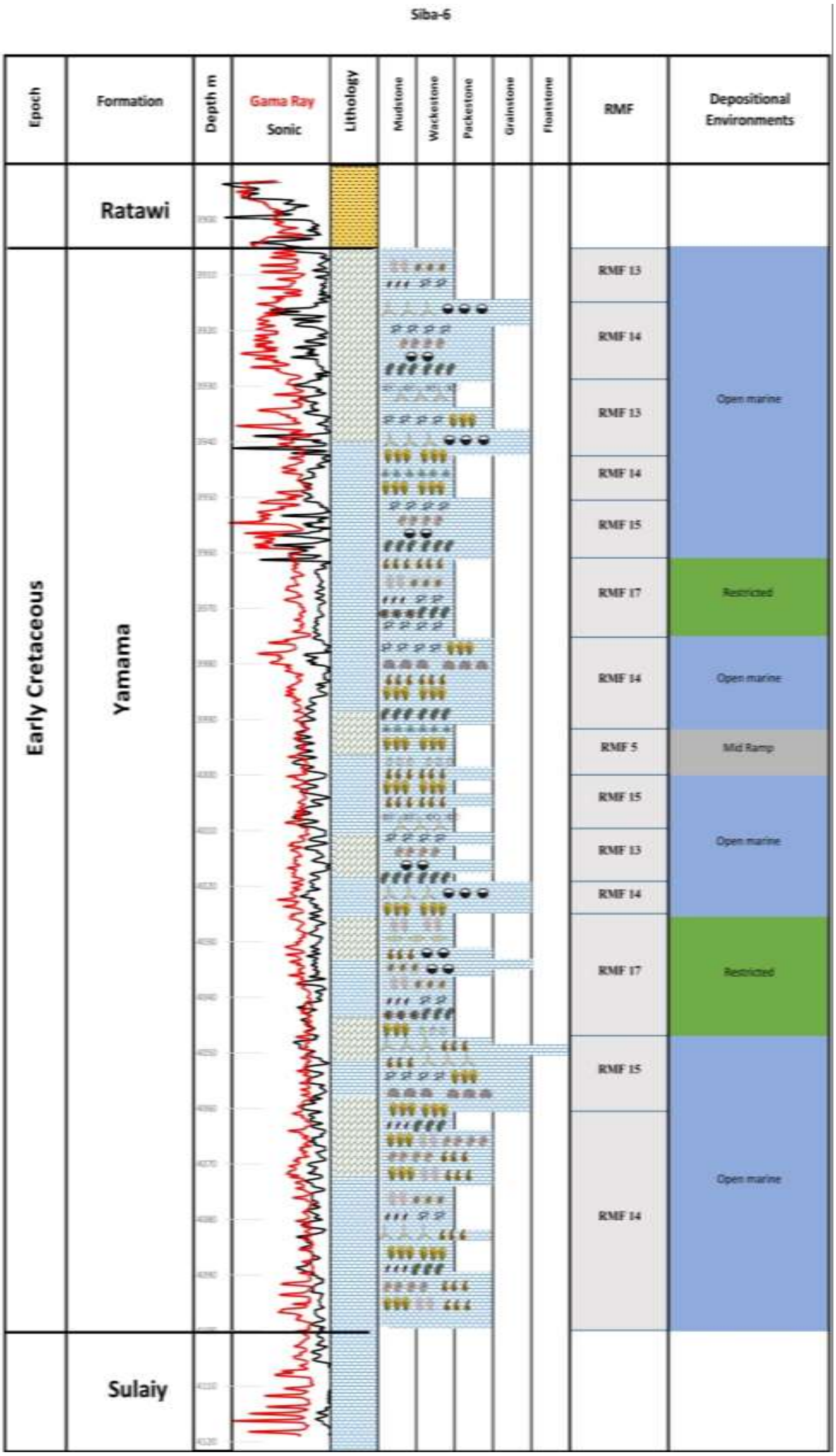


Figure 4: Facies architecture and environments in the Yamama Formation, Siba-06

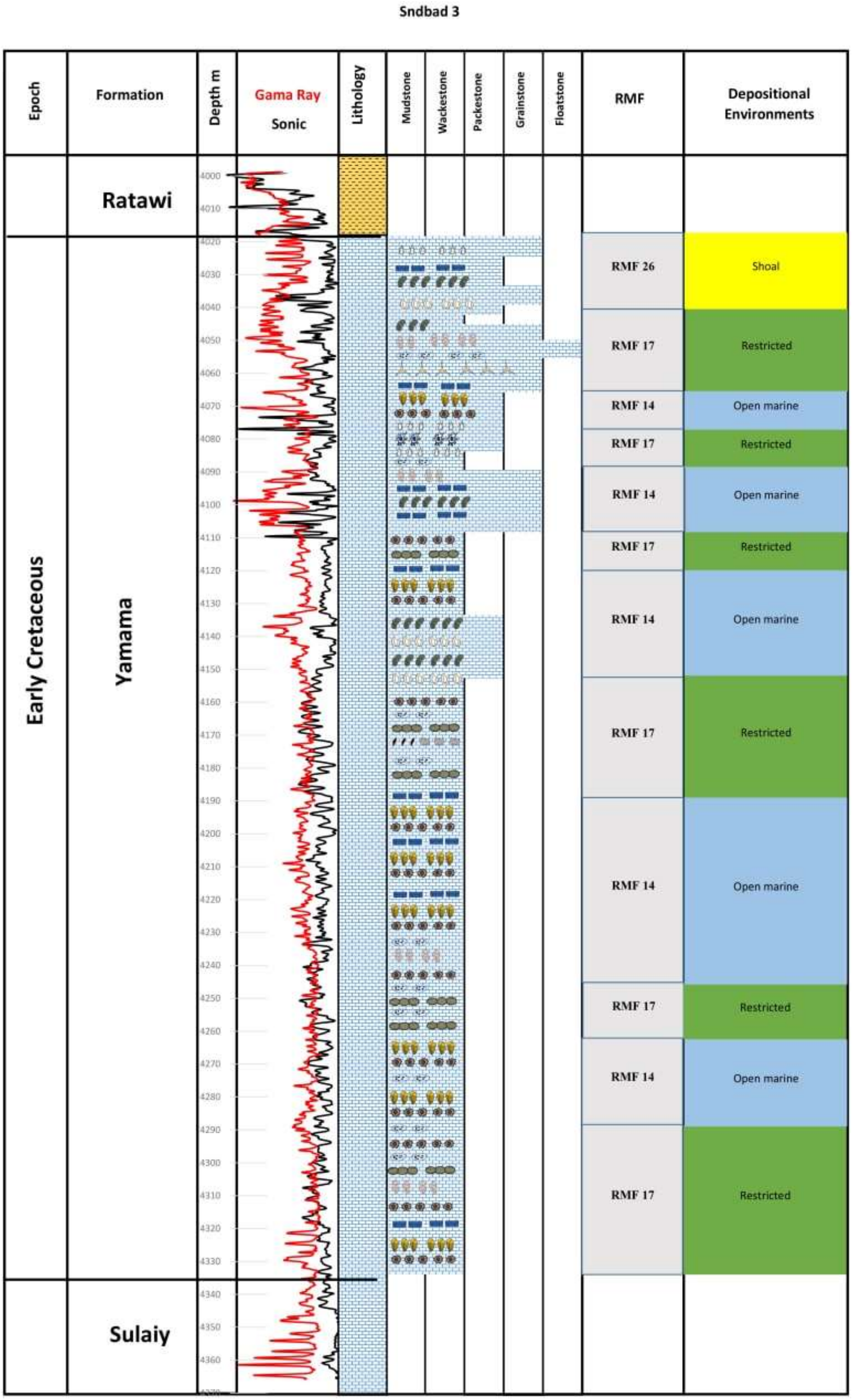


Figure 5: Facies architecture and environments in the Yamama Formation, Sindbad-03

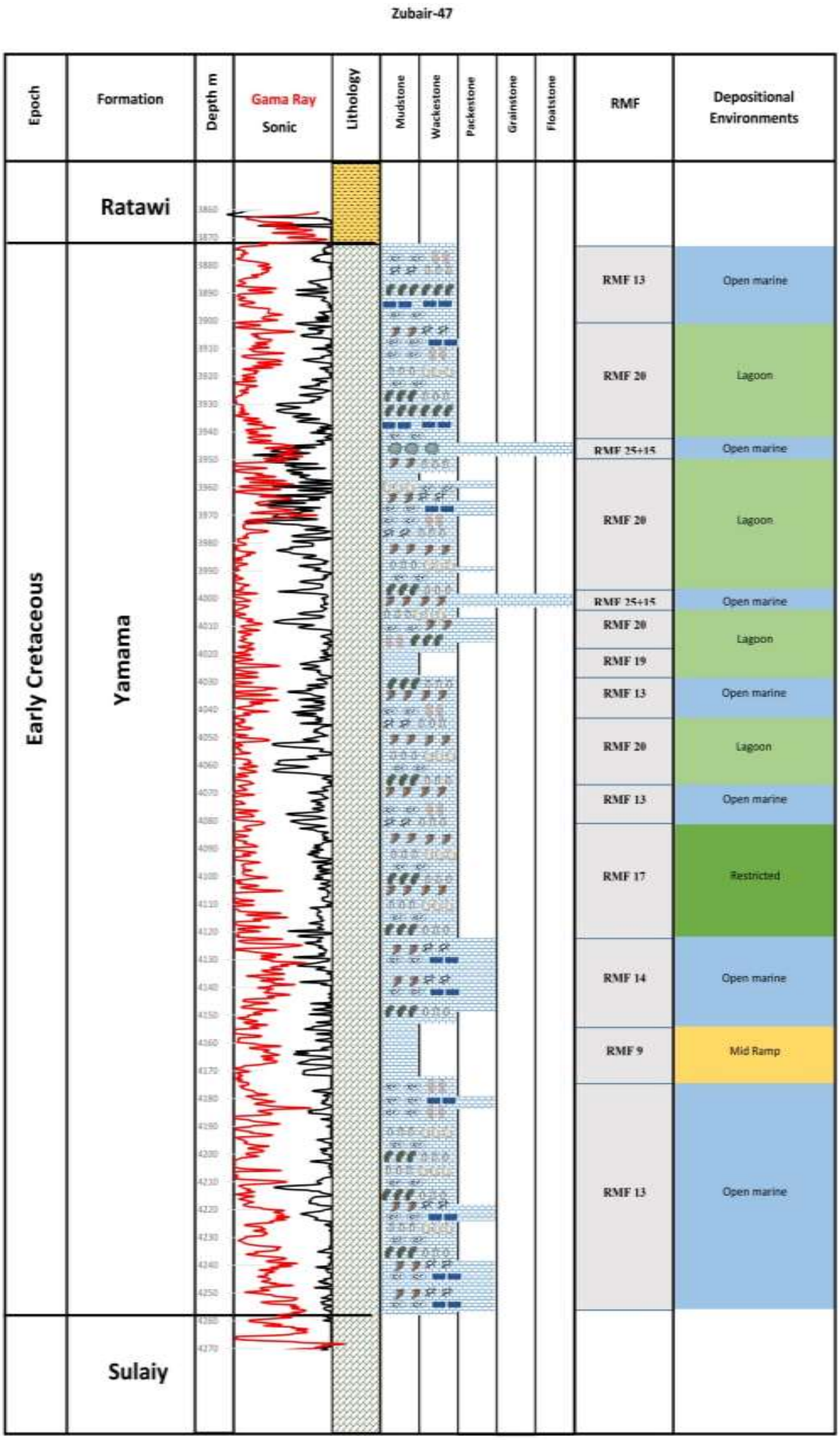


Figure 6: Facies architecture and environments in the Yamama Formation, Zubair-47

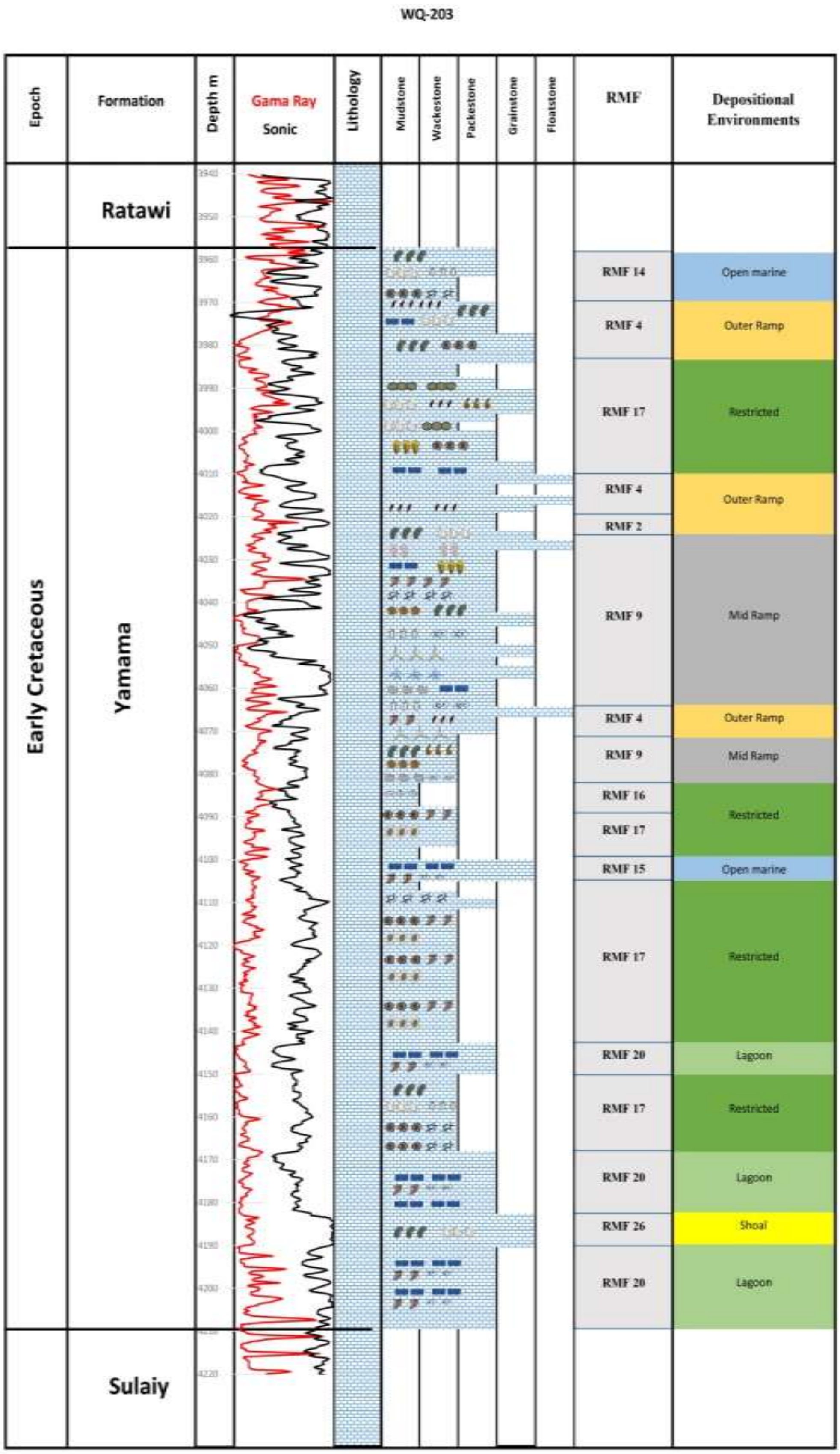


Figure 7: Facies architecture and environments in the Yamama Formation, West-Qurna-203

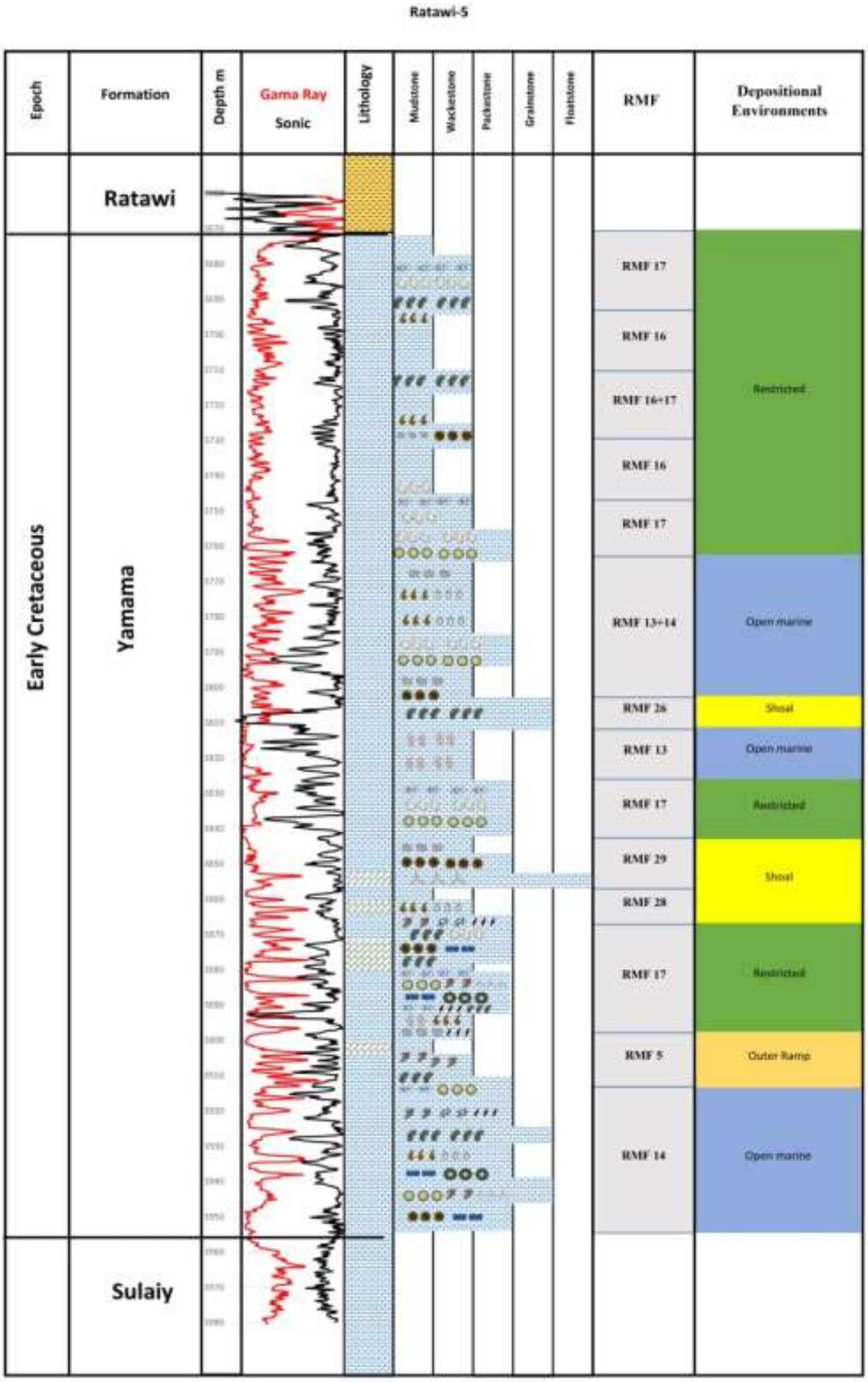


Figure 8: Facies architecture and environments in the Yamama Formation, Ratawi-05

5. Discussion

Based on the core descriptions, petrographic studies, sedimentary texture, and fossil sedimentary features, the Yamama Formation was deposited on a ramp setting during transgressive and highstand systems tracts.

The abundant facies Bioclastic-Wackestone/packstone, peloidal/ooids packstone /grainstone, and rudstone with particles derived from the reef. The Yamama facies are characterized by the presence of lagoonal facies (algal- foraminiferal bearing, bioclastics common and pelletal wackestone/packstone change into reef facies (corals, bryozoans rudist, lamellibranchs, gastropods) - back reef environments. These sediments represented the inner and middle ramps of the formation. The algae were identified such as *Actinoporella podolica* ALTH, *Mastropora* sp. Cros & Lemoine, *Cyllindroporella sugdeni* ELLIOTT, *Neomeris cretacea* STEINMANN, *Lithocodium aggregatum* ELLIOTT, mixed with other shallow water forms larger foraminiferids such as *Pseudocyclammina lituus*, *Pseudocyclammina* sp.YOKOYAMA, *Chrysalidina intracretacea* Sinni, *Chrysalidina gradata*, *Trocholina alpina* LEUPOLD, *Trocholina elongata* LEUPOLD, *Trocholina altispira* LEUPOLD, *Trocholina conica* LEUPOLD *Rotalia skourensis*, *Septatrocolina* sp.,*Protopeneropiis ultragranulata* Gorbatchik, Okay & Altıner, *Austrotrillina* Neagu, sp, *Psedolituouella* sp.,*Maynicina Bulgaria* Laug Peybernes Rey,*Natuliculina oolithica* MOHLER, *Quinqueloculina*.sp., *Lenticulina* sp. Lamarck, *Textularia* sp. These are represented shallow marine environments within light penetration.

The preponderance of calcareous green algae in the Yamama Formation Early Cretaceous deposits suggests their significant contribution to the carbonate rocks. Green calcareous algae (dasycladaceae)common in Yamama formation refer to a shallow environment. *Actinoporella podolica* is the typical biofacies of intertidal and restricted carbonate shelves. Green algae, e.g. *Clypeina* sp., and stromatoporoids e.g. *Cladocoropsis* occupied a deeper water paleoenvironment (outer neritic) [31]. In the other side (Red and coralline algae) are also common in the Yamama Formation; Red Algae are likely to be found in the deepest water, and reef origin deposits have consisted of largely coralline algae bioherm because of their ability to secrete calcium carbonate, these are associated with petroleum deposits . The study recorded Charophytes for the first time in Ratawi-05. Charophytes represent a non-marine green alga that lives on the bottom of ancient and recent lakes and other non-marine environments [32]. This case agreement with twelve to fourteen depositional sub-cycles may occur during the Early Cretaceous, bounded by exposed continental areas containing the plant remains [33].

6. Conclusions

The Yamama basin in the studied oil fields is indicated as a ramp setting of the carbonate platform. According to the carbonate association facies of this formation, accompanied by siliciclastic sediments (sandstone), deposits of this succession are deposited in warm and humid climate conditions. The Yamama Formation, rich with marine foraminifera and calcareous algae, is the basic concept for forming a thick-bedded Cretaceous limestone. Investigating the lithofacies and microfossils of this formation resulted in identifying five main microfacies and twelve sub-microfacies. These refer to ramp carbonate setting, deposition in pelagic waters with normal marine to hypersaline conditions within the inner ramp and gradient to middle and outer ramp conditions.

Acknowledgement

The authors acknowledge the University of Basrah for their support. We also thank all the Basra Oil Company affiliates for their cooperation (Geology and Control Geology Department) and Dr Kalid Habil for his valuable comments and support. The authors are very grateful to the reviewers, Editor in Chief Prof. Dr Moutaz A. Al-Dabbas, the Secretary of Journal, Mrs Wafaa Husain Abaas and the Technical Editors for their great efforts and valuable comments.

References

[1] M. Steineke and R. Bramkamp, “A Mesozoic of Eastern Saudi-Arabia”. APPG. 36 (5), 909. American Association Of Petroleum Geologists.1444 S BOULDER AVE, PO Box 979, Tulsa, 1952.

[2] F. Sadooni, "Stratigraphie Sequence, Microfacies, and Petroleum Prospects of the Yamama Formation, Lower Cretaceous, Southern Iraq." *AAPG bulletin* 77.11: 1971-1988, 1993.

[3] M. Al-Shahwan, “Thermal maturity patterns of the lower Cretaceous succession, southern Iraq-implication of hydrocarbon potential”.PhD dissertation (unpublished), College of Science, Baghdad University, Iraq, 2002.

[4] S. Daud, “Organic Geochemistry study of Yamama Formation in West Qurna field”. M.Sc.Thesis,College of Science, Basrah University, Un Published Thesis, (In Arabic), 2003.

[5] R. Fuloria, "Petroleum prospects analysis of southern Iraq, with particular reference to Yamama Formation." *Unpublished report, Iraq National Oil Company, Southern Petroleum Organization, Geological Laboratories, Basra, Iraq,* 1976.

[6] M. Saleh, “Sequence Stratigraphy and Characteristics of Source Reservoir rocks for the Yamama / Sulaiy succession, Southern Iraq”. University of Baghdad, 1999.

[7] Idan, R. M., Salih, A. L. M., Al-Khazraji, O. N. A., & Khudhair, M. H. "Depositional environments, facies distribution, and porosity analysis of Yamama Formation in majnoon oilfield. Sequence stratigraphic approach." *The Iraqi Geological Journal*, 38-52, 2020.

[8] M. Al-Mintfky, “Geological and Quantitively Assessment Of Yamama Formation in West Qurna field”. M.Sc. Thesis, College of Science, Basrah University, Un Published Thesis, In Arabic, 2017.

[9] N. Al-Hakeem, “Petrophysical and Geological Modeling Of Yamama Formation in Subba, Luhis and Ratawi fields, Southern Iraq”. Ph.D. Thesis, College Off Science, Baghdad University,Un Published Thesis, 2019.

[10] M. Hussein, “Evaluation of the Reservoir Properties of Yamama Formation in Sindbad, Siba and Zubair Oil Fields, Southern Iraq”. M.Sc Thesis,College Off Science, Baghdad University,Un Published Thesis, 2020.

[11] A. Al-Siddiki, "Subsurface geology of southeastern Iraq." 10th Arab *Petroleum Congress, Tripoli, Libya*. 47, 1978.

[12] S. AL-Obaidi, “The reservoir properties for Ratawi field in Yamama reservoir and relationships of petroleum production”. M.Sc. Thesis, Baghdad University. Un Published Thesis, 2001.

[13] T. Buday, “The regional geology of Iraq; Stratigraphy and Palaeogeography”. State Organization for Minerals, Baghdad, 1980.

[14] H. Jaffar, and W. Abdulnaby. "Stress regime of Rumania oilfield in southern Iraq from borehole breakouts." *IOSR Journal of Applied Geology and Geophysics* 6, 25-35, 2018.

[15] P. Rabanit, "Rock units of Basrah area." *BPC, unpublished report*, 1952.

[16] H. Dunnington, “Lexique Stratigraphic international, Asia, Iraq”. 10 a : Centre National de la Recherche Scientifique, 304-305,1959.

[17] M Ala, "Salt diapirism in southern Iran." AAPG Bulletin 58.9, 1758-1770, 1974.

[18] S. Jassim, J. Goff, “Geology of Iraq”. Published by Dolin, Prague and Moravian Museum, Brno, 341 p. 5 ical Transactions of the Royal, 2006.

[19] W. Koop, and R. Stoneley. "Subsidence history of the Middle East Zagros basin, Permian to recent." Philosophical Transactions of the Royal Society of London. Series A, Mathematical and Physical Sciences 305.1489, 149-168, 1982.

[20] R. Dunham, "Classification of carbonate rocks according to depositional textures." 108-121, 1962.

[21] A. Embry, and E. Klovan. "A late Devonian reef tract on northeastern Banks Island, NWT." Bulletin of Canadian petroleum geology 19.4, 730-781, 1971.

[22] J. Wilson, "The lower carboniferous Waulsortian facies." Carbonate facies in geologic history. Springer, New York, NY, 148-168, 1975.

[23] E. Flügel, “Microfacies of carbonate rocks: analysis, interpretation and application”. Vol. 976. Berlin: springer, 2010.

[24] T. Burchette, and V. Wright. "Carbonate ramp depositional systems." Sedimentary geology 79.1-4, 3-57, 1992.

[25] H. Chafeet, "Yamama reservoir characterization in the West Qurna oil field, Southern Iraq." Iraqi Journal of Science 57.2A, 938-947, 2016.

[26] S. Altala, and T. Mahdi. "Reservoir Units of Yamama Formation in Gharaf oilfield, Southern Iraq." Iraqi Journal of Science, 697-710, 2018.

[27] M. Jamalian, and M. Adabi. "Geochemistry, microfacies and diagenetic evidences for original aragonite mineralogy and open diagenetic system of Lower Cretaceous carbonates Fahliyan Formation (Kuh-e Siah area, Zagros Basin, South Iran)." Carbonates and evaporites 30.1, 77-98, 2015.

[28] T. Aigner, "Dynamic stratigraphy of epicontinental carbonates, Upper Muschelkalk (M. Triassic), South-German Basin. Fossil-Lagerstätten No. 59." Neues Jahrbuch fuer Geologie und Palaeontologie. Abhandlungen 169.2, 127-159, 1984.

[29] F.Calvent, and M.Tuker, “Outer ramp carbonate cycles in Upper Muschelkak,Catalon basin,N,E,Spain”.Sediment.Geol,57, 185-198, 1988.

[30] M. Tucker,and V. Wright, “Carbonate sedimentology”. Oxford, Blackwell scientific publications, 482, 1990.

[31] M. Boudagher-Fadel, “Evolution and Geological Significance of Larger Foraminifera”. University college London, UCL press., 2008.

[32] E. Musacchio, "Biostratigraphy and biogeography of Cretaceous charophytes from South America." Cretaceous Research 21.2-3, 211-220, 2008.

[33] A. A. Aqrawi, , J. C. Goff, A. D. Horbury & F. N. Sadooni, "The petroleum Geology of Iraq. Scientific press Ltd.". 424, 2010.