Arab J Geosci (2014) 7:3175–3190
DOI 10.1007/s12517-013-0991-5

ORIGINAL PAPER

Microfacies and environmental study of the lower cretaceous yamama formation in Ratawi field

Afrah H. Saleh

Received: 3 March 2013 / Accepted: 28 May 2013 / Published online: 14 July 2013

Abstract The Yamama Formation is the main Lower Cretaceous (late Berriasian–Valangenian) carbonate reservoir in southern Iraq. Petrographic study from thin-section examination shows that the skeletal grains included calcareous algae from both red and green algae. Red algae is concentrated in the upper part of the Formation, and the most important of this algae species is *Permocalculus* ssp. Green algae is less common, and its concentration is in the middle part of the Formation. The most species found in the Yamama Formation is dasycladeans, and both small and large species of benthonic foraminifera such as *Nautiloculina*, *Textularia*, *Trocholina*, *Pseudocyclammina*, and *Everticyclammina* are also present. The non-skeleton grains included oolites, pellets, and micrite. Six cyclic type microfacies have been recognized for Yamama Formation in Ratawi-3 (Rt-3) and Ratawi-4 (Rt-4) Wells, namely peloidal packstone–grainstone, algal wackestone–packstone, oolitic–peloidal grainstone, bioclastic wackestone–packstone, foraminiferal wackestone, and mudstone microfacies. The latter has been divided into two submicrofacies: argillaceous lime mudstone and fossiliferous lime mudstone. The lateral extension of these microfacies has been identified by integrating the thin-section data and well logs' character variations with similar characteristic for microfacies. The Yamama Formation was affected by five diagenetic processes, which are micritization, cementation, recrystallization, silicification, and stylolites. The Yamama Formation was deposited during a regressive period within the outer ramp, shoal, and inner ramp setting.

Keywords Microfacies · Ratawi Oil Field · South Iraq

A. H. Saleh (✉)
University of Baghdad, Baghdad, Iraq
e-mail: d.afrah@yahoo.com

Introduction

The Yamama Formation is considered as one of the important carbonate reservoirs in southern Iraq within the Lower Cretaceous sediments. It consists of shoal sedimentation containing components in the peloidal limestone, oolitic and pseudo-oolitic limestone, and fragment and organic fossils of calcareous algae and foraminifera.

Yamama Formation belongs to the late (Berriasian–Aptian) cycle. The cycle is represented from shore to deep basin by Zubair, Ratawi, Garagu, Yamama, Shuiaba, and Sarmord (Buday 1980).

Yamama Formation was first described by Steineke and Bramkamp (1952) in abstract about the Mesozoic rocks in Saudi Arabia. They mentioned that the Yamama Formation belongs to the Thamama Group, along with the Buaib and Sulaiy Formations. Dunnington (1959) described the Yamama Formation and combined it with Sulaiy Formation.

Yamama Formation is divided into five lithologic units: three reservoir units, designated from top as YR-A, YR-B, and YR-C, separated by two permeability barrier units, YB-1 and YB-2. These reservoir units are thought to be at least partially isolated from each other (Al-Siddiki 1978a, b). The best oil prospects are within the oolite shoals and the patch reef buildups in the crestal parts of the structures (Sadooni 1993).

The area of study

The Ratawi Field is located about 70 km north of Basra City and west of the North Rumaila Field (Fig. 1) in the flat semi-desert.

The Yamama Formation is located at a depth of about 3,499 m below the sea level in a Ratawi well (Rt-3). The studied sections included five wells of the field that penetrate the Formation, namely Rt-3, Rt-4, Rt-5, Rt-6, and Rt-7.

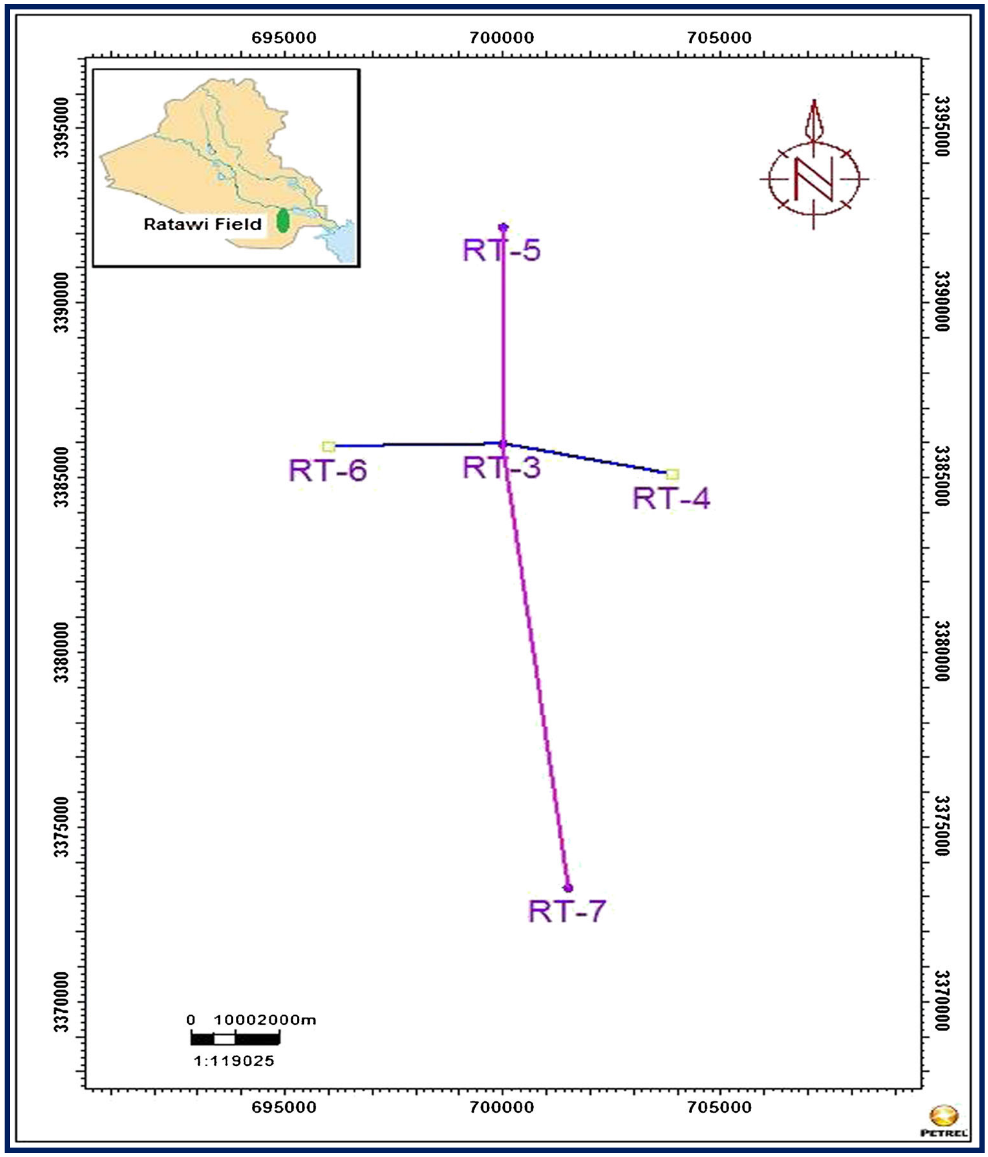


Fig. 1 The distribution of the wells and the studied cross-sections

Yamama boundaries

The Yamama Formation is underlain conformably by the Sulaiy Formation, which made up of mud-supported argillaceous limestone with calcispheres and small benthonic foraminifera. The Yamama grades upward into the Ratawi Formation, which is a heterogeneous suite of limestone, shale, siltstone, and sandstone (Fig. 2).

In this study, the logs have been depended on to delineate the top and bottom of the Yamama Formation; Yamama Formation has been delimited at the first appearance of the clean limestone unit occurring below the shale and the argillaceous limestone of the Ratawi Formation. The lower contact has been placed at the first appearance downward of argillaceous limestone characteristic of the Sulaiy Formation. The boundary has been delimited according to the spontaneous potential (SP) log and the gamma-ray log at the depths shown in Table 1 for the wells of the study (Figs. 3 and 4), showing a response of the low gamma-ray log at appearance of Yamama Formation, with positive deflection for SP log due to the resistivity of mud filtrate (rmf) that is less than the resistivity of the formation water (R_w).

The lower contact placed at the first appearance downward of argillaceous limestone characteristic have been distinctive at log pattern on the gamma-ray log and SP log.

Petrographic description

Through the thin-section examination for Yamama Formation in the Ratawi Field for two wells (Rt-3 and Rt-4), the petrography has been studied as it shows the following:

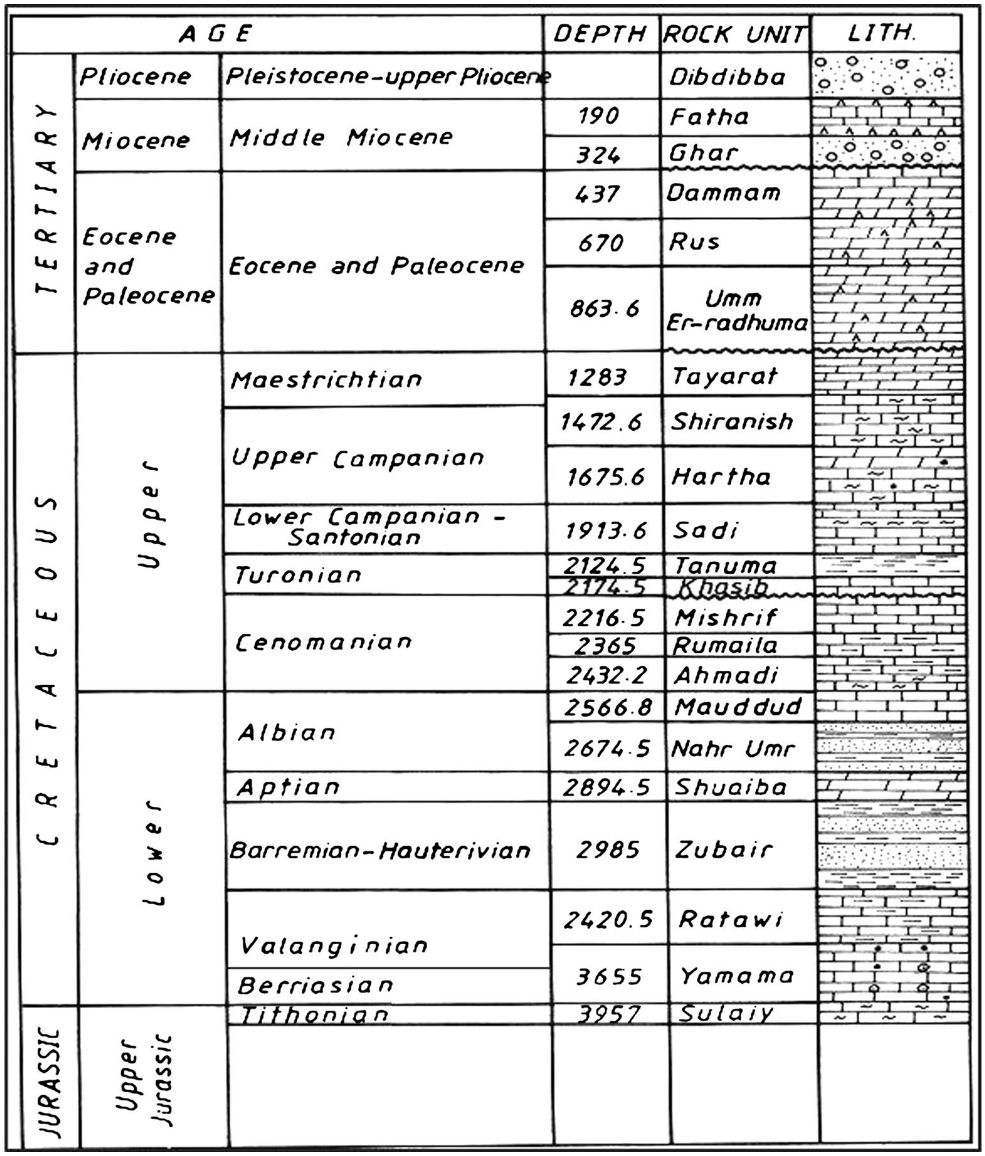


Fig. 2 Sequence boundary for Ratawi Field in well Rt-7

Skeletal grains

The characteristic of Yamama Formation contains a large number of skeletal grains representing the red and green algae, foraminifera, and some spicules of sponges.

Calcareous algae

Calcareous algae comprise most of the fossils of the Yamama Formation. Algae are aquatic photosynthetic benthonic and planktonic plants ranging from micron-sized unicellular forms to giant kelps several meters long.

Controls on the distribution of recent benthonic algae comprise (a) physical factors: intensity and quality of light, water temperature, water energy, and substrate; (b) chemical factors: water chemistry, salinity, dissolved gases, and pH values; and (c) biological factors: nutrients, competing and herbivorous organisms, and ecological successions (Flugel 2004).

The following is a description of the two main families of algae for Yamama Formation in the study area:

Table 1 The Boundary of the Yamama Formation from logs

Wells	Rt-3	Rt-4	Rt-5	Rt-6	Rt-7
Top of Yamama	3533 m	3675 m	3672 m	3643 m	3655 m
Top of Sulaiy	3834 m	3981 m	3991 m	3938 m	3957 m

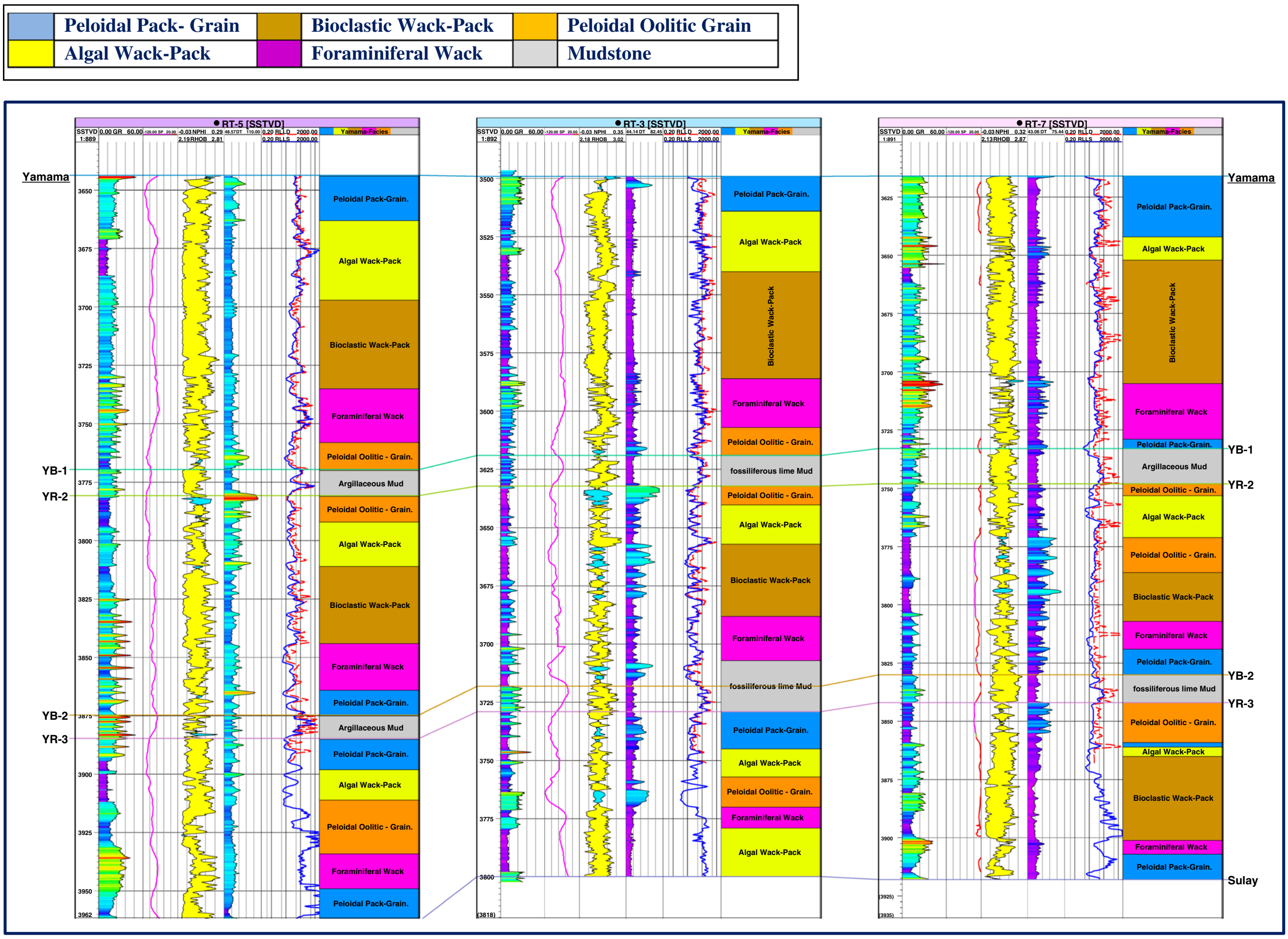


Fig. 3 North–south cross-section for Yamama Formation in Ratawi Field

Red algae

Red algae are abundant in the rock of the Yamama Formation and are concentrated in the upper part of the Formation, and the most important of these algae species is *Permocalculus* ssp. In general, red algae prefer normal marine water in tropical and subtropical areas. They flourish in lower tidal area to a few meters below sea level. Water depth usually does not exceed 90 m. They favor hard sea floor and their most suitable environments are reefs or open marine environments (Wilson 1975; Wray 1977; Reeckmann and Friedman 1982).

Green algae

Green algae are less common and are concentrated in the middle part of the Formation. The most group found in the Yamama Formation is dasycladeans of which most of their skeletons were dissolved and became filled by sparry calcite cement. In most cases, algae are mixed with shell fragments (mainly pelecypods).

Green algae are known to prefer normal marine waters, but may be found in isolated lagoons. Green algae favor tropical to subtropical areas and flourish in subtidal depths of 3–5 m and range to depths of 30 m. The water usually is of low energy and the algae live below the wave base. The sea floor may be muddy or sandy. Generally, sheltered lagoons and protected reef flats are the most favorable areas for green algae production (Wilson 1975; Wray 1977).

Foraminifera

Foraminifera are small, predominantly marine heterotrophic protists that construct chambered shells. Foraminifera provide time markers for biozonations of shallow and deep marine carbonates, are excellent environmental proxies, and permit ancient depositional systems to be reconstructed. The two major groups of foraminifera are benthonic, living in or on sediments on the sea floor, and planktonic, living in the upper 100 m of the oceans.

Foraminifera1 environments include shelves, platforms, ramps, reef, slopes, and basins. Most modern foraminifera

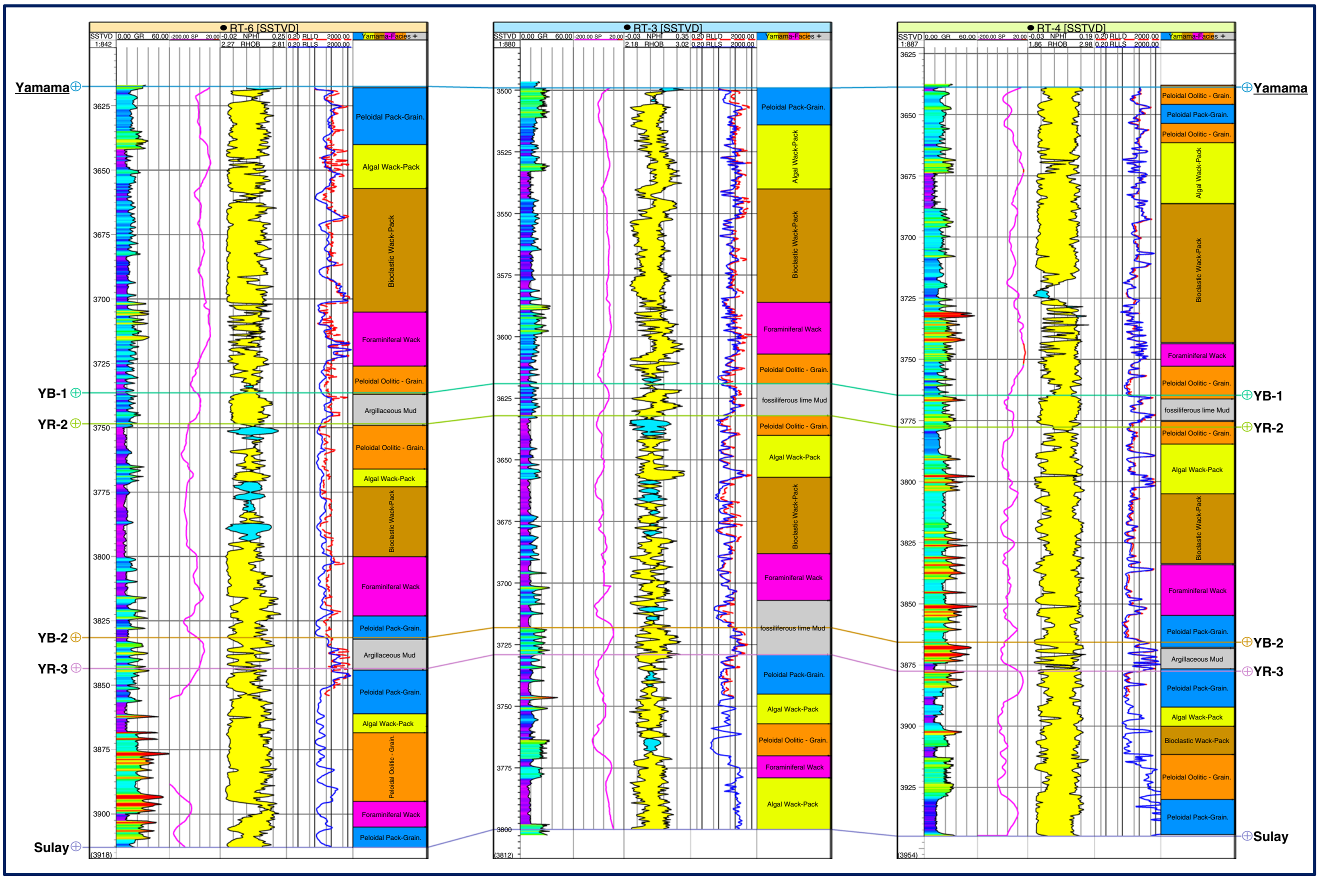


Fig. 4 West–east cross-section for Yamama Formation in Ratawi Field

are marine and benthonic, and live from the intertidal zone down to the deep sea. Some benthonic foraminifera inhabit fresh and brackish waters. Planktonic foraminifera live in the upper part of the open oceans (Flugel 2004).

Benthonic foraminifera are found in various facies with other shell and fragments of algae, and these benthonic foraminifera are small and large such as *Trocholina*, *Nautiloculina*, *Textularia*, *Everticyclammina*, and *Pseudocyclammina*.

Non-skeletal grains

The non-skeletal grains in Yamama Formation include oolites and pseudo-oolites, pellet, and micrite as follows:

Oolites and pseudo-oolites

Ooids are spherical and egg-shaped carbonate or non-carbonate coated grains exhibiting a nucleus surrounded by an external cortex, the outer part of which is concentrically smoothly laminated. Most ooids are smaller than 2 mm in diameter; many ooids are about 1 mm in size. Modem calcareous ooids consist of aragonite and/or calcite (Flugel 2004). A rock composed dominantly of ooids is termed an "oolite". That term is commonly misused, however, to describe the constituent ooid grains (Scholle 2003).

Thin-section examination shows that the ooids are large and well developed. The common type, according to the classification of Flugel (1982), with two to three rings surrounding the nucleus is characterized by harmony, and their size does not exceed 2 mm in diameter. Due to the compaction process, the shape of ooids tend to be elongated, and the relatively large size of most of the pellets or fossil fragments have been strongly affected by diagenesis process, leading to the removal of some of their original structures so-called pseudo-oolites. The ooids were found at the zone in the thickness range 5–29 m, their size decreasing and their sorting deteriorating downward.

Peloides

A pellet is a grain (allochem) composed of lime mud (micrite) generally lacking a significant internal structure. Pellets commonly are rounded, spherical to elliptical, or ovoid in shape, and most are considered to be the fecal products of invertebrate organisms. As such, pellets are generally small (0.03 to 0.3 mm) and of uniform size and shape in any single sample (Scholle 2003).

Peloids are common in shallow-marine tidal and subtidal shelf carbonates and in reef and mud mounds, but they are also abundant in deep-water carbonates. By contrast to the abundance of peloids in tropical shallow-marine carbonate, peloids are rare or absent in non-tropical cool water carbonates (Flugel 2004).

Thin-section examination shows that some zones of the Yamama Formation are made of peloidal-bearing limestone, most abundant in the studied thin sections, which is different in size, shape, and sorting.

Micrite

Micrite was proposed as a genetic term referring to lithified mechanically deposited lime mud (Folk 1959). In general, micrite is understood to be the fine-grained matrix of carbonate rocks and the fine-grained constituent of carbonate grains. The crystal size of micrite ranges from cryptocrystalline to microcrystalline (individual crystals recognizable with a petrographic microscope but not visible with a binocular microscope and hand lens) (Flugel 2004).

Micrite represents the rock matrix of the Yamama Formation which consists of microscopic grains of calcite crystallization of the size range 1–4 μm resulting from the replacement of the original lime mud formed by the calcite high magnesium and/or aragonite.

Diagenesis

Diagenesis is all of the changes that happened to sedimentary rocks after deposition and before metamorphism. All changes in size, shape, volume, chemical composition, or crystalline structure of a sedimentary rock after its detrital, biogenic, or crystalline constituents have been deposited. The mechanisms of diagenesis may be mechanical, biological, or chemical, or several of them in some combination (Wayne 2008).

The most important diagenetic processes affecting in the Yamama Formation includes micritization, cementation, recrystallization, silicification, and stylolite.

Micritization

Micritization is a process whereby the margins of carbonate grains or the total volume of grains are replaced by crypto- or microcrystalline carbonate crystals. Incomplete micritization leads to the formation of cortoids, whereas complete micritization can bring about a gradual to total alteration of the original grain (Flugel 2004). In the Yamama Formation, micritization comprises the boring process and the voids that were filled with micrite material after the death of the organism (Plate 1-1).

Two kinds of micritization were found. The first extensive micritization appeared clearly in the large benthonic foraminifera, when most of the biological components altered to the pseudopeloids by extensive micritization. The second kind is the partial micritization in shoals facies especially in oolites (Rozarian 1995).

Cementation

Cementation is the diagenetic process by which voids and porosities are filled by calcite cement during the deposition, by filling the interparticle porosity, or after deposition, by filling the porosity resulting from dissolution process or fractures and joints resulting from compaction (Moore 1997). In Yamama Formation, two kinds of cementation have been recognized, blocky granular cement and granular mosaic cement (Plates 1-2 and 1-3).

Blocky granular cement deposition from water saturated with $CaCo_3$ was represented by anhedral or subhedral calcite crystals generally 10–60 mm in size and usually with a preferred orientation of crystals. Coarsening of calcite crystal toward pore centers may be a distinctive characteristic of early cementation in a freshwater phreatic environment (Flugel 1982).

Granular mosaic cements are characterized by small pore-filling calcite crystals without a preferred orientation in meteoric–vadose, meteoric–phreatic, and burial environments (Flugel 2004).

Recrystallization

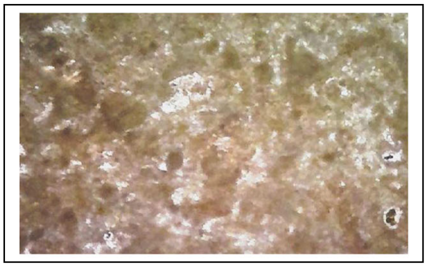
Recrystallization refers to changes in crystal size, crystal shape, and crystal lattice orientation without changes in mineralogy; it results in a replacement of former larger crystals by tiny crystals due to changes in crystal texture or changes in mineralogy (Flugel 2004).

This process is diagnosed within the middle parts of the Yamama Formation which re-crystallized fine calcite crystals (Plate 1-4) and increased comparatively the size of these crystals made up of intercrystalline.

Silicification

Silicification of carbonate rocks involves replacement of carbonate by silica as well as precipitation of pore-filling silica cement, and the major sources of silica in sediments are (1) siliceous tests and skeletal elements of organisms, (2) river input of solutions from the weathering of continents in semi-arid climates, and (3) silica supplied in solution by hydrothermal volcanic systems (Flugel 2004).

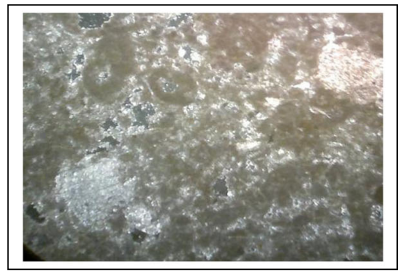
Silica was found in Yamama Formation in two cases: the first is the sedimentary origin of the clastic quartz (sand or silt grains) within mudstone facies, which reflect the effects of sub-continental basin sedimentation; and the second is diagenetic autogenic by replacement of fine silica crystals



1-1 Micritization
Depth (3782m) in RT-3

1-2 Blocky calcite cement
Depth (3768m) in RT-3

1-3 Granular mosaic cement
Depth (3760m) in RT-3



1-4 Recrystallizations
Depth (3724m) in RT-3

1-5 Stylolites
Depth (3757m) in RT-3

Plate 1 Diagenesis processes (×40)

from coral skeleton to replace calcite crystals which do not reflect the specific environment but spread to the general Formation (Rozarian 1995).

Stylolite (pressure solution)

Stylolites are thin zones of discontinuity within the rock. In thin section, they have undulated zigzag sutures; in general, they consist of conical to columnar projections with intervening depression. Pressure solution resulting in stylolites and solution seams formed under burial conditions. Stylolites are irregular, suture-like contacts produced by differential vertical movement under pressure accompanied by solution (Flugel 2004).

In the Yamama Formation, the stylolite (Plate 1-5) represents the effect of the pressure solution as a late diagenetic process affecting mainly the high compaction especially in the mudstone facies intervals; these stylolites are mostly vertical and amplitudes of stylolites may be about 10 cm, which can be retarded and prevented by the presence of oil or organic matter between and on grain surfaces.

Microfacies

Microfacies study is the most important characteristic of the carbonate rock that aims to distinguish the depositional environment and reconstruction of the depositional model depending on the type of skeletal and non-skeletal grains. In the present study, the carbonate rock of the Yamama Formation classified according to Dunham's classification (1962) of carbonate rocks and Wilson's standard microfacies (1975) were used.

Six microfacies have been characterized vertically through the examination of thin section from Yamama Formation in Ratawi Field from two wells (Rt-3and Rt-4). The following is a description of the facies:

Peloidal packstone–grainstone microfacies

These facies consist mainly of peloid-bearing limestone. These peloids are different in size, shape, and sorting (Plate 2-1). This microfacies is characterized by the abundance of medium- and large-size, well-sorted peloids that reflect moderate energy environment.

These pellets are either fecal pellets formed by low-energy sheltered environment or they were originally ooids but were transported by current and waves from the oolite shoals and distributed over the basin. When comparing these facies with Wilson standard microfacies type (Wilson 1975), Flugel zones (Flugel 1982) found to be similar to facies (17) within the range (8) were deposited in the inner ramp (open lagoon).

Algal wackestone–packstone microfacies

The proportion of the algae in these facies is about 30 % wackestone algae debris facies (Plate 2-2), which are described by Elliot (1958), and packstone, which is made mainly from algae. This facies can be subdivided according to the algae types into two subfacies:

Green algae-bearing wackestone–packstone microfacies

This facies is concentrated in the middle parts of the Formation and is decreasing towards the top of the Formation where the red algae dominate. This facies consists mainly of skeletons of green algae from the dasycladacean group. Most of their skeletons were dissolved and filled by sparry calcite cement. Most algae are mixed with shell fragment and may also contain some large benthonic foraminifera such as *Everticyclammina* ssp. and *Pseudocyclammina* ssp.

Red algae-bearing wackestone–packstone microfacies

Red algae are abundant in the rock of the Yamama Formation. The most important of these algae species is the *Permocalculus* ssp. group, which is the main red algae group preserved as fossils, and most of the red algae belonging to this group are characterized by perforated skeletons. Most of them are well preserved due to extensive filling by calcite cement (Dhihny 1993).

Red algae concentration is in the upper part of the Formation, and fragments of these algae are found in most facies. When comparing these facies with Wilson standard microfacies type (Wilson 1975), Flugel zones (Flugel 1982) found to be similar to facies (9) within the range (7) were deposited in the inner ramp environment.

Peloidal–oolitic grainstone microfacies

This facies consists of grainstone, the non-skeleton grains that include mainly oolites and pseudo-oolites, as well as pellets (Plate 2-3); the skeleton grains include echinoderm pieces and shell fragments. In the Yamama Formation, this facies contains large pieces of stromatoporoid. The oolites are large and well developed, and their size decreases and sorting deteriorates downward that changed into a mixture of ooids, peloids with shell fragments, and algae debris. Then the large oolites appear again, which indicates that there are more than one cycle for oolite development, and the echinoderm pieces are rounded, indicating the high energy during the deposition.

When comparing these facies with Wilson standard microfacies type (Wilson 1975), Flugel zones (Flugel 1982) found to be similar to facies (15) within the range (6) were deposited in shoal environments.

Bioclastic wackestone–packstone microfacies

This microfacies consists of abundant bioclasts of algae, gastropods, echinoderms, mollusks, and foraminifera such as *Textularia*, *Trocholina*, and *Pseudocyclimina* (Plate 2-4).

When comparing this facies with Wilson standard microfacies type (Wilson 1975), Flugel zones (Flugel 1982) found to be similar to facies (9) within the range (2) for dominance of the packstone on the wackestone were deposited in the outer ramp.

Foraminiferal wackestone microfacies

This facies consists of 25–50 % benthonic foraminifera, large and small, especially *Pseudocyclimina*, *Trocholina*, and *Textularia*, as well as few green algae debris and shell fragments (Plate 2-5). This facies is characterized by higher compaction and presence of bioturbation.

When comparing this facies with Wilson standard microfacies type (Wilson 1975), Flugel zones (Flugel 1982) found to be similar to facies (8) within the range (2) were deposited in the outer ramp (open marine) environment.

Mudstone microfacies

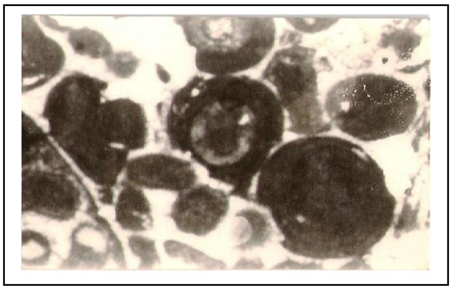
Mudstone defined according to the Dunham (1962) classification as containing high lime mud (more than 90 % lime mud) and as micrite by Folk (1962).

Mudstones are muddy carbonate rocks containing less than 10 % grains measured as grain-bulk percent. The name is more or less synonymous with calcilutite (Flugel 2004).

The mudstone microfacies are divided into two main submicrofacies as follows:

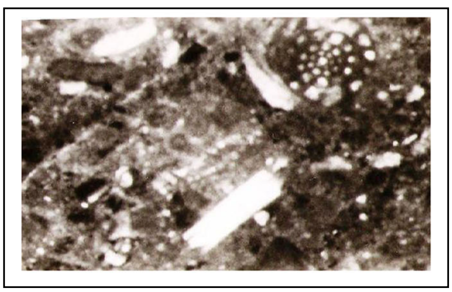
2-1 Peloidal packstone - Grainstonemicrofacies
Depth (3703 m) in RT-3

2-2 Algal wackestone – Packstonemicrofacies
Depth (3690 m) in RT-3

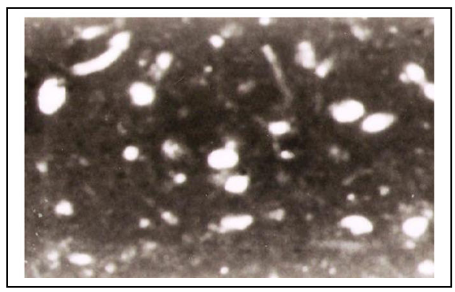


2-3 Peloidal - Oolitic grainstonemicrofacies
Depth (3818 m) in RT-4

2-4 Bioclastic wackestone – Packstone microfacies
Depth (3720 m) in RT-3



2-5 Foraminiferal wackestone microfacies
Depth (3735 m) in RT-3



2-6 fossiliferous Lime mudstone microfacies
Depth (3753 m) in RT-3

Plate 2 Microfacies (×40)

Argillaceous lime mudstone submicrofacies

This facies consists of shale and dense micrite with considerable amount of marl. This facies is mostly dark in the microscope; the facies changes into shale containing quartz grains.

The topography of the seabed is that the control on the deposition of this facies represents restricted platform and swamp shore within an open restricted lagoon environment.

When comparing this facies with Wilson standard microfacies type (Wilson 1975), Flugel zones (Flugel 1982) found to be similar to facies (23) within the range (9) were deposited in the outer ramp environment.

Fossiliferous lime mudstone submicrofacies

This submicrofacies contains less than 5 % fine bioclastic fragments (Plate 2-6) of which mostly less than 3 % were neglected. This facies consists of pure calcite micrite with a few spicules that may be sponge spicules. This sponge may trap lime mud sediments, forming mud mounds, and then dissolves and remains the spicule which indicated the sponge.

Mud mounds are regarded as a specific carbonate factory that differs fundamentally from the tropical and from the cool-water carbonate factories (Schlager 2004).

When comparing this facies with Wilson standard microfacies type (Wilson 1975), Flugel zones (Flugel 1982) found to be similar to facies (1) within the range (1) were deposited in the outer ramp environment.

The lateral extension of these microfacies has been identified by integrating the thin-section data and logs (sonic, neutron, density, spontaneous potential, and gamma ray) characters variation with similar characteristic for microfacies (Figs. 3 and 4). The vertical facies distribution and environments for

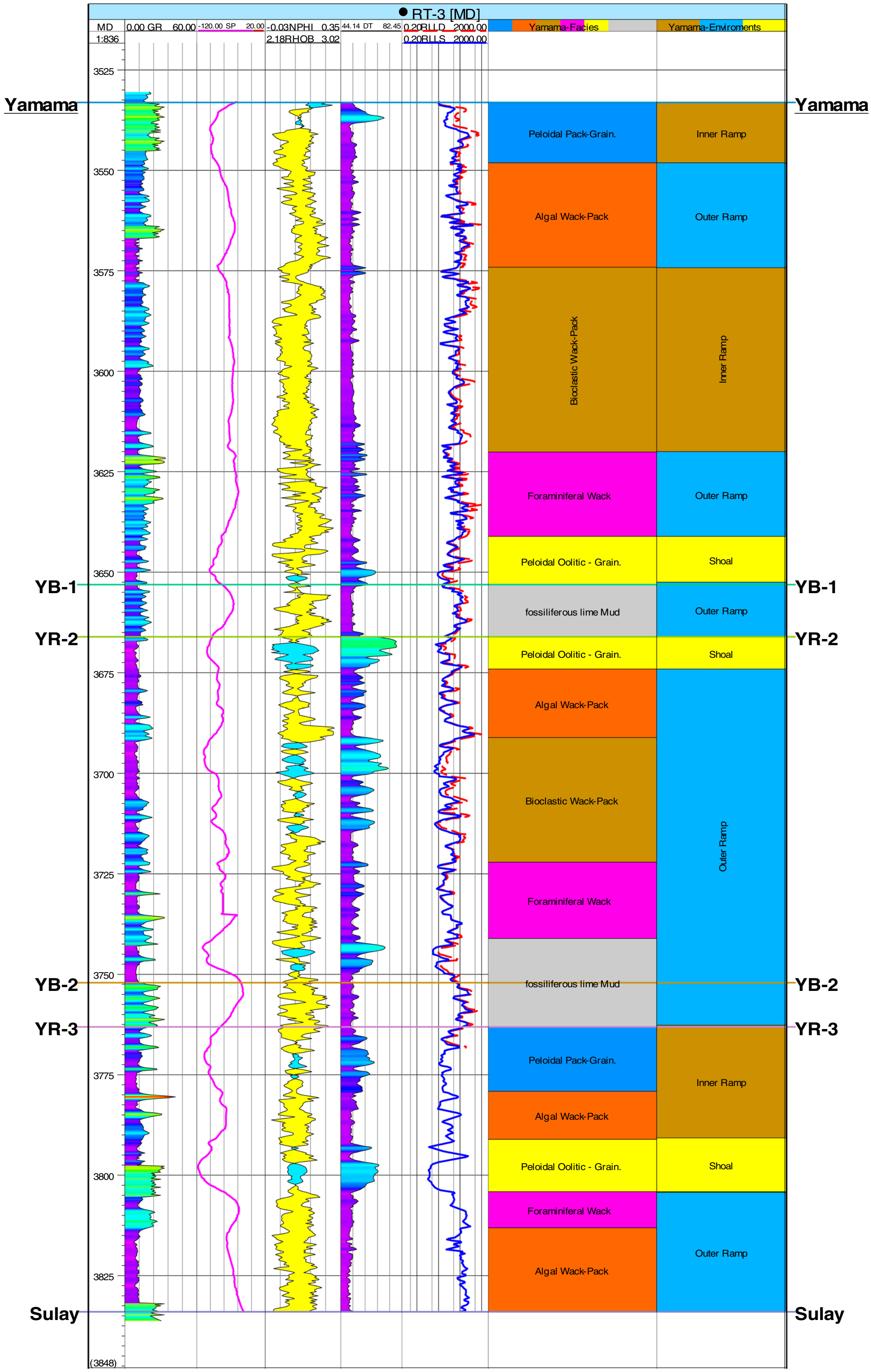


Fig. 5 The vertical Facies distribution and environments for the Yamama Formation in the well (RT-3)

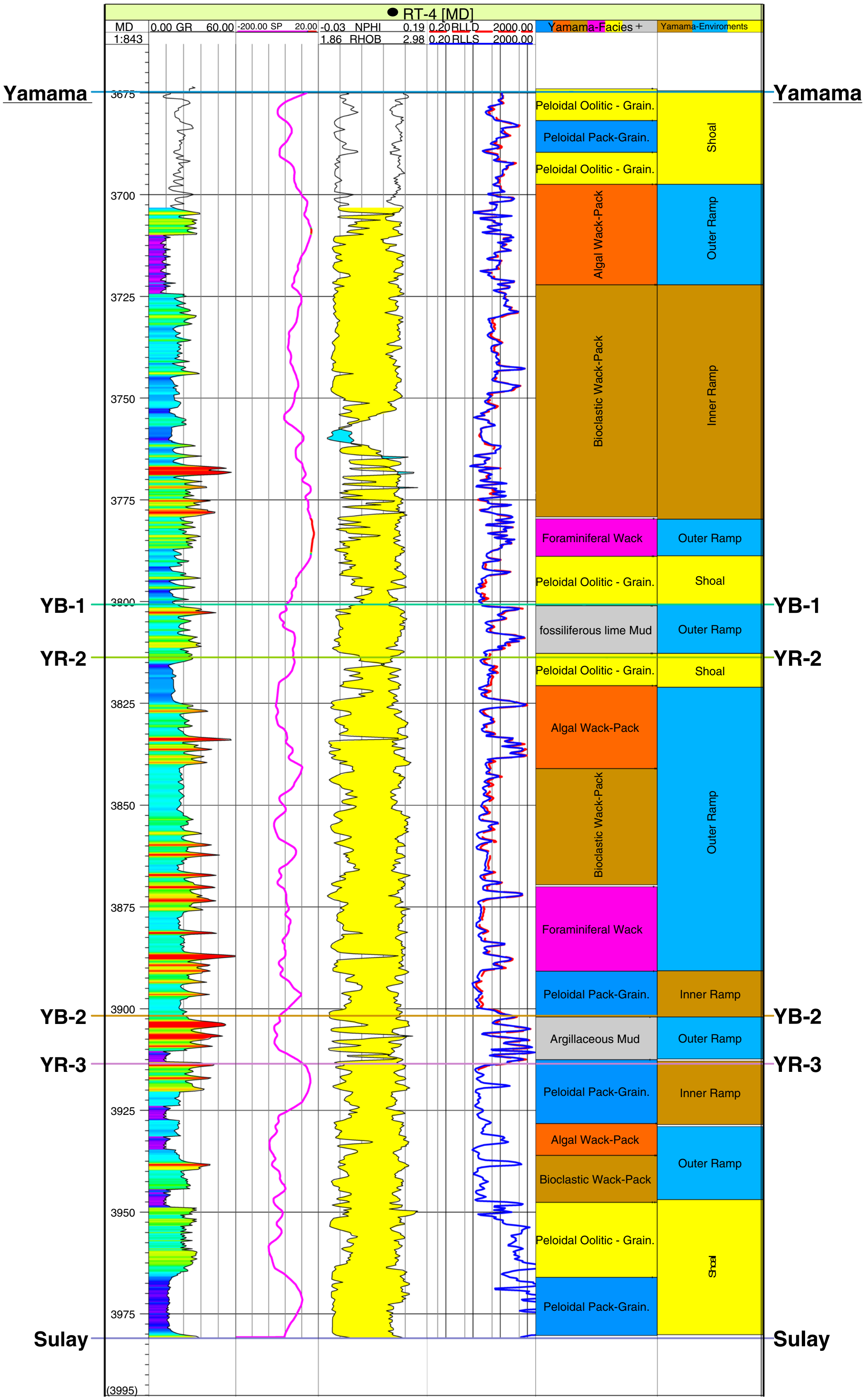


Fig. 6 The vertical facies distribution and environments for the Yamama Formation in well RT-4

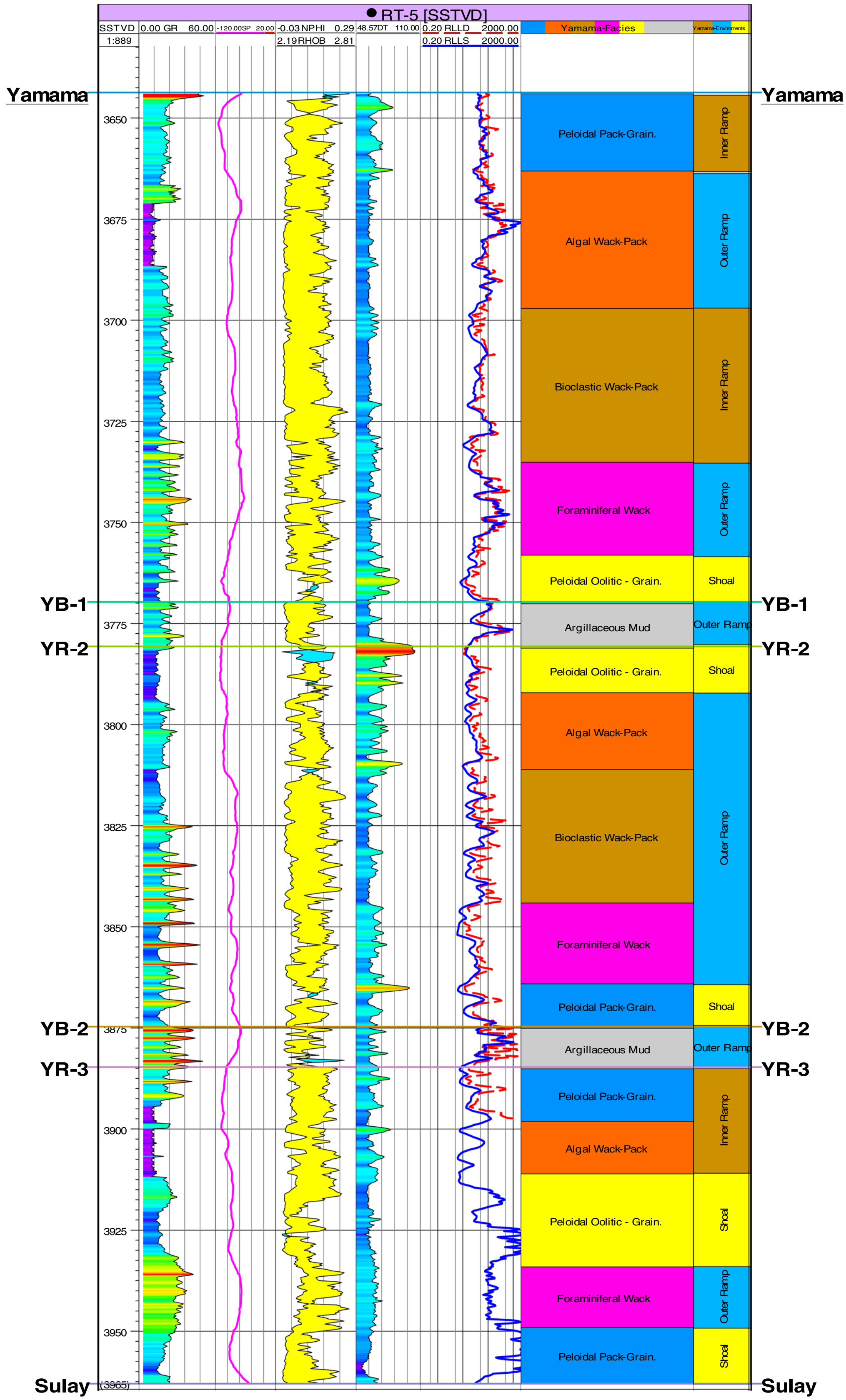


Fig. 7 The vertical facies distribution and environments for the Yamama Formation in well RT-5

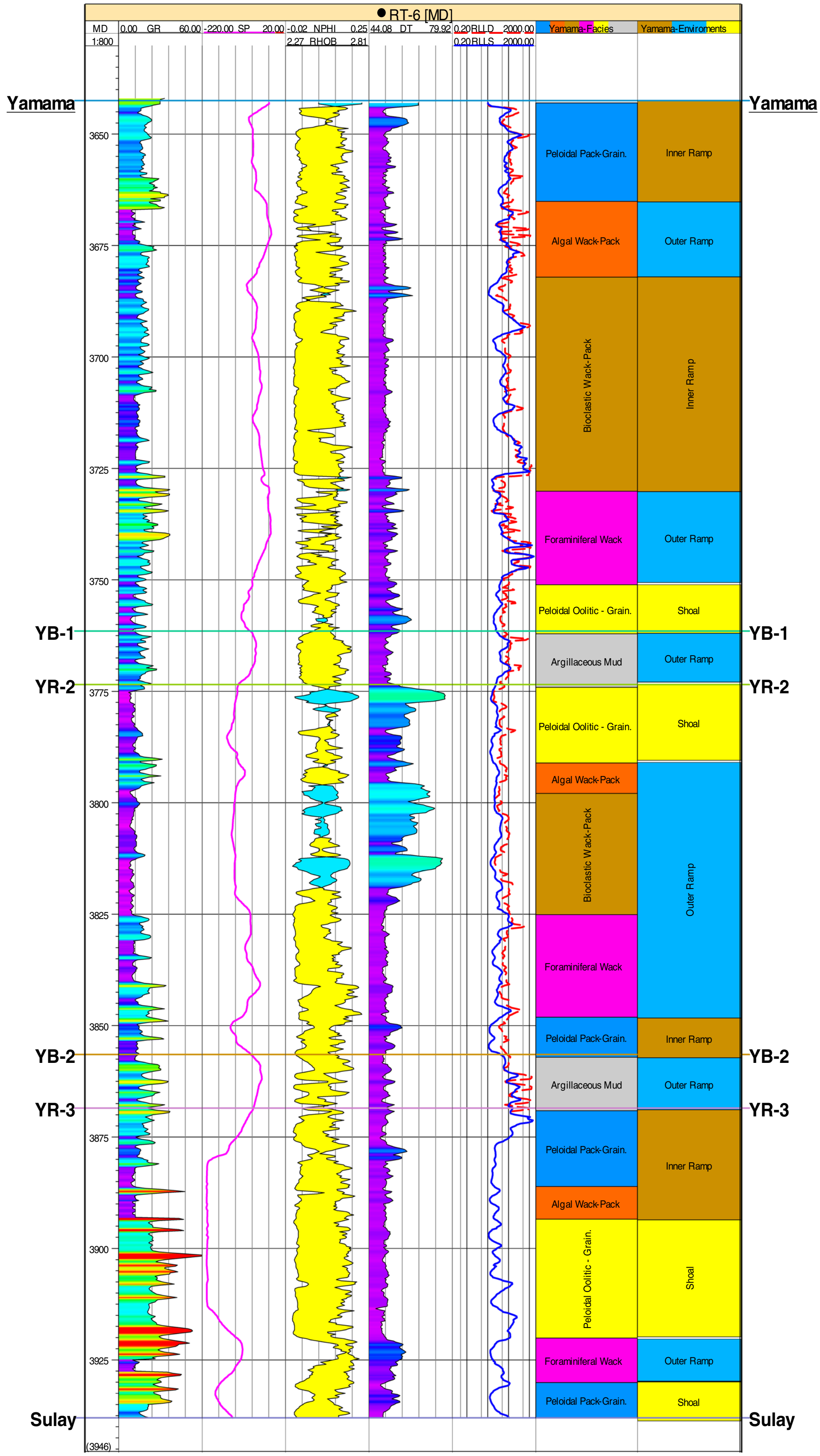


Fig. 8 The vertical facies distribution and environments for the Yamama Formation in well RT-6

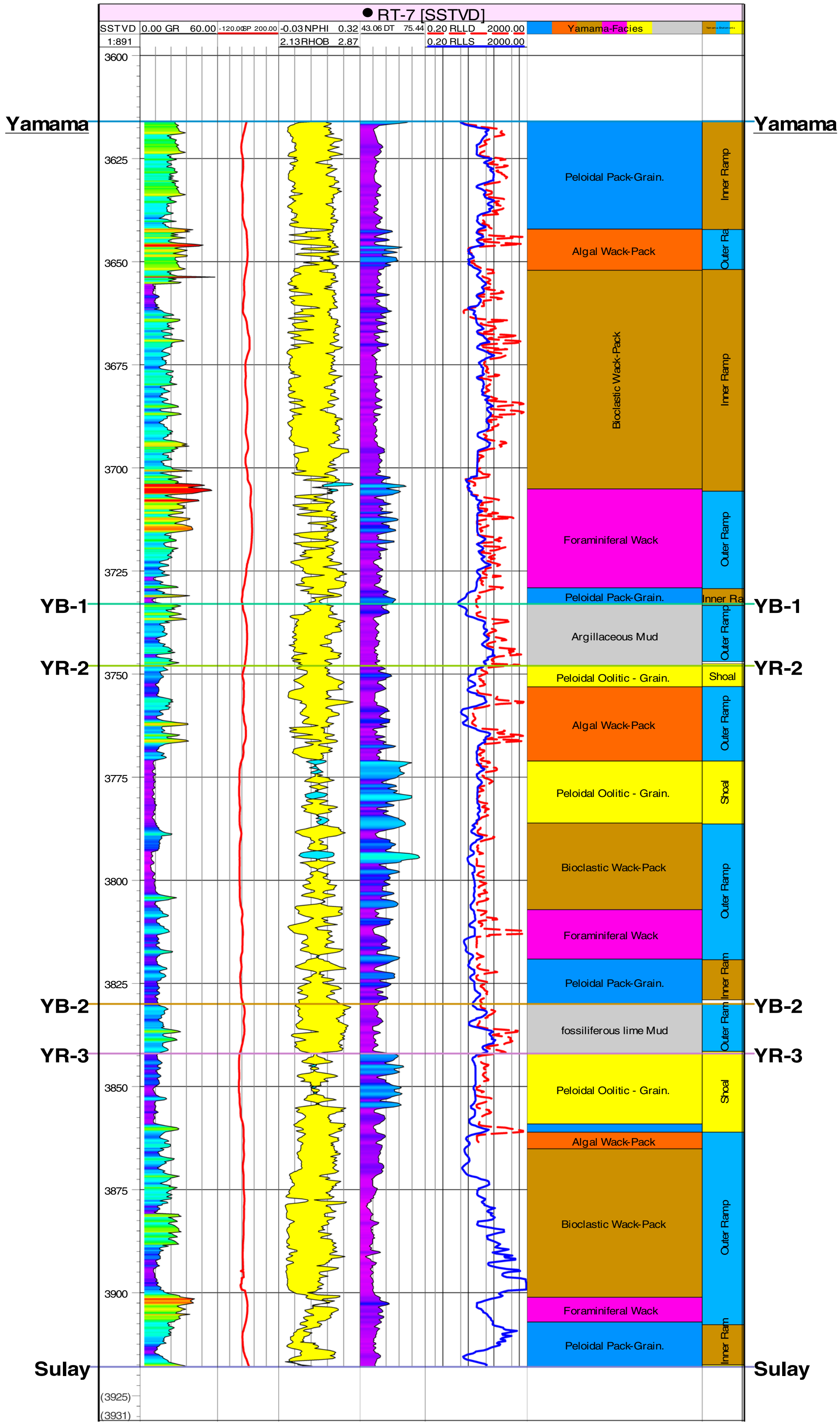


Fig. 9 The vertical facies distribution and environments for the Yamama Formation in well RT-7

Yamama Formation in each well are shown in Figs. 5, 6, 7, 8, and 9.

Yamama depositional environments

The Yamama was deposited on a ramp carbonate platform within the inner ramp; shoal, to outer ramp-Bain setting. The deposition phase continued until the regression in the sea level resulted in unconformity between Yamama and the overlying Ratawi Formation.

The inner ramp environment is the zone above fair weather wave base; this environment in Yamama Formation is represented by the peloidal packstone–grainstone, bioclastic wackestone–packstone, and algal wackestone–packstone.

The shoal environment, which represents the zone between fair weather wave base and storm wave base, in Yamama Formation is dominated by the peloidal–oolitic grainstone facies.

The outer ramp-basin environments are reflected by foraminiferal wackestone, fossiliferous lime mudstone, and argillaceous mudstone.

The lower part of the Yamama succession represents the end of the transgressive cycle (outer ramp) bounded below by conformable surface with Sulaiy Formation. It consists of gradual deepening succession of basin marine facies of Sulaiy Formation to inner ramp, middle ramp, to outer ramp facies of Yamama Formation (Fig. 10). This is followed by an episode of relative sea level fall represented by the deposition of the shoal and shallow restricted facies representing the (regression) end of cycle represented by unconformity surface that separated Yamama Formation with overlaying Ratawi Formation in studied wells.

Conclusion

The present study aimed to study the microfacies and the depositional environments of Yamama Formation in Ratawi Field, revealing the following conclusions:

1. The skeletal grains included calcareous algae from red and green algae. Red algae concentration is particularly in the upper part of the Formation, and the fragments of these algae are found in most facies of the Formation. The most important of these algae species is *Permocalculus* ssp. Green algae is less common and is concentrated in the middle part of the Formation. The most species found in the Yamama Formation is dasycladeans, and both small and large species of benthonic foraminifera such as *Nautiloculina*, *Textularia*, *Trocholina*, *Pseudocyclammina*, *Everticyclammina* are also present. The non-skeleton grains included oolites, pellets, and micrite.
2. Six cyclic type microfacies have been recognized for Yamama Formation in Rt-3 and Rt-4 wells. These are as follows: peloidal packstone–grainstone, algal wackestone–packstone, oolitic–peloidal grainstone, bioclastic wackestone–packstone, foraminifera wackestone, and mudstone microfacies. The latter has been divided into two submicrofacies: argillaceous lime mudstone and fossiliferous lime mudstone.
3. The lateral extension of these microfacies has been identified by integrating the thin-section data and well logs' character variations with similar characteristic for microfacies.
4. The Yamama Formation was affected by five diagenetic processes, which are micritization, cementation, recrystallization, silicification, and stylolite.

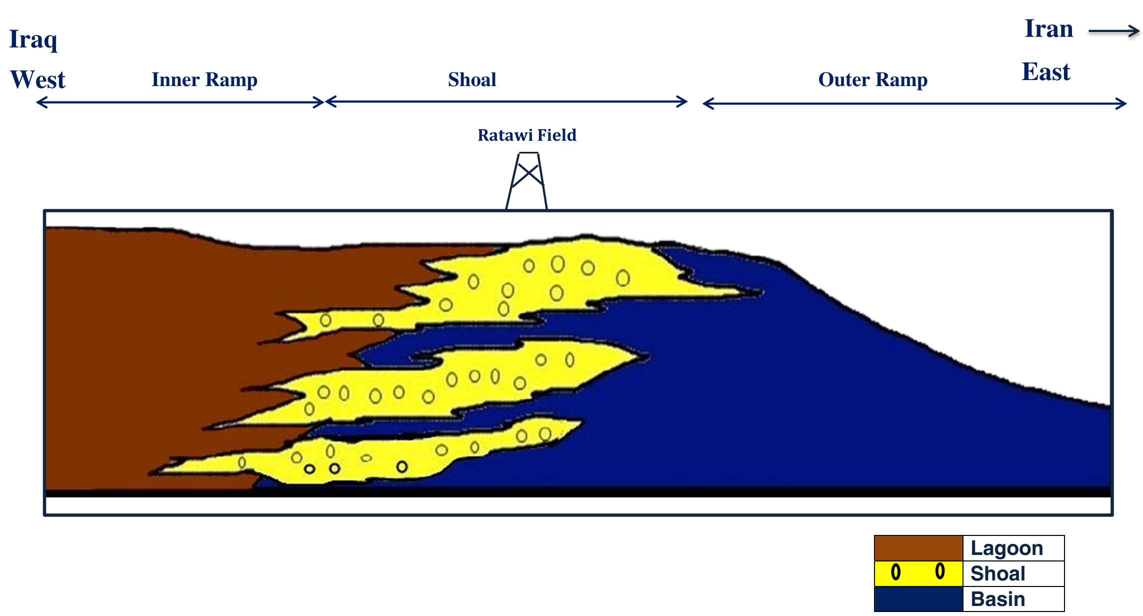


Fig. 10 Schematic environmental model shows the vertical and lateral distribution of the Yamama environments in the study area

5. The Yamama Formation was deposited during a regressive period within the outer ramp, shoal, and inner ramp setting.
6. The boundary of Yamama Formation has been delimited at the first appearance of the clean limestone unit occurring below the shale and the argillaceous limestone of the Ratawi Formation. The lower contact has been placed at the first appearance downward of argillaceous limestone characteristic of the Sulaiy Formation, according to the spontaneous potential (SP) log and the gamma-ray log.

References

Al-Siddiki AAM (1978a) The geology and the hydrocarbon prospects of the Ratawi, Yamama and Sulaiy formations in Southeastern Iraq, Subsurface Section. Unpublished report, Southern Petroleum Organization, 28 p

Al-Siddiki AAM (1978b) Yamama's oil, a big exploration project executed by national staff (in Arabic). INOC, 1st Scientific Conference, 23 p

Buday T (1980) The regional geology of Iraq, VI: stratigraphy and paleontology. SOM, Baghdad

Dhihny GA (1993) Yamama Formation Southern Iraq. The depositional model and diagenetic history, regional study. Internal report, INOC, Baghdad

Dunham RJ (1962) Classification of carbonate rocks according to depositional texture. In: How WE (ed) Classification of carbonate rocks, vol 1, AAPG Memoir., pp 108–121

Dunnington HV (1959) Mesozoic (Cretaceous). In: Van Bellen RC, Dunnington HV, Wetzel R, Norton DM (eds) Lexique Stratigraphique International, Asie, Iraq: 10a. Centre National de la Recherche Scientifique, Paris, 333 pp

Elliot GF (1958) Algal debris facies of the Cretaceous of the Middle East. Paleontology 1:234–259

Flugel E (1982) Microfacies analysis of limestones. Springer, Berlin, p 633, Translated by K Christensen

Flugel E (2004) Microfacies of carbonate rocks. Springer, Berlin, 976 pp

Folk RL (1959) Practical petrographic classification of limestones. AAPG Bull 43(1):1–38

Folk RL (1962) Spectral subdivision of limestone types. In: Ham WE (ed) Classification of carbonate rock. AAPG Memoir 1, pp. 62–84

Moore CH (1997) Carbonate diagenesis and porosity. Developments in sedimentology, 46, 338 pp. Paleontology. SOM, Baghdad

Reeckmann A, Friedman GM (1982) Exploration for carbonate petroleum reservoirs. Wiley, New York

Rozarian A (1995) Sedimentological and depositional history of the Yamama Formation, Southern Iraq. Internal report, INOC, Basra

Sadooni FN (1993) Stratigraphic sequence, microfacies and petroleum prospects of the Yamama Formation, L. Cretaceous, Southern Iraq. AAPG Bull 77(11):1971–1988

Schlager W (2004) Fractal nature of stratigraphic sequences. Geology 32(3):185–188

Scholle PA (2003) A color guide to the petrography of carbonate rocks: grains, textures, porosity, diagenesis. AAPG Memoir 77. The American Association of Petroleum Geologists, Tulsa, OK, p 459

Steineke M, Bramkamp RA (1952) Mesozoic rocks of Eastern Saudi Arabia (Abs.). AAPG 36(5):309

Wayne MAHR (2008) Geology of carbonate reservoirs: the identification, description, and characterization of hydrocarbon reservoirs in carbonate rocks. Wiley, Hoboken, p 277

Wilson JL (1975) Carbonate facies in geologic history. Springer, New York, 471 p

Wray JL (1977) Calcareous algae: development in paleontology and stratigraphy 4. Elsevier, New York, 185 p