ISSN: 0067-2904

Microfacies Architecture and Stratigraphic Development of the Yamama Formation, Southern Iraq

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Abstract

The Yamama Formation belongs to the late Berriasian-Aptian succession, which was deposited during the Lower Cretaceous period within the main shallow marine depositional environment.

Petrographic study and microfacies analysis enabled the recognition of six main microfacies for three association facies. These are the Semi-restricted, Shallow open marine and Shoal environments. The study succession represents deposition of three third order cycles, these cycles where deposited during successive episodes of relative sea level rises and still stand.

The presence of shoal association facies (oolitic packstone microfaces) between the Sulaiy and Yamama formations refer to continue the deposition during the same stage, and may suggest the end of Sulaiy Formation was maximum flooding surface (mfs). The first stage started with occurrence of the shallow open marine association facies underlain by semi-restricted association and then shoal association facies.

There are three cycles of this sequence consistently in the south of the study area, so that it continues to the lower part of the Ratawi Formation to be the upper contact of the Yamama Formation of a conformable and continuous in sedimentation

To the north of the study area (near of Rf-1 and Hf-5 wells) the shoal association was only shown once at the bottom of the Yamama Formation and these cycles to became unclear. This suggest that the paleo-high was developed to the south of studied area, while the open sea was characterized the northern part.

Keywords:- Microfacies Architecture, Stratigraphic Development, Yamama Formation, Sothern Iraq.

البنية السحنية و التطور الطباقي لتكوين اليمامة في جنوب العراق

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الخلاصة

ينتمي تكوين اليمامة إلى تتابع البرياسي – الابتي المتأخر. حيث ترسب خلال فترة العصر الطباشيري السفلي ضمن البيئة الترسيبية البحرية الضحلة الرئيسية. مكنت الدراسة الصخرية وتحليل السحنات الدقيقة من التعرف على ستة سحنات رئيسية لثلاث مترافقات سحنية. وهي البيئات البحرية شبه المقيد ، الضحلة ، والصحلة. تمثل خلافة الدراسة ترسب ثلاث دورات النظام الثالث ، وهذه الدورات التي ترسبت خلال دورات متتالية من ارتفاع و سكون مستوى سطح البحر النسبي. يشير وجود مترافقة الحاجز الضحل (سحنة الواكي السرئي) بين تكوين السلي واليمامة إلى الترسيب خلال نفس المرحلة ، و يعتقد بأن نهاية تكوين السلي هو

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السطح الأقصى لمستوى سطح البحر(mfs). ان المرحلة الأولى تبدأ مع ظهور مترافقة البحر الضحلة المفتوحة تحت مترافقة البحر شبه المحجوز ومن ثم مترافقة الحاجز البحري الضحل.

يتكرر هذا التتابع ثلاث مرات بشكل متناسق في جنوب منطقة الدراسة ، بحيث يستمر في الجزء السفلي من تكوين الرطاوي ليكون أعلى تكوين اليمامة متوافق ومستمرة في الترسيب.

إلى الشمال من منطقة الدراسة وبالقرب من حقل الرفاعي و الحلفاية النفطيين لم تظهر مترافقة الحاجز البحري الضحل إلا مرة واحدة في أسفل تكوين اليمامة وأصبحت الدورات اعلاه غير واضحة. هذا قد يشير إلى أن تطور مرتفع قديم إلى جنوب المنطقة المدروسة ، في حين كان الجزء الشمالي متميز ببحر المفتوح.

Introduction

The Yamama Formation is a part of the late Berriasian-Aptian succession, which was deposited during the Lower Cretaceous period within the main retrogressive depositional cycle (Berriasian - Aptian) south of Iraq. This sequence is represented from shore to deep basin by the Shuiaba, Zubair, Ratawi, Yamama, and Sulaiy formations [1].

The basin of the Yamama Formation was located over two tectonic regimes, the north eastern part of the stable Arabian platform and the Mesopotamian Zone. This situation and the probable syntectonic deposition of the formation over growing structures created complex carbonate lithologies. From this tectonic setting and the facies distribution, it seems that the Yamama Formation was deposited within a range environment from inner to an outer ramp [2].

Five Oil fields represented by Rachi-2, Rifaei-1, Ratawi-3, Halfaia-5, and Luhais-12 are included in this study. They are located in the southern part of Iraq. This basin is covered by loess and fluvial plain sediments of Quaternary deposits within the Mesopotamian Zone (Buday ,1980).

The study area is located in the southern part of Iraq within the Mesopotamian Zone between (30º 58′-32º 08′ latitude) and (46º 52′ -47º 56′ longitude). At the present day, the basin forms a flat- lying area located between northern central Iraq and Kuwait. Anticline and horst lie beneath undeformable or gently deformed Neogene cover and frequently related to long- lived paleo-structure in the Basrah area.

The aim of this study are microfacies and well log facies analysis of the studied succession to determinate the depositional environment and establishing the sequence stratigraphic framework.

Methodology

The present study was completed by two major stages:

1. Field observation and sampling stage:

This stage is represented by going to the Luhais and Rachi oil fields where the core and cutting samples of the studied sections were collected and sampled of the core and cutting samples of the core and cutting samples of Table 1.

2. Laboratory and office works

- Make thin sections in the petrology lab of Geology Department/College of Science/ University of Baghdad; for microfacies study.
- Digitizing well logs using Digger software
- Study of available well logs and relate the log response to facies changes for the studied succession intervals.

Table 1-The depth intervals of Yamama Formation and location of studied wells

Field Name	Well No.	Formation	Easting	Northing	Top	Bottom	Thickness (m)
Rachi	Rc-1	**Yammama**	696279.5	3346441.5	3855	3950.9	95.9
Rifaei	Rf-1	**Yammama**	699800	3498000	4230	4430	200
Ratawi	Rt-3	**Yammama**	700000	3386000	3664.3	3803	138.7
Halfaia	Hf-5	**Yammama**	731000	3506000	4558	4610	52
Luhais	Lu-12	**Yammama**	672900.0	3356650.0	3608.8	3770.2	161.4

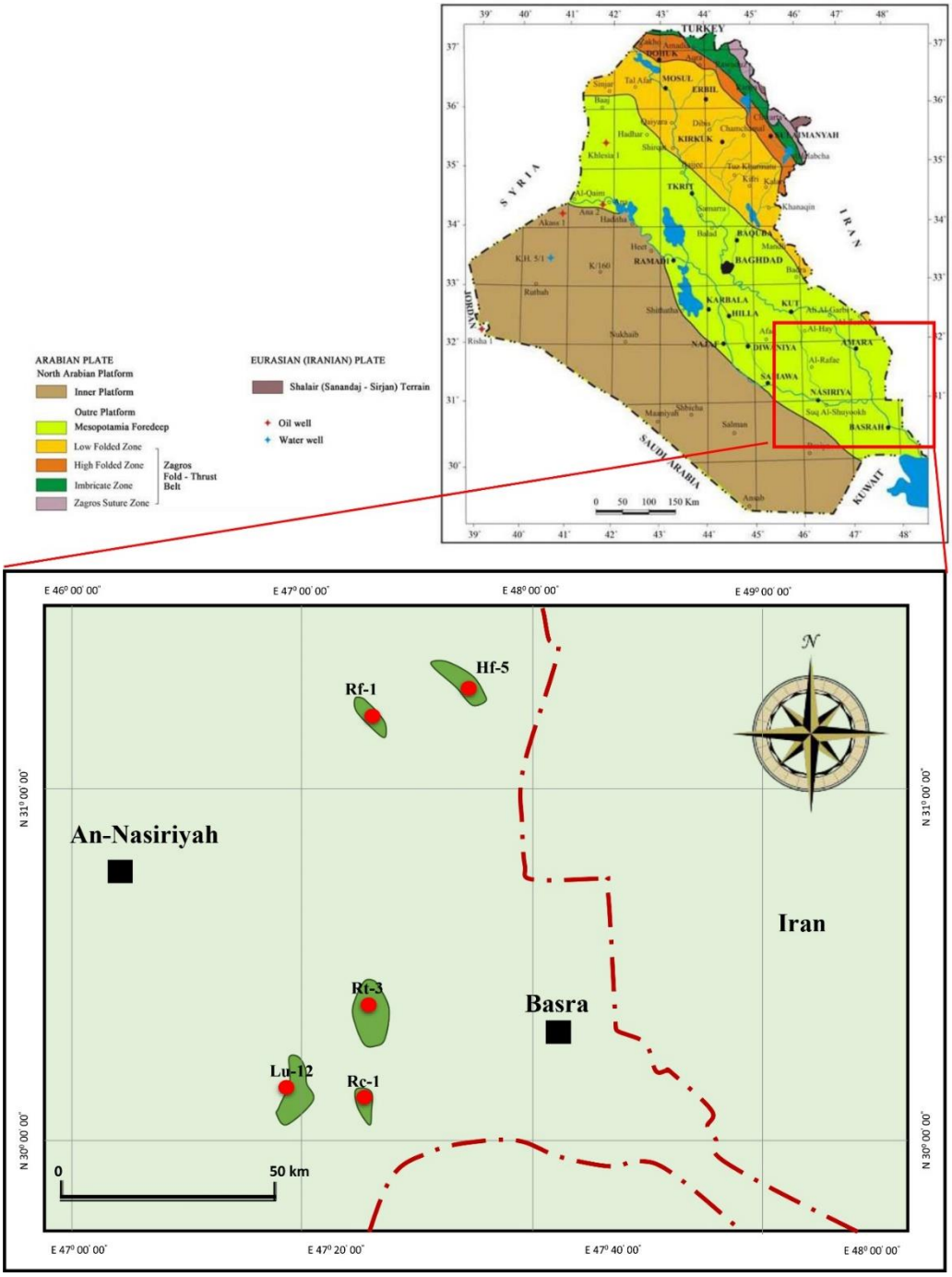


Figure 1-Location of study area with tectonic subdivisions by Fouad [3]

Stratigraphy and tectonic settings

During the Late Tithonian-Valanginian period the Southern Neo-Tethys opened with the separation of the Bisitoun (Avroman) microplate from Arabia. The Upper Berriasian to Lower Valanginian palaeogeography (Yamama Formation) is summarized in Figure-1. The intra-shelf basin comprised inner and outer shelf (basinal) areas [4].

The Mesopotamian Zone witnessed repeated open marine incursions leading to deposition of alternating shallow water carbonates and outer shelf marls. Sedimentation began with deposition of the transgressive Sulaiy and Yamama formations and ended with deposition of the Ratawi Formation during a highstand [5]. The Yamama Formation in the southern Iraq comprises of argillaceous

limestones and oolitic, pelloidal, pelletal and pseudo-oolitic shoal limestones which deposited in the outer shelf environment (Figure-2).

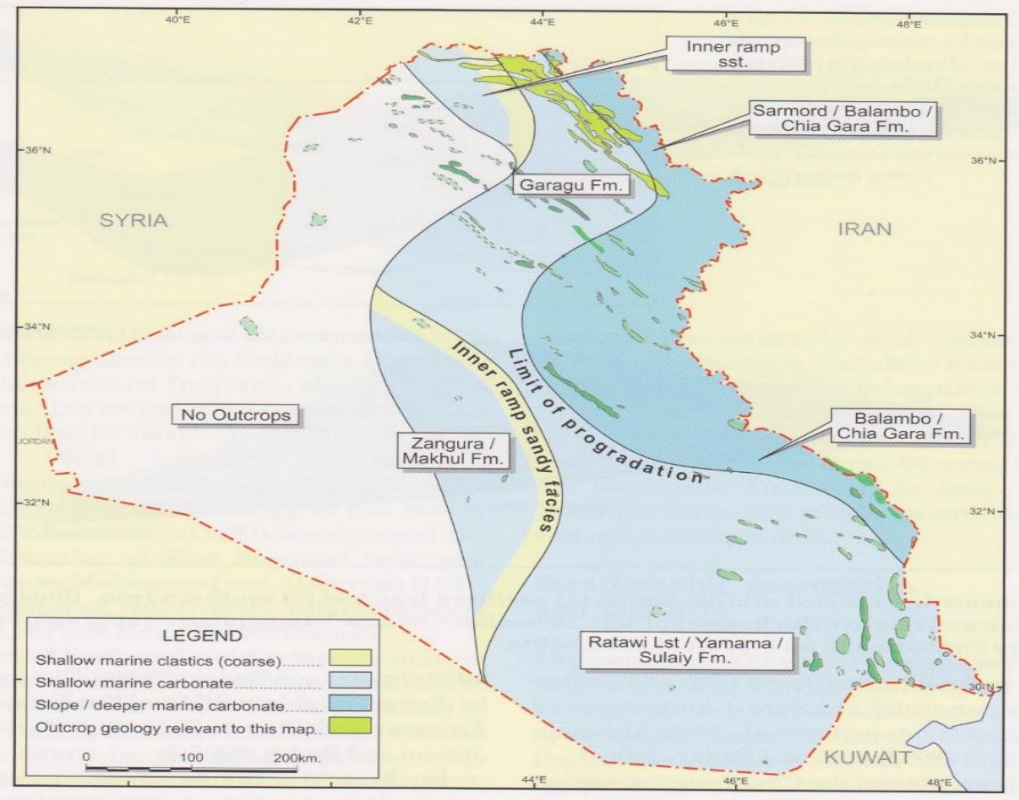


Figure 2-Late Tithonian – Middle Valanginian paleogeography of Iraq [6]

Yamama Formation is more or less continuous pellety limestone sequence which underlies the shaly Ratawi formation in the Ratawi well of southern Iraq. Loose ooliths abundant at the base. Pseudocyclammina aff. lituus and large *Trocholina* spp. throughout. *Spirocyclina* sp. at the base. The age of the formation is from basal Valanginian or Berriasian units [7]. From its stratigraphic position an age range of Upper Berriasian to Lower Valanginian age is likely (140 to 136 Ma.). In Kuwait the Yamama Formation is assigned a Berriasian age [5]. The Yamama Formation was deposited in alternating of oolitic shoal and deep inner shelf environments, probably controlled by paleo structural highs within a carbonate ramp [8]. The Minagish Formation in Kuwait is the equivalent of the Yammama Formation [5]; was deposited as a transgressive unit within the inner shelf environment.

Microfacies Analyasis

Seven major microfacies are recognized in the studied succession which represented by Yammama Formation depending on Dunham classification [8] of Carbonate rock which deals with depositional texture that used to determine their characteristic grain types and depositional texture enabled the recognition of paleoenvironment.

Microfacies (A):- Foramineferal- peloidal wackestone to packstone

This facies is mainly composed of forams mainly Textularia and miliolids in addition to shell fragments (mollusk) and calcareous algae in RF-1 (Plt.1A). Such microfacies reflect a shallow open marine condition.

Microfacies (B):- Peloidal bioclastic packstone

The second most common microfacies is the peloidal - bearing limestone. With few shell fragments (mollusk), echinoderm and algae (Plt.1B). This may reflect a semi-restricted shallow marine.

Microfacies (C):- Bioclastic wackestone-packstone.

This facies is mainly composed of bioclast of mollusk and echinoderm. Such microfacies reflect shallow open marine. Associated facies include bioclastic mudstone. The mainly facies compose of bioclastic of mollusk and echinoderm (Plt.1C).

Microfacies (D):- Orbitiolina wackestone.

This microfacies is compose of mainly orbitiolina with micrite mass ground (Plt.1D), which indicate open marine condition.

Microfacies (E):- Foraminefera Bioclastis wackestone-packstone.

The microfacies is composed of foraminifera and bioclasts such as miliolid and orbitiolina in addition to echinoderm and algae (Plt.1E).

Microfacies (F):- Oolitic bioclastic packestone-grainstone.

This include:

1.Oolitic peloidal wackestone-packestone**.**

This microfacies mainly composes of ooids and bioclasts (mollusk, pelecypods) with peloidal and few benthic foraminifera represented by orbitiolina. The presence of ooids with peloids indicated shoal environment (Plt.1F).

2. Oolitic grainstone

Oolite grainstone is defined as a grain-supported carbonate rock that contains less than 1% mud-grade material. This definition has recently been clarified as a carbonate-dominated rock that does not contain any carbonate mud and where less than 10% [8].

Paleoenvironments

Three major association facies can be recognized within the Yamama Formation according to [9-11]; these are shallow open marine association , semirestricted shallow marine association and shoal association facies Figures-(3, 4, 5, 6, and 7).

Semirestricted environment

The semirestricted environment is represented by *Orbitolina* wackestone to packstone microfacies and Milliolids wackestone microfacies. The microfacies with *Orbitolina* as main components with few small benthic foraminifera may refer to the semirestricted environment (deep part for this environment), but the microfacies with the Milliolids as the major component may refer to more shallow environment [11].

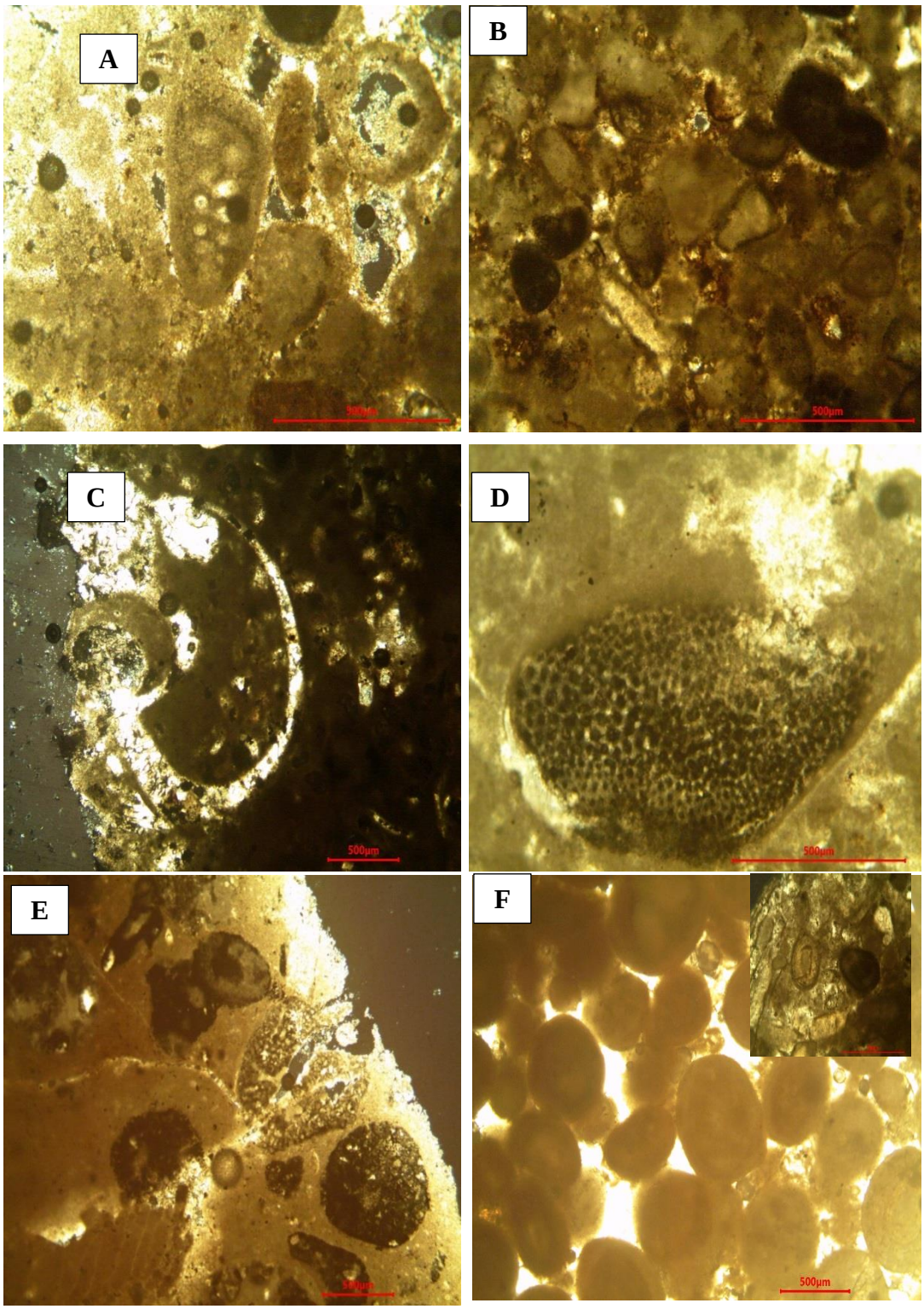
Shallow open marine environment

The *Orbitolina* - Milliolids wackestone to packstone is the main microfacies which reflect open marine conditions [9, 12]. It is characterized by high diversity of components where orbitolina and milliolids as the major components in addition to Echinoderms, gastropod fragments, small benthic foraminifera and Lithothamnium algae.

Shoal environments

Two major microfacies characterized the shoal environment [12], they include; the peloidal grainstone characterized by fine, well sorted peloids and ooidal to peloidal grainstone which consist mainly of ooids and peloids with some bioclasts and benthonic foraminifera.

Plate.1



A. Foramineferal- pelodial wackestone (Rf-1 4250-60m)
B. Peloidal bioclastic packstone (Rf-1 4241-35m)
C. Bioclastic wackestone-packstone (Rt-3 3790-25m)
D. Orbitiolina wackestone (Lu-12 3657-40m)
E. Foraminefera Bioclastic wackestone (Lu-12 3621m)
F. Oolitic packstone - grainstone (Rt-3 3690m)

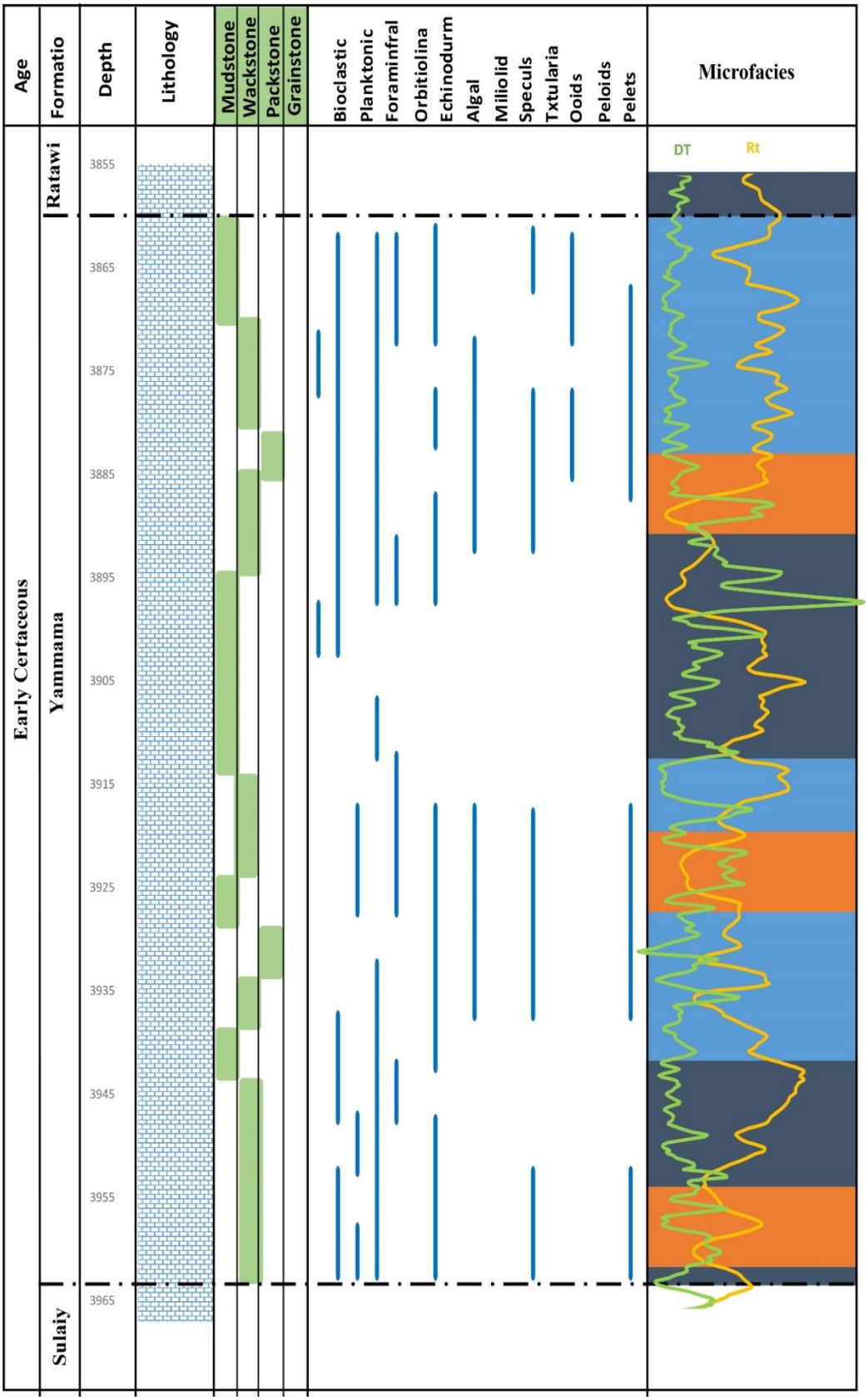


Figure 3-Stratigraphic columnar section shows microfacies and facies associations of well Rc-1.

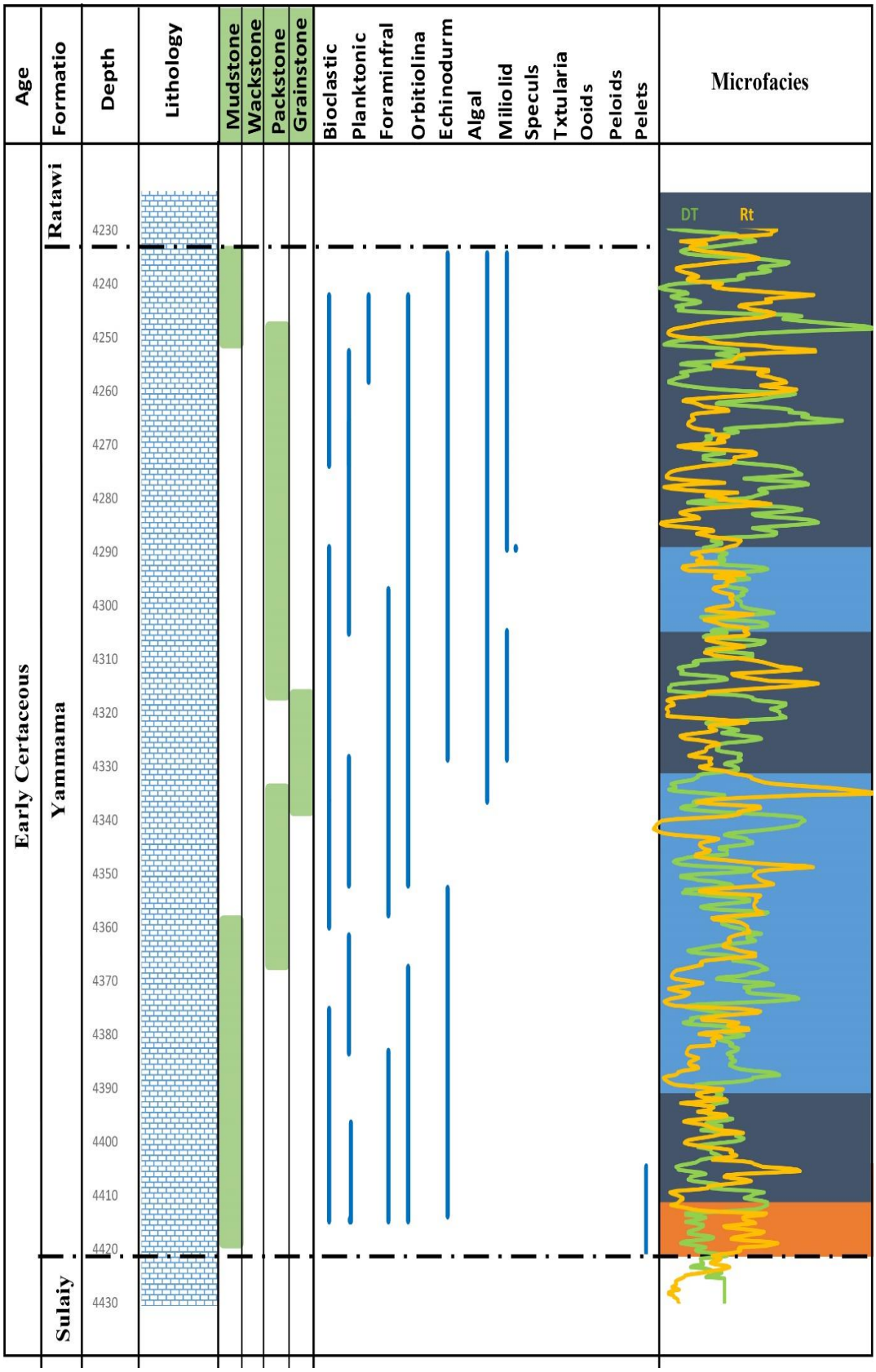


Figure 4-Stratigraphic columnar section shows microfacies and facies associations of well Rc-1.

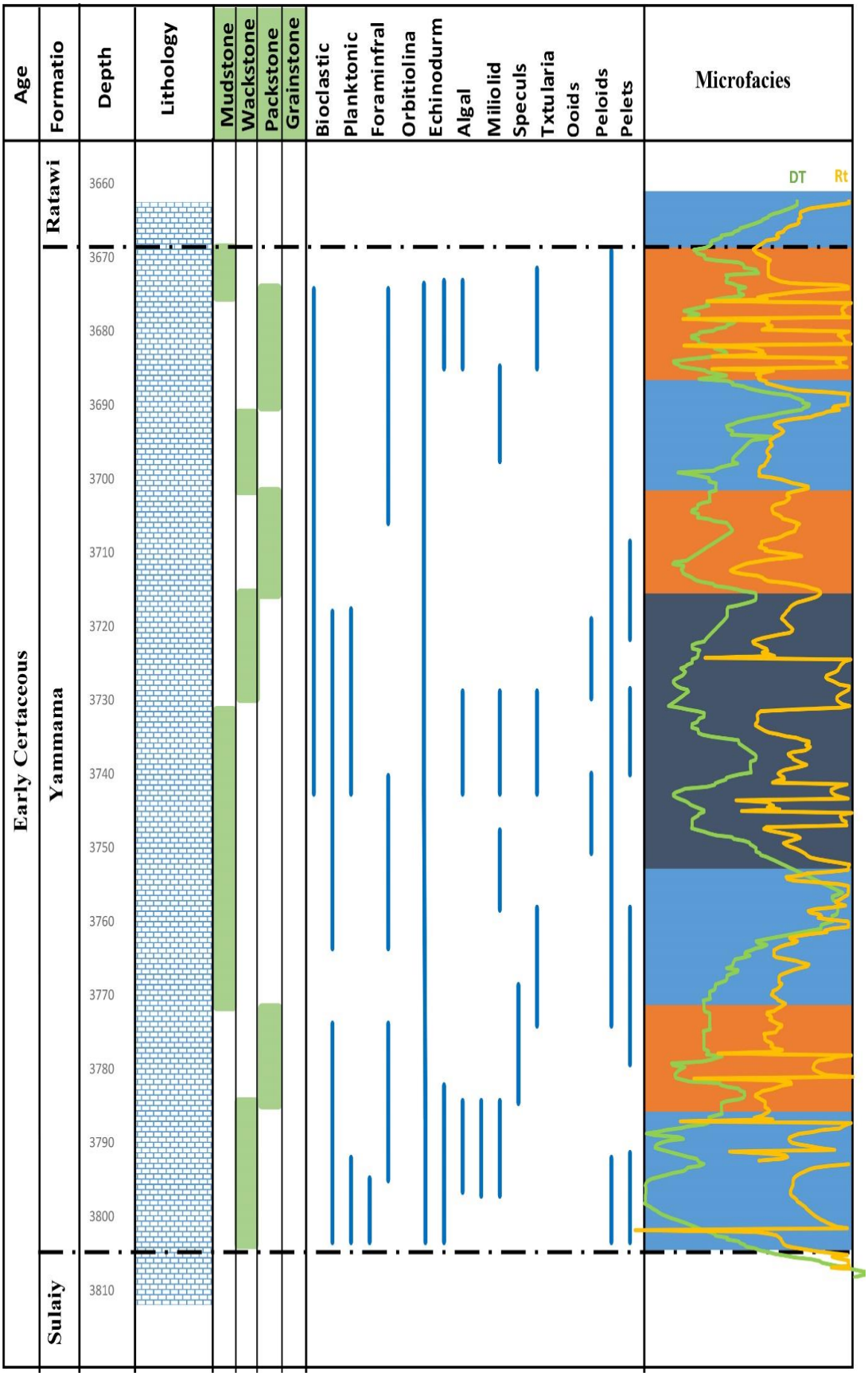


Figure 5-Stratigraphic columnar section shows microfacies and facies associations of well Rt-3.

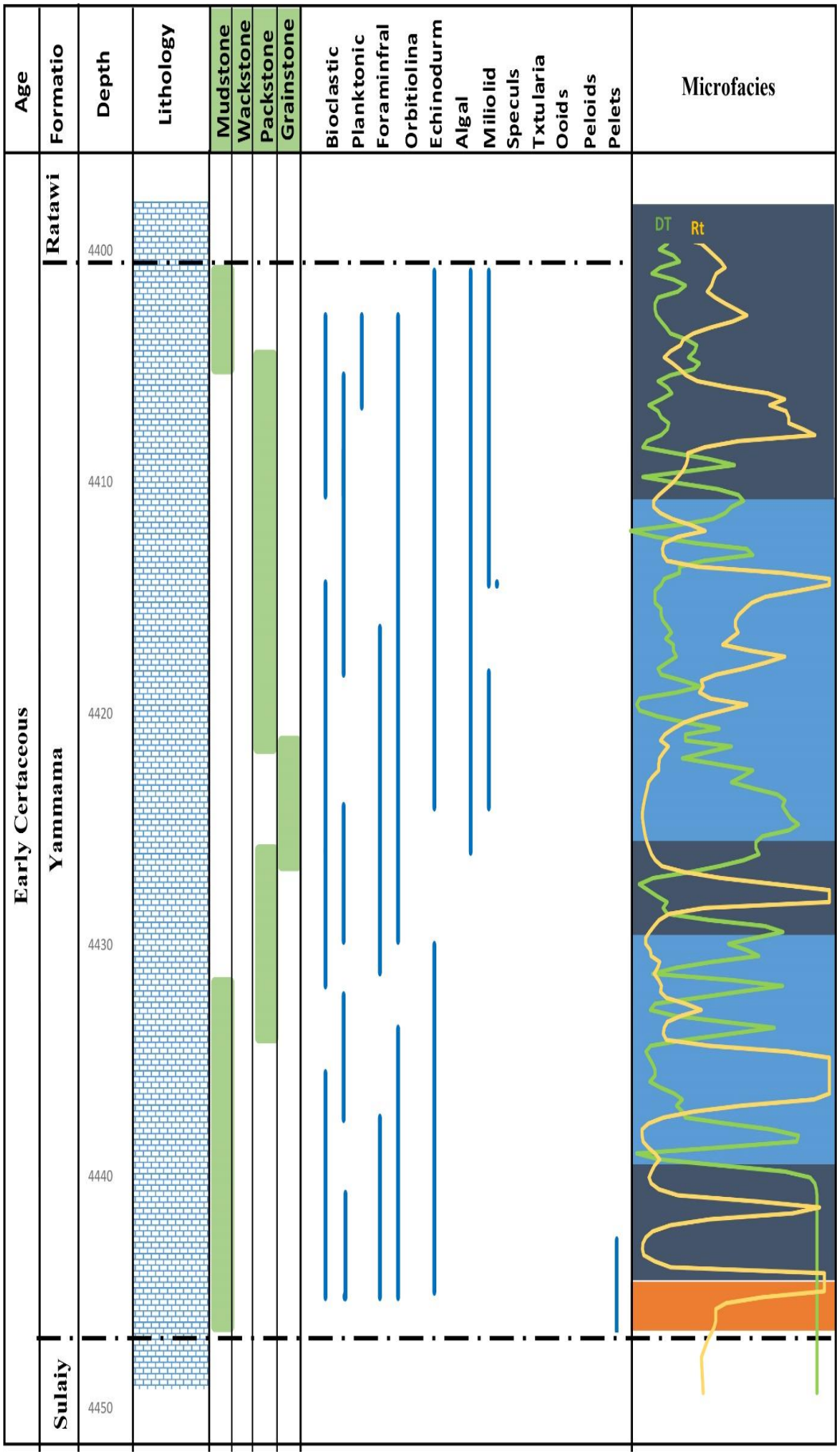


Figure 6-Stratigraphic columnar section shows microfacies and facies associations of well Rf-1.

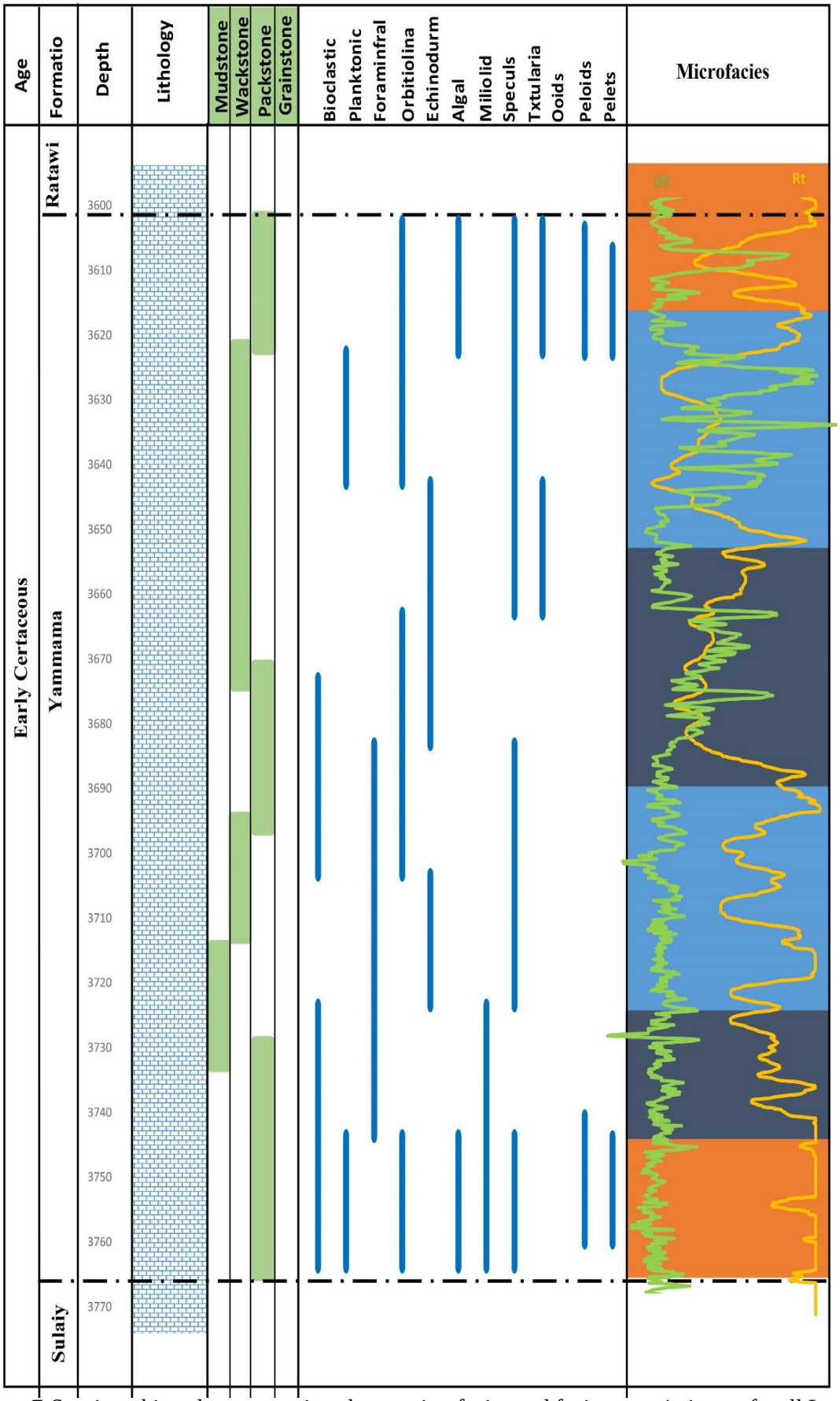


Figure 7-Stratigraphic columnar section shows microfacies and facies associations of well Lu-12.

Stratigraphic development

Sequence stratigraphy is the study of the sedimentary rocks relationships within a chronostratigraphic framework of repetitive genetically related strata bounded by the unconformity surface, or their correlative conformities [13, 14]. The stratigraphic signatures and strata patterns in the sedimentary rock record are the result of the interaction of tectonics, eustasy, and climate parameters. [15].

In order to study the development of this cycle in the southeastern Iraq in more details, the Mesopotamian foredeep has experienced active syntectonic sedimentation leading to the formation of giant structures that were apparently simultaneously growing during deposition of the Yamama Formation. These structures probably were induced by diapiric warping caused by the Infracambrian Hormuz Salt Series which is believed to underline parts of southern Iraq [1]. The formation extends (Figure-8) and facies association (Figure-9) show the basin is characterized by one main depocenter to the east of the studied area. This cycle was divided into four stages of highstand system tracts, the first and the last were interplay with the older formations (Sulaiy) and younger (Ratawi).

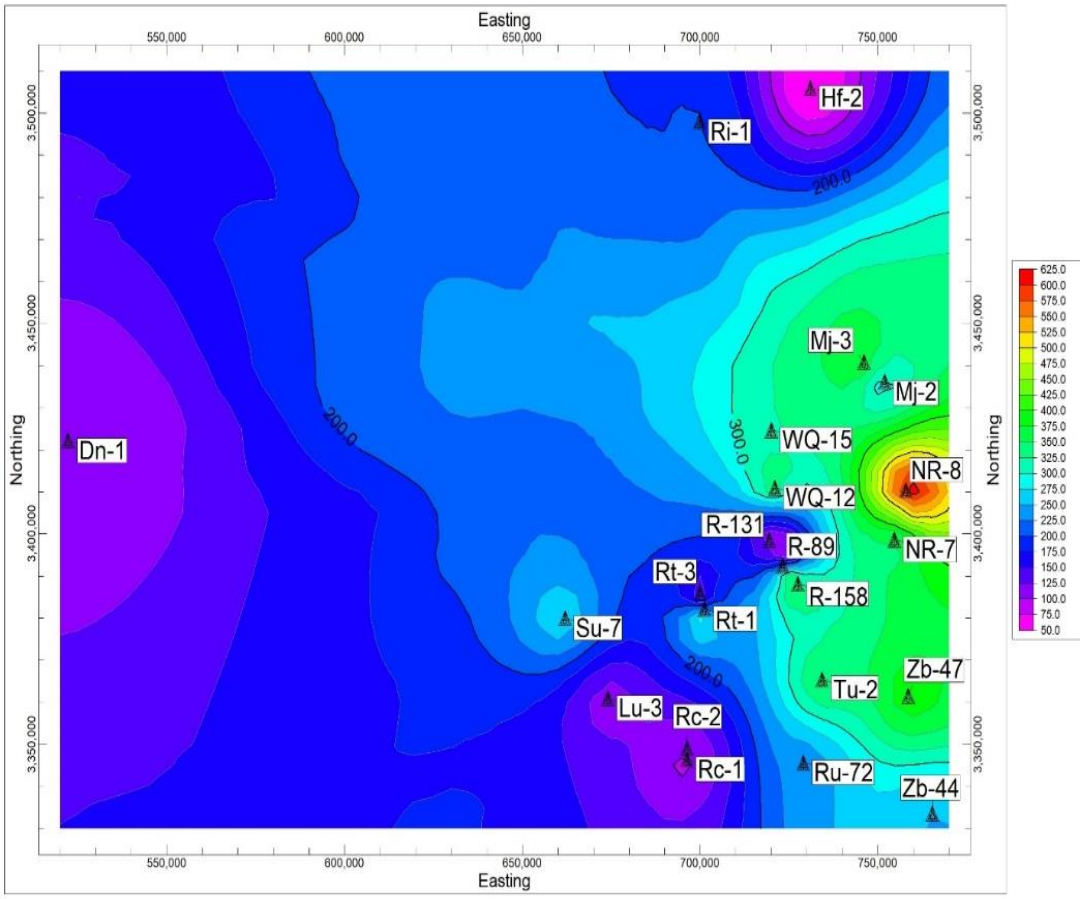


Figure 8-Isopach map shows the main depocenter of Yamama Formation.

This sequence is repeated three times consistently in the south of the study area, so that it continues to the lower part of the Ratawi Formation to be the upper contact of the Yamama Formation of a conformable and continuous in sedimentation

To the north of the study area (near of Rf-1 and Hf-5 wells) the shoal association was only shown once at the bottom of the Yamama Formation and these cycles to became unclear. This suggest that the paleo-high was developed to the south of studied area, while the open sea was characterized the northern part.

The tectonic setting contributed to the emergence of the passive margin in the east and northeast Arabian plate, and made it facing the Neo-Tethys [16]. The Yamama Formation is conformably underlain by the Sulaiy Formation except in some parts of the Salman Zone where it is unconformably overlain by the Zubair Formation [17].

The presence of shoal association facies (oolotic packstone microfaces) between the Sulaiy and Yamama formations refers to continuous deposition during the same stage, and may suggest the end of Sulaiy Formation was represented by maximum flooding surface (mfs). This first stage stated with the shallow open marine association facies underlain by semi-restricted association and then shoal facies association.

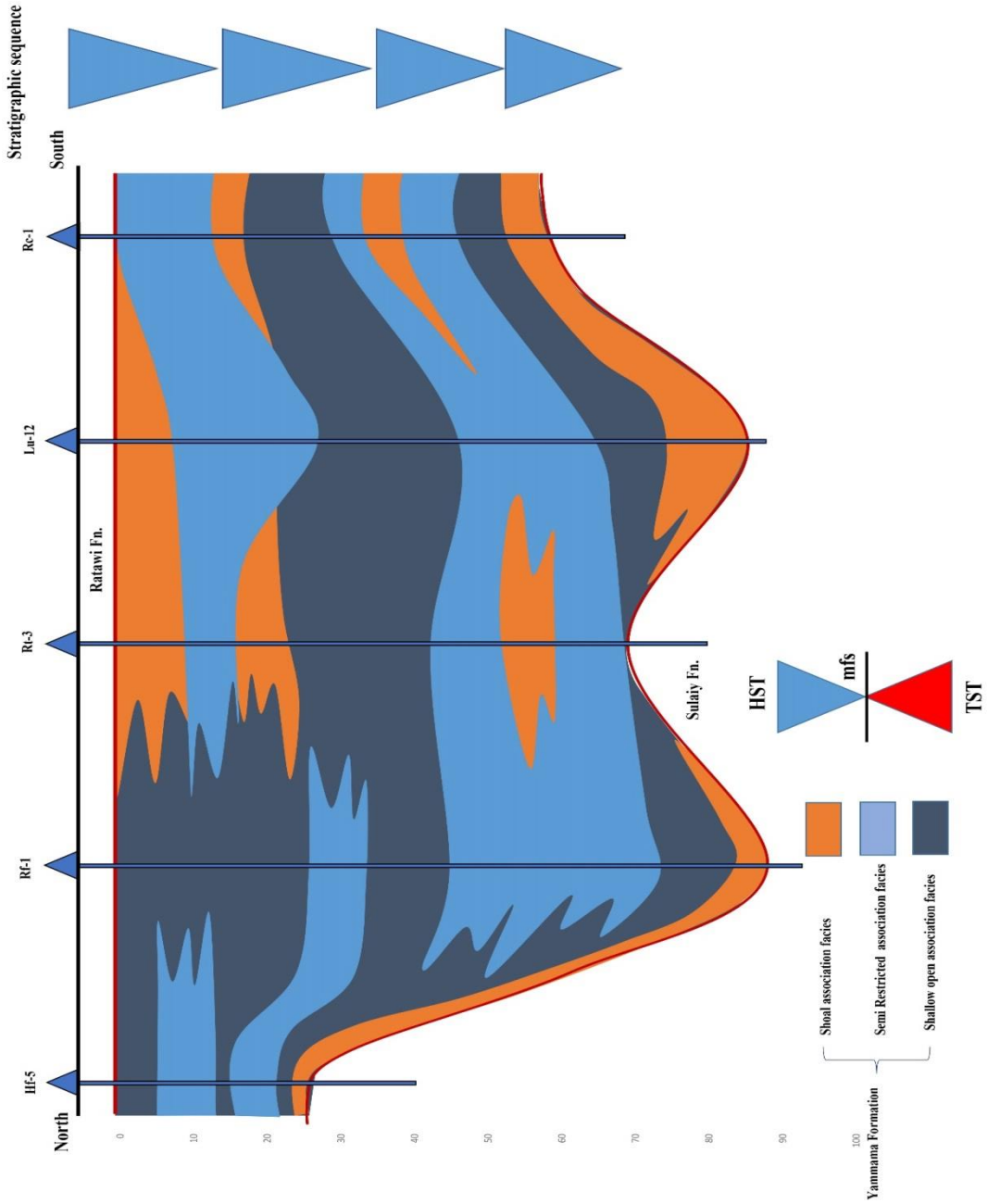


Figure 9-Stratigraphic cross section shows facies associations distribution of studied oil fields**.**

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