IASJ المجلات الاكاديمية العراقية

Tikrit Journal of Pure Science

ISSN: 1813 – 1662 (Print) --- E-ISSN: 2415 – 1726 (Online)

Journal Homepage: http://tjps.tu.edu.iq/index.php/j

Microfacies and Palaeoenvironment of Avanah Formation (Middle Eocene) Geli Bessri in Dohuk City / North of Iraq

Mustafa A. Abdullah , Faris N. Hassan , Abdulsalam. M.Saleh

Department of Applied Geology, College of Science, University of Tikrit, Tikrit, Iraq

https://doi.org/10.25130/tjps.v25i1.217

ARTICLE INFO.

Article history:

-Received: 12 / 9 / 2019

-Accepted: 29 / 11 / 2019

-Available online: / / 2019

Keywords: Avanah, Formation, Palaeoenvironment, Microfacies.

Corresponding Author:

Name: Mustafa A. Abdullah

E-mail:

mustafaalmajmiei999@gmail.com

Tel:

ABSTRACT

This research is based on (23) Samples selected from the Avanah Formation (Middle Eocene) in the Geli Bessri section in Dohuk to recognize the microfacies and depositional environments. The Avanah Formation consists of rocks of marly limestone and limestone containing *Alveolina* and thin layers of sandstone lithofacies found in the lower part of the Formation. The depositional environment was determined depending on skeletal and non- skeletal grains. The facies of the Avanah Formation were divided into four main microfacies and four submicrofacies based on skeletal and non- skeletal grains: The mudstone and wackestone, which is divided into benthic foraminifera wackestone and Rotaliids wackestone, the Formation also contains the packstone which is divided into the Rotaliid - Miliolid Lime packstone submicrofacies and benthic foraminifera lim packstone submicrofacies, in addition to the lime grainstone and also contains the Sandstone lithofacies located at the bottom of the Formation. The Avanah Formation in the middle and upper part is subjected to diagenesis process early dolomization and it is observed this through floating dolomite rohmb. According to the results of the facies analysis and the presence of foraminifera fossils, the Formation was deposited in open marine platform to restricted platform interior.

1- Preface

During the petrographic study it was found that skeletal components were represented as benthic foraminifera *Rotaliid-Miliolid and Textulariid* in addition to the large foraminifera represented by *Alveolina* and *Nummulite*s, Gastropoda, Ostracoda and bioclasts, were all of these skeketal components were diagnosed located in a matrix of micrite and microspar. As for the non-skeleta components, that represented by ooids and peloids and these are found in micrite and microspar matrix. The diagenetic processes that effected the formation rocks are represented by cement, porosity of all kinds neomorphism , micritization and dolomitization. The study of the palaeoenvironment depends on the interpretation of sedimentary rocks in terms of sedimentation and transport processes and then determine the environment and the location of sedimentation. The study of the palaeoenvironment includes facies analysis and facies associations that reflect the palaeoenvironment [1].

2- Introduction

The study of the Avanah Formation is one of the most important studies that dealt with the study of rock facies and the development of the depostional environment. The section was measured in detail at N: 32^{o} $73^{/}$ $43^{//}$ and E: 40^{o} $810^{/}$ $78^{//}$figure (1). The Formation was first described by [2] in Kirkuk well 116 [3], which is located on the dome of Avanah in the anticline fold in the Kirkuk within the foothill zone. The thickness of Avanah Formation in the type section is (210m), which consists of dolomatic limestone from shoal facies with layers of lagoonal limestone, and the Formation contains foraminifera fossils such as *Nummulites, Alveolina*, and *Discocyclina* [4].

The Avanah Formation was deposited in shallow marine platform (inner-outer shelf zone) during the Eocene [3].In the present study, the thickness of the Formation was determined (50m) were consists of

sequences of marley limestone, marl, limestone and a thin layer of sandy limestone. The *Alveolina* fossils were fieldly diagnosed within the limestone layers. The larger benthic foraminifers have proven to be excellent palaeoecological indicators [5]. From the tectonic point of view, the study area is located within the high folded zone in the anticline fold of Bekhair at southwestern flank, the Bekhair anticline is classified as asymmetrical fold, where the slope of the southern flank is from (52-50^{o}), while the slope of the northern flank is from (50-40^{o}). The length of this fold up to (80km), and the width in the city of Dohuk is (8km) and is northwest-southeast direction, and the Bekhair anticline is divided into an eastern fold called the anticline Spi Res and the western fold called the anticline Gara Barran[6]. The purpose of this study is to interpret the depositional environment of the formation based on microfacies and draw the depositional model of this formation.

3- Methodology

The presented results depend on (23) thin sections from samples selected in the Geli Bessri section of the Avanah Formation. Thin section was stained using the method of Friedman to differentiate calcite from dolomite [8].The petrographic study for carbonates is based on classification[9], [10,11] standard microfacies (SMF) were also used. Microfacies studies involve the examination of grains , matrix, fossil content, petrographic, energy index, and standard microfacies zone.

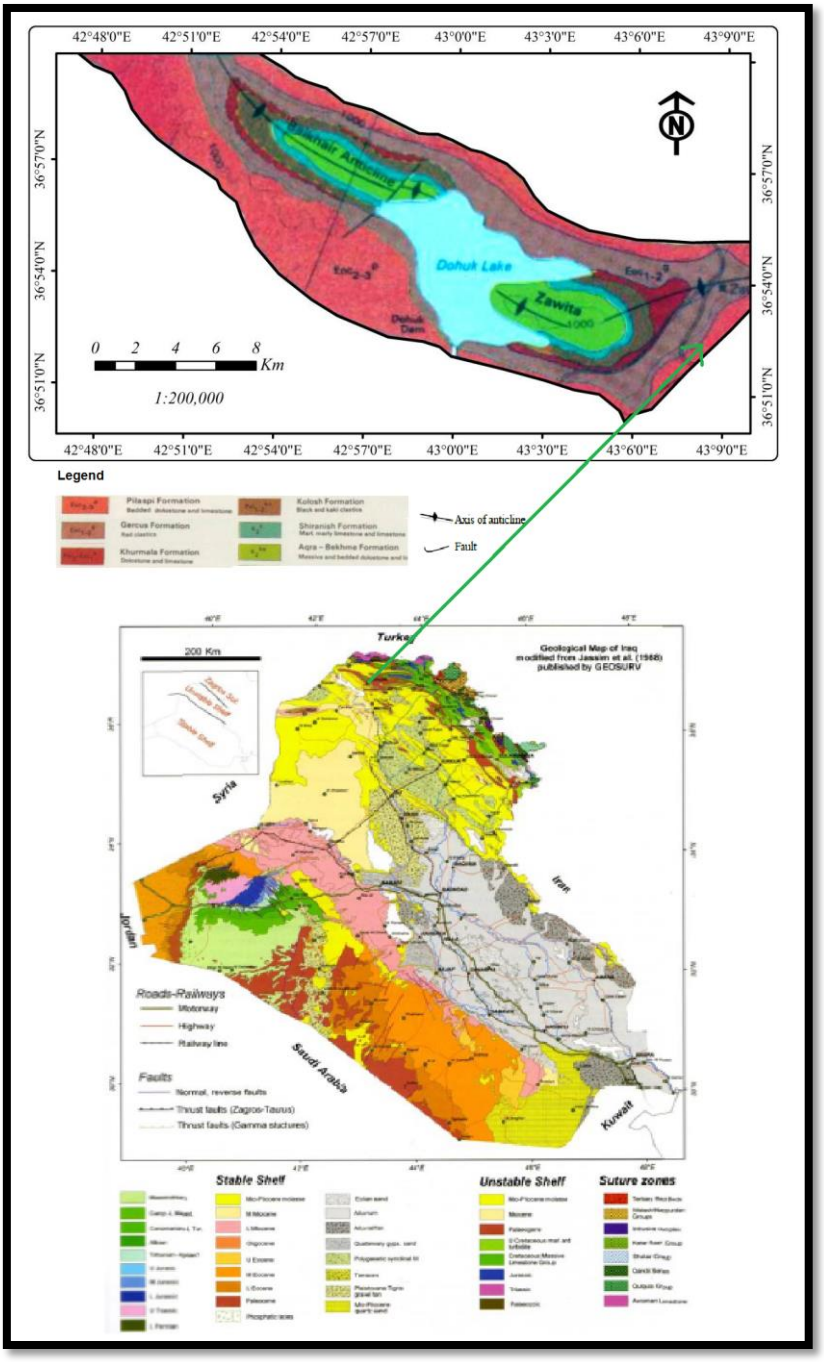

Fig. 1: Geological map of Iraq[7].

4- Microfacies of Avanah Formation

Detailed examination of Avanah Formation thin sections is carried out through the bases classification [9] and using the standard microfacies (SMF), a range of environments are designated for each rock based on its depositional texture and its fossil content. Based on skeletal and non-skeletal components, the facies of the Avanah Formation were divided into four main microfacies and four submicrofacies as in the figure (2).

4-1 Lime Mudstone Microfacies (LMA)

The percentage of skeletal and non-skeletal grains in this facies is less than (10%). This facies is divided into two classes based on their matrix, where the first type represents a non- fossil facies, and it consists of a microspar matrix as a result of recrystallization of the mudstone (plate1-a) which indicates the diagenetic process called neomorphism, and the facies are located in the lower part of the Avanah Formation with a thickness of (10 m).This facies it repeated in the middle part of the Formation with a thickness of (1.5 m). Most of the quartz grains appear to be monocrystalline, and there is little polycrystalline quartz (plate1-b), the quartz grains in formation are derived from source rocks. The majority of quartz grains are derived from plutonic granite rocks, schists and acid genisses [12]. The second type represents a matrix of the micrites, with a thickness of (3 m) containing large and small quartz granules, round and rhombic forms and chert granules plate (plate1-c), and this facies is found in the lower part of the formation and this facies is repeated in the middle part of the composition with a thickness of (0.5 m) and also consists of a matrix of micrite and have a low percentage of *Rotalia* (plate1-d), determine the presence of dolomite rhombs scattered due to partial dolomitization of micrite (plate1-e).The presence of such dolomite rhombs indicates the early stages of the heterogeneous dolomitization process. This type of fabrics is called floating - rhomb texture [13].The presence of unbroken fossils and micritic matrix indicates this microfacies deposited in a low-energy environment. This facies is equivalent to the standard microfacies (SMF: 23) which deposited within the Facies Zone (FZ 8) and which show the tidal environment (Restricted platform interior) [10,11].

4-2 Sandstone lithofacies (SMA)

This facies is located in the lower part of the formation where the thickness (0.5 m), which contains quartz grains (plate1-f), and chert and a high proportion of lithicfragments compared to quartz grains and chert. The pyrite mineral of the authigenic mineral originating high in this facies. The current study is tries to deposition this facies within the tidal flats closest to the coast. The grains are subrounded to rounded, and this indicates to a high energy environment.

4-3 Lime Wackestone Microfacies (LWM)

The percentage of skeletal components in this facies is (10 - 40%) depending on the classification [9].This facies is divided into two submicrofacies .

4-3-1 Benthic Foraminifera Lime Wackestone Submicrofacies(BWA1)

This facies is located at the bottom of the formation with a thickness of (4 m).The benthic fossils represent the skeletal grains represented by the (*Nummulites*) (plate1-g), (*Textularia*) (plate1-h), and (Gastropoda) (plate1-i).Determine the floating - rhomb texture (plate1-j), which is in the form of dolomite rhombs on the surface of this facies [13].This fabric refers to the heterogeneous dolomization processes in their early stages.

The same facies are repeated in the middle part of the formation, it is composed of a micriter and skeletal grains is exceed (20%) represented *Textularia* (plate1-k), as well as the presence of the shells of the *Rotalia* (plate1-l), and pieces of Echiniderms plate (2-a), in addition to the presence of faecal pellet (plate2-b).The presence of a mud matrix indicates this microfacies deposited in a low to moderate energy environment. The general characteristics of these facies are identical to the standar microfacies (SMF: 18) located within the facies zone (FZ 7) which represents the open sea environment of the marine interior platform [10,11].

4-3-2 Rotalide Lime Wackestone Submicrofacies (RWA2)

This facies is located in the upper part of the formation and a thickness (0.5 m), where skeletal grains comprise (30%) of the existing facies which in turn consists of a micrite. The existence of *Rotalia* indicate a depositional environment about (20m) depth. The *Rotalia* fossils are the main component of the skeletal grains reaching (80%) compared to other fossils (plate2-c), and this facies contains a large benthic fossil *Alveolina* exposed to physical compaction (plate2-d), as well as contains Coral (plate2-e). The process of dolomite is diagnosed by dolomite rhombs scattered in micrite (plate2-f), which leads to the formation of floating rhomb texture [13]. The presence of a mud matrix indicates this microfacies deposited in a low to moderate energy environment. Compared to standard microfacies, this facies conform to the standar microfacies (SMF: 18) that are deposited in the (FZ 8) deposited in restricted platform interior in the shelf zone, which reflects the calm and warm watershore lagoon with high salinity relatively [10,11].

4-4 Lime Packstone Microfacies (LPM)

The percentage of skeletal components in this facies is (60-40%). It was divided into two submicrofacies based on the abundance of fossils.

4-4-1 Rotaliid-Miliolid Lime Packstone Submicrofacies (RPA1)

This facies is located at the top of the formation and thickness (0.5 m). The *Rotalia* fossils are made make up the largest proportion of other fossils such as

Alveolina, Osrtacoda and pelecypoda (plate2-g), and *Rotalia* fossils are characterized by a variety of sizes (plate2- h). This facies is repeated with a thickness (1 m) in the upper part of the Avanah Formation, and this facies is characterized by an abundance of miliolid (up to 60%) with micrite matrix and high presence of faecal pellets (plate2-i).The genera of the Milliolide family diagnosed in this facies are the genus *Quinqueloculina* (plate2-j),and the genus *Triloculina* (plate2-k), in addition to *Alveolina* (plate2-l), as well as were identified ostracoda plate (3-a), *Rotalia* plate(3-b), pieces of large and small Echinoderms plate (3-c), (3-d), *Discorbis* (plate3-e). The bioclast due to the shells of the mollusks (plate3-f), and Red alge (plate3-g). Fossils assemblages are highly complex in these facies , in addition, to the mud matrix .The feature of these facies indicates moderate energy environment. This facies is similar to the standard microfacies (SMF: 18) found in the facies zone (FZ 7) known as the open marine platform interior [10,11].

4-4-2 Benthic Foraminifera Lime Packstone Submicrofacies (BPA2)

This facies is located at the top of the formation composition with a thickness of (1.5 m) and this facies have a high percentage of the fossils of *Alveolina* and *Rotalia*, where these fossils are the largest proportion of other fossils found in this facies (plate3-h), (plate3-i). The facies contain a Gastropods (plate3-j), and the floating - rhomb texture appears (plate3-k) [13]. This facies is repeated with a thickness of (2m) which consists of the micrite (plate3-l), where the proportion of skeletal grains in between (35-50%) and is composed mainly foraminifra species *Textularia* and *Rotalia* (plate4-a), but the latter form the most presence of *Textularia* (plate4-b) in addition to the presence of pieces of Echinoderms (plate4-c), in low rate. This facies deposited in a moderate energy environment. This facies is comparable to the standard microfacies (SMF: 18) which is deposited in the facies zone (FZ 8) and is known as restricted platform interior environment [10,11].

4-5 Lime Grainstone Microfacies (LGA)

This facies is located in the middle of formation and is (5 m) thick. The skeletal and non-skeletal grains constitute more than (60%) of the total content of the thin section while the skeletal grains constitute the largest percentage, and it is characterized by the presence of different sizes and a variety (plate4-d).The fossils of the family Miliolidae reach more than (50%) of the total skeletal grains where benthic foraminifera fossils represent the largest proportion of other fossils and includes genera *Quinqueloculina* (plate4-e), *pyrgo* (plate4-f),and *spiroloculina* (plate4-g). *Nummulites* (plate4-h), *Alveolina* (plate4-i), are also present. Add to this the presence of the genera of the tubular foraminifera fossil and biserial (plate4-j), (plate4-k). As well as the diagnosis of ostracoda (plate4-l), in low rate. The non-skeletal grains spread within this facies are represented by the ooids (plate4-m) and faecal facel pellet (plate4-n).The absence of micrite in this microfacies shows that, as in general, the deposition was in a high energy environment. This facies is similar to the standard micro facies (SMF: 18) found in the facies zone (FZ 7) known as the open marine platform interior environment [10,11].

5- Depositional Enviroment of Avanah Formation

Throughout investigation , it is noticed that by studying the fine facets of the formation it was found that the composition consists of lime mudstone microfacies, benthic foraminifera lime wackestone submicrofacies, Rotalide lime wackestone submicrofacies, Rotalidi-Miliolidae lime packstone Submicrofacies, benthic foraminifera lime packstone submicrofacies, and lime grainstone microfacies.

One of the biomarkers identified in this Formation is the presence of *Rotalia*,and the presence of such fossils in a matrix of micrite indicates a behind the shore or lagoon environment [14]. As well as the presence *Nummulite*s, *Textularia* and gastropoda are evidence of a shallow low-energy environment [15], and the presence of fragments of echinoderms indicates a shallow open marine environment with moderate salinity [16].

The important life evidence is the presence of *Alveolina* fossils, which refers to shallow and quiet environments of warm tropical seas with depths of (10-80m)[14]. The presence of oyster shells (pelecypoda) and ostracoda refer to large shallow environmental areas [17].

The existence of family Miliolidae (*Spiroloculina*, *Quinqueloculina*, *Triloculina* and *Pyrgo*) are found in warm waters and are found in barrier reef lagoons [14]. Other life guides are found in the formation composition are the fossils of the *Quinqueloculina* and *Alveolina* of the large Foraminifera, these life guides refer to shallow inner platform environments [18].The presence of red algae, which has a role in sediment cohesion indicates an open marine environment with moderate salinity[14]. The presence of dolomite rhombs in the middle and upper part of the Avanah Formation indicates early dolomitization [13]. From the relying on life evidence and facies analysis of formation, fossils are more common in the shallow platform. Consequently, these facies deposited within the zone of the open platform - restricted platform. The presence of dolomite rhombs scattered and the accompanying of *Alviolina*, *Rotalia* and Miliolidae indicate the early dolmatization. The model of the sedimentary formation was proposed based on these results as they are shown in figure (3).

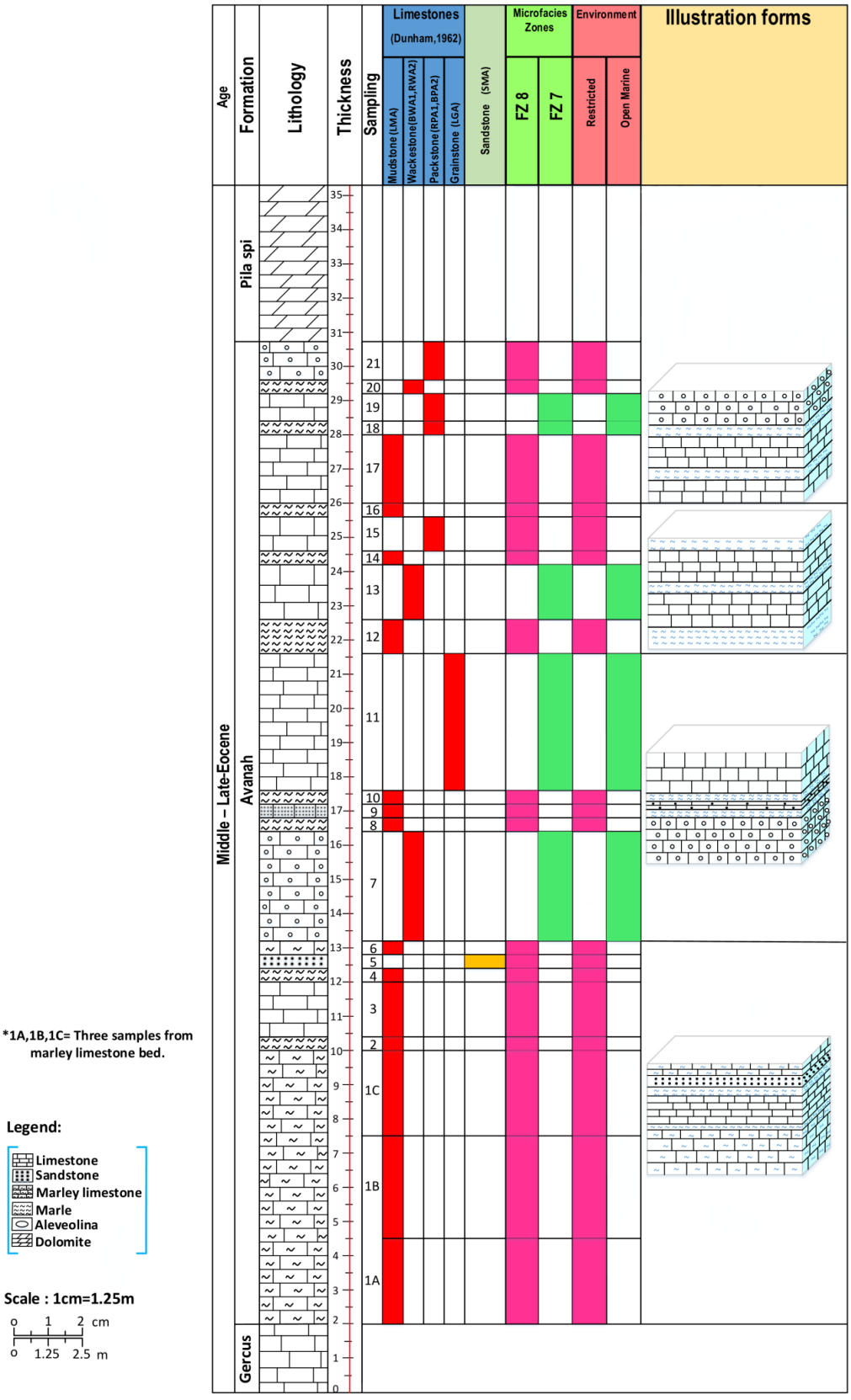

Fig. 2: Environnment distribution of Avanah Formation at the Geli Bessri section Dohuk.

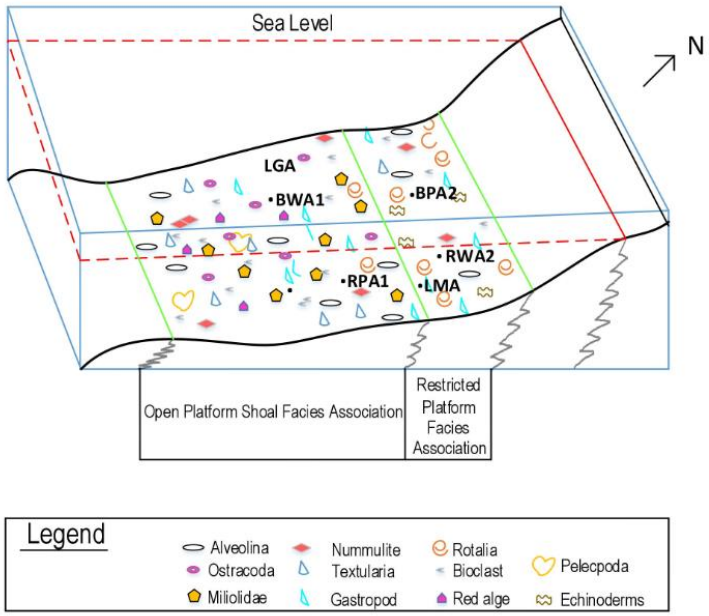

Fig. 3: Depositional model of Avanah Formation.

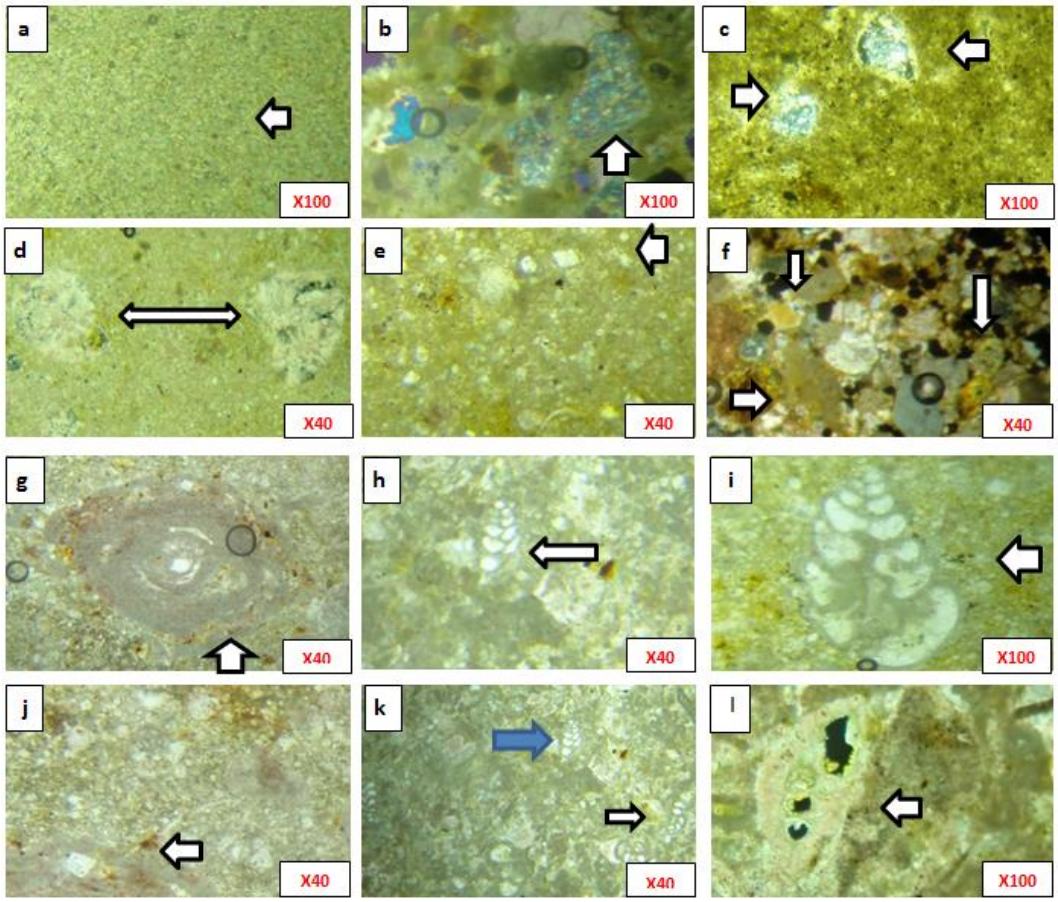

Plate1: a Microspar in(LMA) (x100) b Monocrystalline and polycrystalline quartz in(LMA) (x100) c Chert grains in(LMA) (x100) d Lime Mudstone Microfacies in(LMA) (x40) e Dolomite rhombs scattered in micrite in (LMA) (x40) f Quartz, chert, lithicfragment, and pyrite in (LMA) (x40) g *Nummlites* in(BWA1) (x40) h *Textularia* in(BWA1) (x40) i Gastropod in(BWA1) (x100) j dolomite rhombs in (BWA1) (x40) k *Textularia* in (BWA1) (x40) l *Rotalia* in (BWA1) (x100).

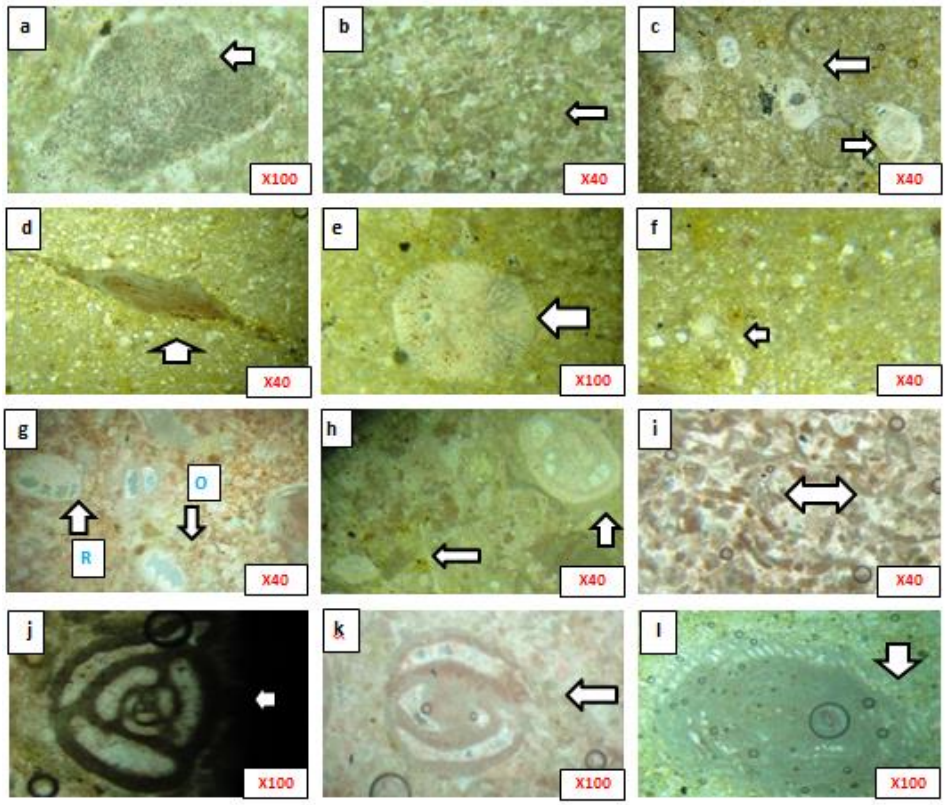

Plate 2: a Echinoderms in(BWA1) (x100) b Facel pellets in(BWA1) (x40) c *Rotalia* in(RWA2) (x40) d *Alveolina* in(RWA2) (x40) e Coral in(RWA2) (x100) f Dolomite rhombs in(RWA2) (x40) g *Rotalia* and Ostracoda in(RPA1) (x40) h Big and small *Rotalia* in(RPA1)(x40) i Faecal pellet in(RPA1) (x40) J *Quinqueloculina* in(RPA1)(x100) k Triloculina in(RPA1) (x100) l *Alveolina* in(RPA1)(X100).

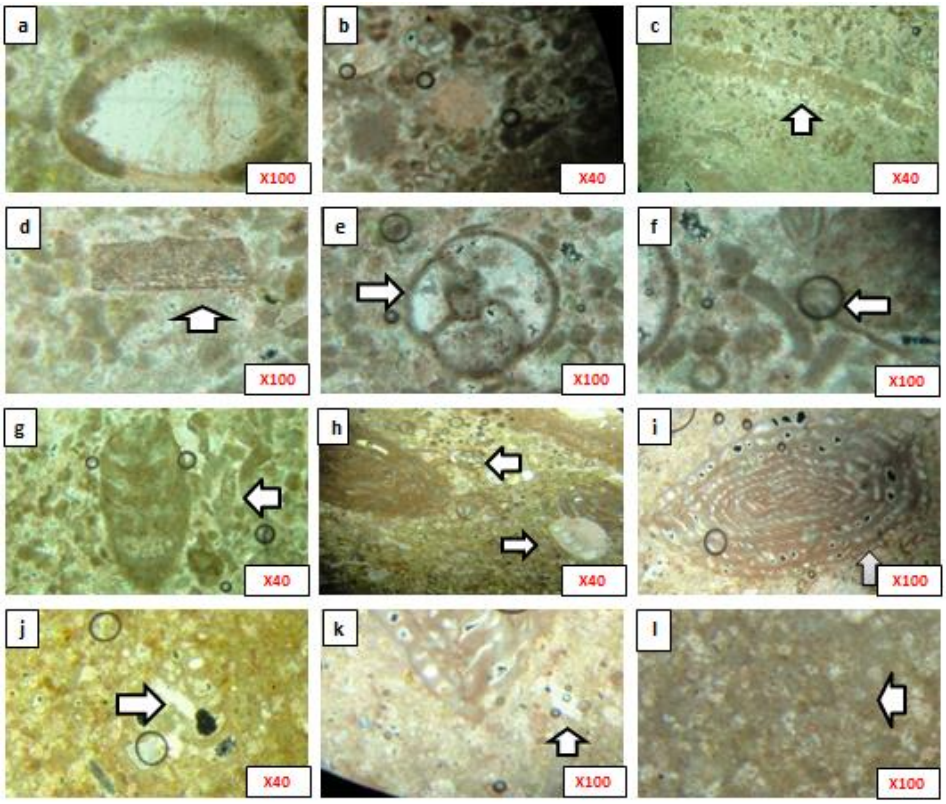

Plate3: a Ostracoda in(RPA1) (x100) b *Rotalia* in(RPA1) (x40) c Big Piece of Echinodems in(RPA1) (x40) d small piece of Echinoderms in(RPA1) (x100) e *Discorbs* in(RPA1) (x100) f Bioclact in(RPA1) (x40) g Red alge in(RPA1) (x40) h *Rotalia* and *Alveolina* in(RPA2) (x40) i big *Alveolina* in(RPA2) (x100) j Gastropod in(RPA2) (x40) k Dolomite rhombs in(RPA2) (x100) l Micrite matrix in(RPA2) (x100).

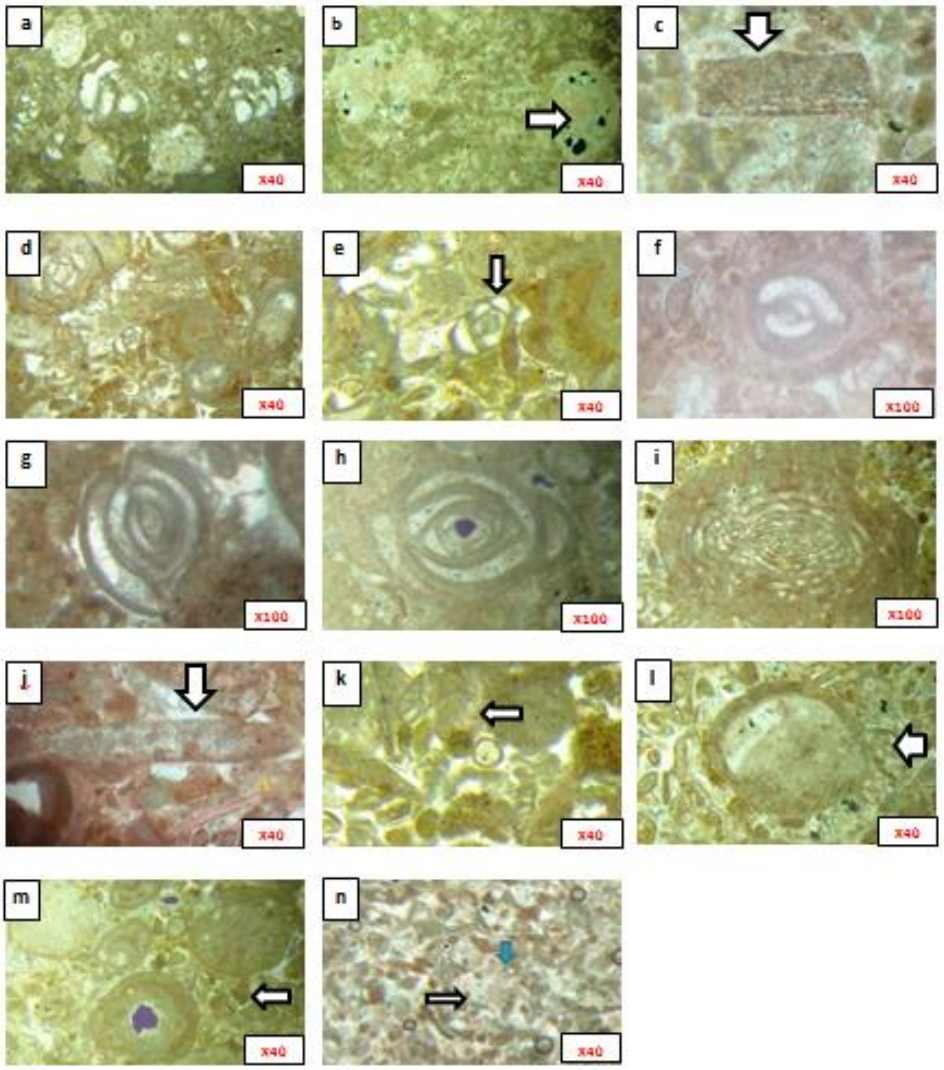

Plate 4: a *Textularia* and *Rotalia* in(RPA1) (x40) b *Rotalia* in(RPA1) (x40) c piece of Echinoderms in(RPA1) (x100) d diversity of fossils in(LGA) (x40) e *Quinqueloculina* in(LGA) (x40) f Pyrgo in(LGA) (x100) g Spiroloculine in(LGA) (x100) h *Nummulites* in(LGA) (x40) i *Alveolina* in(LGA) (x100) j tubular Foramanefra in(LGA) (x40) k biserial Foraminefra in(LGA) (x40) l Ostracoda in(LGA) (x40) m Ooids in(LGA) (x40) n Pellet in(LGA) (x40).

6- References

[1] Nichols, G.(2009). Sedimentology and stratigraphy. 2th edn., UK: Wiley- Blackwell Publishing Company: 419 PP.

[2] Bellen, R. C. Van, Dunnington, H. V., Wetzel, R. and Morton, D. M. (1959). Lexique Stratigraphique International, ASIE, Vol. 111 , Fascicule 109 , Iraq.

[3] Sherbazheri,k. (1983). Study of foraminifera and microfacies of the Avanah Limestone(Middle Eocene), Dohuk Area-North Iraq. M.Sc. thesis, Mosul University, Mosul, Iraq: 103pp.

[4] Jassim, S.Z. and Buday, T. (2006a). Late Turonian – Danian Megasequence (AP 9) In: Jassim, S.Z and Goff, J.C. (eds.),Geology of Iraq. Publ. Dolin. Prague and Moravian Museum. Brno: 141-151.

[5] Hallock, p and Clenn, E.C. (1986). Larger foraminifera: a tool for paleoenvironmental analysis of Cenozoic carbonate depositional facies. Palaois, 1:55-64.

[6] Al-Alawi, M. N. (1980). Structural study of Upper Cretaceous and Tertiary Section in Jabl Bekhair Dohuk area . North. M.Sc. thesis, Mosul University, Mosul, Iraq: 203pp.

[7] Jassim , S. Z and Goff, J.C. (2006). Geology of Iraq. Published by Dolin, Prague and Moravian Mus. Brno: 314 pp.

[8] Friedman, G.M.(1969). Identification of carbonate minerals by staining methods. Journal of Sedimentary Research, 29 (1):87-97.

[9] Dunham, R.J. (1962). Classification of carbonates rocks according to the depositional texture. In: Ham, W. E. (eds.), Classification of carbonate rock. American Association of Petroleum Geologists, Memoir:108 – 121.

[10] Wilson, J. L.(1975). Carbonate facies in geologic history. Springer – Verlag, Berlin: 471 pp.

[11]Flugel, E. (2004). Microfacies of carbonate rocks, analysis, interpretation and application. Berlin: Springer: 976 pp.

[12]Tucker, M.E. (2001). An Introduction to the Origin of Sedimentary Rock. 3thedn., UK: Black well Science: 262pp.
[13] Randazzo, A. F. and Zachos, L. G. (1984). Classification and description of dolomite fabrics of rocks from the Floridian aquifer. Sedimentary Geology, 37: 151 – 162.
[14] Ghose, B. K. (1977). Palaeoecology of the Cenozoic reefal foraminifera and algae - a brief review, Palaeogeography, Palaeoclimatology, Palaeoecology , 22: 231 - 256.
[15] Brasier, M.D. (1980). Microfossils. London: George Allen and Unwin Ltd:193 pp.
[16] Milliman, J.D. (1974). Marine carbonate. New York: Springer - Verlag Berlin, Heidelberg: 375 pp.
[17] Scholle, P.A. and Ulmer-Scholle, D.C. (2003). Acolor Guide to the Petrography of Carbonate Rock : Grains, Textures, Porosity, Diagenesis, A.A.P.G. Men.-77., U.S.A: Tulsa, Okla: 474 pp.
[18] Flügel, E. (2010). Microfacies of Carbonate Rocks: Analysis, Interpretation and Applications. 2th edn., Berlin : Springer-Verlag:1006 pp.

السحنات الدقيقة والبيئة القديمة لتكوين أفانا (الايوسين الأوسط) كلي بيسري دهوك / شمال العراق

مصطفى عبدالرحمن عبد الله ، فارس نجرس حسن ، عبدالسلام مهدي صالح

قسم علوم الارض التطبيقية ، كلية العلوم ، جامعة تكريت ، تكريت ، العراق

الملخص

جمعت النماذج الصخرية (23نموذج) لتكوين افانا (الايوسين الأوسط) من منطقة كلي بيسري دهوك لتحديد البيئة الترسيبية القديمة. يتكون تكوين أفانا من صخور من الحجر الجيري المارلي والحجر الجيري الحاوي على الألفيولينا وطبقات نحيفة من الحجر الجيري الرملي المتواجدة في الجزء الأسفل من التكوين, وتم تحديد البيئة الترسيبية القديمة اعتمادا على المكونات الهيكلية وغير الهيكلية الى اربعة سحنات رئيسية دقيقة وأربع سحنات دقيقة ثانوية وهي: سحنة الحجر الطيني الرئيسية وسحنة الحجر الجيري الواكي الرئيسية والتي تنقسم الى سحنة الحجرالجيري الواكي الثانوية الدقيقة الحاوية على الفورامنيفرا القاعية والى سحنة الحجر الجيري الواكي الثانوية الدقيقة الحاوية على الروتاليد,وأيضا يحتوي التكوين على سحنة الحجرالجيري المرصوص الرئيسية والتي تقسم الى سحنة الحجر الجيري المرصوص الثانوية الدقيقة الحاوية على الروتاليد والمليوليد والى سحنة الحجر الجيري المرصوص الثانوية الدقيقة الحاوية على الفورامنيفيرا القاعية وإضافة الى سحنة الحجر الجيري الحبيبي الدقيقة الرئيسية, ويتعرض التكوين في الجزء الوسطي والأعلى منه الى عملية دلمتة مبكرة ونلاحظ هذا من خلال معينات الدولمايت الطافية. واعتمادا على نتائج التحليل السحني وتواجد متحجرات الفورامنيفرا تبين إن التكوين ترسب في بيئة الرصيف البحري المفتوح الى الرصيف المحصور الداخلي(open marine platform to restricted platform interior).