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Facies Analyses and Diagenetic features development of Albian - Aptian Succession in the Wset Qurna oil field, Southern Iraq

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Abstract

The Carbonate-clastic succession in this study is represented by the Shuaiba and Nahr Umr Formations deposited during the Albian - Aptian Sequence. The present study includes petrography, microfacies analyses, and studying reservoir characterizations for 5 boreholes within West Qurna oil field in the study area. According to the type of study succession (clastic – Carbonate) there are two types of facies analyses:-Carbonate facies analysis, which showed five major microfacies were recognized in the succession of the Shuaiba Formation, bioclastic mudstones to wackstone, *Orbitolina* wackestone to packstone, Miliolids wackestone, Peloidal wackestone to packstone and mudstone to wackestone identified as an open shelf toward the deep basin. Clastic facies analyses which shown five major facies were recognized in the succession of the Nahr Umr Formation according to petrographic observation with gamma ray and spontaneous potential well logs. These facies identified four depositional environments within the Nahr Umr Formation; bay fill, delta plain, delta front, and braided river. The studied sequence was affected by five major diagenetic processes, these are: micritization, cementation, dissolution, dolomitization and compaction. The disparity in the distribution of the effect of diagenetic processes in different studied sections indicates that the sea more quickly and completely receded from the northern region of area study. And the central region remained under the influence of fluctuations in sea level, while the southern region least affected by this fluctuation.

Keywords: facies, depositional environments, diagenetic process.

التحليل السحني وتطور الخصائص التحويرية لتتابع البين _ ابتين في حقل غرب القرنة النفطي جنوب العراق

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الخلاصة

أن التتابع الكاربوناتي الفتاتي قيد الدراسة يتمثل بتكوين الشعيبة ونهر عمر المترسبين خلال الالبين – الابتين. تضمنت الدراسة الحالية دراسة بتروغرافية وتحليل سحنات ودراسة الخواص المكمنية لخمس ابار ضمن حقل غرب القرنة النفطي. بالاعتماد على نوع التتابع قيد الدراسة (فتاتي – كاربوناتي) هناك نوعان من التحليل السحني : تحليل سحنات الحجر الجيري الكاربوناتي الذي اظهر خمسة سحنات مجهرية تم تمييزها في تتابع الشعيبة وهي : bioclastic mudstones to wackstone, *Orbitolina* wackestone to packston,

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Miliolids wackestone, Peloidal wackestone to packstone, Mudstone to wackestone والتي حددت البيئة من بحر ضحل مفتوح الى الحوض العميق. تحليل سحنات الحجر الفتاتي والتي اظهرت خمس سحنات رئيسية تم تمييزها في تكوين نهر عمر وذلك بالاعتماد على الخواص البتروغرافية ومقارنتها مع تغير قيم اشعة كاما ومجس الجهد الذاتي. وهذه السحنات حددت اربعة بيئات ترسيبية رئيسية في تكوين نهرعمر وهي ملئ الخليج، سهل الدلتا، واجهة الدلتا واخيرا بيئة النهر الظفائري. ان التتابع قيد الدراسة تأثر بخمس عمليات تحويرية رئيسية وهي: المكرتة والسمنتة والاذابة والدلمتة وعملية التراص. ان التفاوت في توزيع تأثير العمليات التحويرية في المقاطع قيد الدراسةة المختلفة يشير الى ان تراجع البحر بشكل سريع وبالكامل من الجزء الشمالي لمنطقة الدراسة، والجزء الوسطي بقي تحت تأثير تذبذب مستوى سطح البحر، في حين بقي الجزء الجنوبي مغمور بالمياه لأطول فترة ممكنة.

Introduction

The Carbonate-clastic succession in this study is represented by the Shuaiba and Nahr Umr Formations which deposited during the Albian - Aptian Sequence. The present study includes petrography and microfacies analyses to determinate the lithological variation and facies changes, in addition to reservoir characterizations and diagenetic effects on these properties for studied succession in 5 boreholes within West Qurna oil field Figure-1.

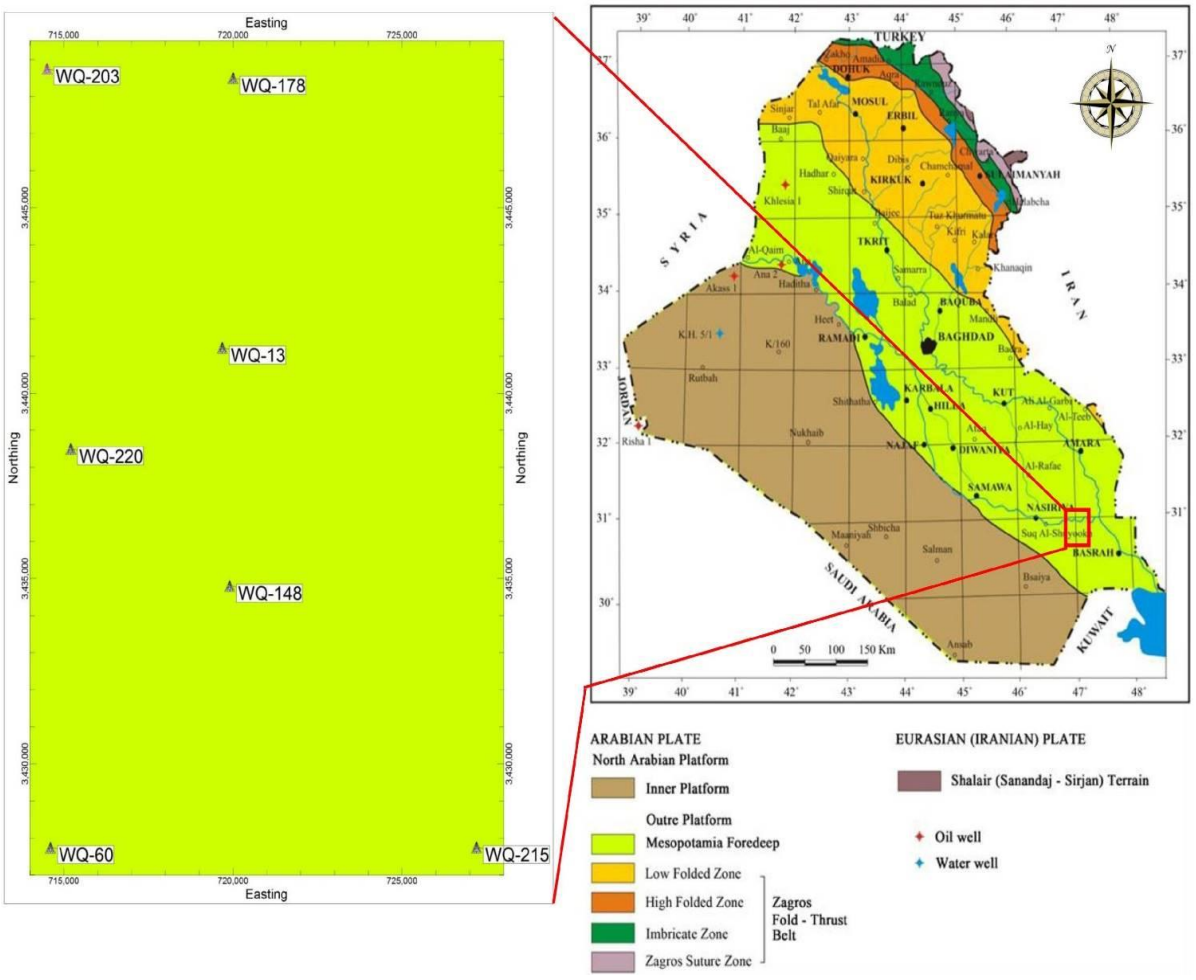


Figure 1- Location map of the Study area

Carbonate-clastic succession which includes the Shuaiba and Nahr Umr Formations representes a part of Alpian - Aptian Sequence (Wasi'a Group). Nahr Umr Formation was defined by Glynn Jones in 1948 (Bellen et al., 1959) from the Nahr Umr structure in S Iraq. It is up to 360 m thick in the South parts of the Salman and Mesopotamian zones. The formation is thickest in S Iraq and Kuwait (around 400 m), south of Baghdad (160 m), and in NW Iraq (where the Rim Siltstone occurs). The two major

depocentres in central and South of Iraq correspond to areas which received clastics from the Rutba Uplift and the Arabian Shield [1]. The Shuaiba Formation was first defined by Owen and Nasr in 1958 [2] from well Zubair-3 in S Iraq. It comprises 62 m of pseudo-oolitic limestone, sometimes sandy, fine-grained organodetrital limestone grading into the chalky limestone and limestone with shale streaks near the top. It contains *Orbitolina cf. discoidea* Gras, *Choffatella decipiens* Schlumberger (at the base only) and globogerinids which (together with the stratigraphic position of the formation) indicate an Aptian age.

Methodology

The present study is divided into two stages:

1. Laboratory stage
    - During this stage the samples were chosen and thin sections were made.
    - The petrographic study and microfacies analyses are based on the study of more than 570 thin sections of cutting from the selected borehole (WQ 13), (WQ-148), (WQ-178), (WQ-203), (WQ-215). The cutting sample are provided by the southern oil company and prepared by the author.
2. Study of the available well logs and relate the log response to facies and diagenetic changes.

Petrography

The Shuaiba Carbonate Formation is classified according to [3] Microfacies are determined according to the types of grains (skeletal and non-skeletal) as well as the depositional textures. While the Nahr Umr clastic rocks classify by using classification of siliciclastic rocks for [4],[5] which based on the four compositional components quartz, feldspars, lithics, and matrix.

According to the types of studied succession there are two type of facies analysis:-

a. Carbonate facies analyses (microfacies)

b. Clastic facies analyses (petrography and well log facies)

Carbonate microfacies

Five major microfacies were recognized in the succession of the Shuaiba Formation; their characteristic grain types and depositional texture enabled the recognition of paleoenvironment.

Microfacies (A):- bioclastic mudstones to wackstone

This facies is mainly composed of micrite with shell fragments (mollusk), echinoderms and calcareous algae Plt-1a. Such microfacies reflect a shallow open marine.

Microfacies (B):- Orbitolina wackestone to packstone

The second most common microfacies are the Orbitolina - bearing limestone. With few shell fragments (mollusk & rudist), echinoderm and calcareous algae Plt-1b. This may reflect a semi-restricted shallow marine.

Microfacies (C):- Miliolids wackestone

The main constituents are miliolids, with few Nezzazata & small benthic foraminifera, and echinoderm fragments and algae Plt-1c. This microfacies reflects a restricted shallow environment.

Microfacies (D):- Peloidal wackestone to packstone

This microfacies consists mainly of peloids with rudist fragments, calcareous algae and miliolids being the less abundant. It can be divided into:- Peloidal wackestone to packstone Plt-3d., and pelletal wackestone to packstone Plt-1e.

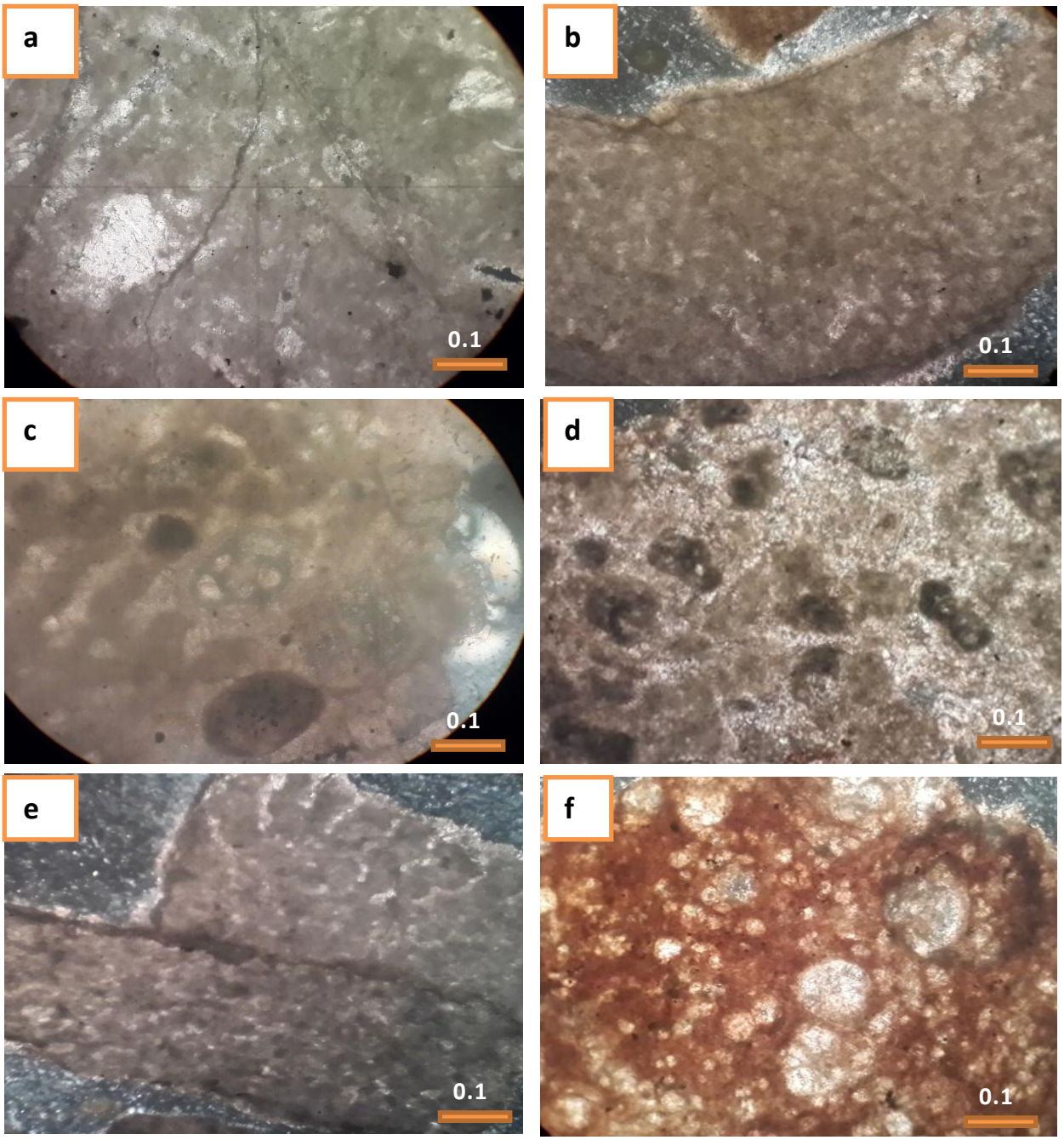
Microfacies (E):- Planktonic small benthic mudstone to wackestone.

This is a less common microfacies and uncertainly distinguished in most wells. It is composed of planktonic foraminifera (Globigerina spp.) and other small benthic foraminifera Plt-1f. This microfacies is identified as an open shelf toward the deep basin.

Clastic facies analysis (petrography and well log facies)

Five major lithofacies were recognized in the succession of the Nahr Umr Formation according to petrographic observation with gamma ray and spontaneous potential well logs to determinate the paleoenvironment.

Plate(1)



a. **bioclastic mudstones to wackstone (Facies A). (WQ -13 , depth 3250 m)**
b. **Orbitolina wackestone to packstone (Facies b). (WQ -203, depth 3315 m)**
c. **Miliolids wackestone (Facies c). (WQ -203, depth 3350 m)**
d. **Peloidal wackestone to packstone (Facies d). (WQ -203, depth 3335 m)**
e. **pelletal wackestone to packstone (Facies d). (WQ -178, depth 3365 m)**
f. **Planktonic benthic mudstone towackestone(Facies d).(WQ-215, depth 3350m)**

Lithofacies (A):- Its represents the sandstone dominated rocks of Nahr Umr. This characterized by well sorted quartz arenite Plt-2a, with very low gamma ray values with box shape of SP log.
Lithofacies (B):- Its represents the upper part of NahrUmr within the sandstone member and charactirized by poorly sorted graywacke sandstone Plt-2b with moderate values of gama ray (funnel shape).

Lithofacies (C):- Its represents the upper part of the shale member of Nahr Umr Plt-2c, which characterized by high gama ray values with box shape.
Lithfacies (D):- This facies appearing within the upper part of shale member Plt-2d, which characterized by high gama ray values with funnel shape and sand lenses.
Lithofacies (E):- Its represents the lower part of the shale member Plt-2e. This characterized by high gamma ray values as two symmetrical cycles with pell to funnel shape.

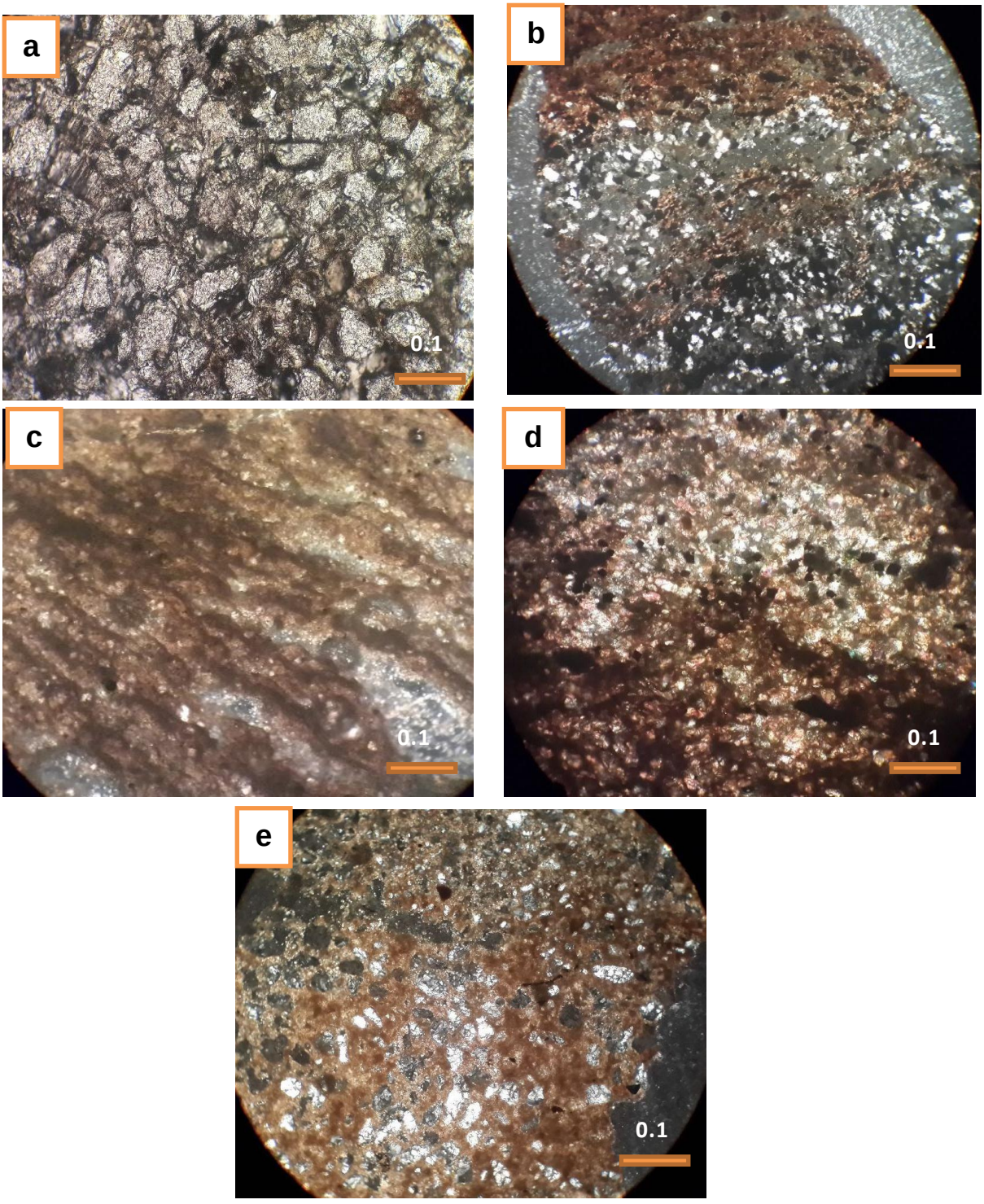
Depostional history

The first depositional stage of the studied area was started with sea level rise after still stand (when the Zubair Formation deposited). During the sea level rise the Shuaiba Formation was deposited within the ramp depositional setting. The facies distribution showed that the restricted and shallower environment was located at the north of the study area, while the outer ramp environment to the south and southeast Figure-2.

The first stage ended with the regional sea level fall during the late Aptian, where the depositional setting became transition to continental environments. Within the studied area the braided river was recognized the lower part of Nahr Umr Formation Figure-2. This part is shown as two cycles in the north at WQ-13, WQ-178 and WQ-203. While to the south the lower part appearing as one cycle and random trend to indicate the direction away from the braided river basin.

The progress of the deltaic environment above the braided river system refers to the sea level rise and the shore face retrogradation. Therefore the studied succession showed the deltaic parasequence started with a river, delta plain, delta front and ended with bay and estuarine environment.

Plate(2)



a. well sorted quartz arenite Lithofacies(A) (WQ-203 , depth 3094 m)
b. poorly sorted graywacke sandstone Lithofacies(b)(WQ-203 , depth 3285m)
c. shale member Lithofacies(c) (WQ-178 , depth 3203m)
d. sandy shale member Lithofacies(d) (WQ-203 , depth 3215 m)
e. Coars sandy mud stone Lithofacies(e) (WQ215 , depth 3270 m

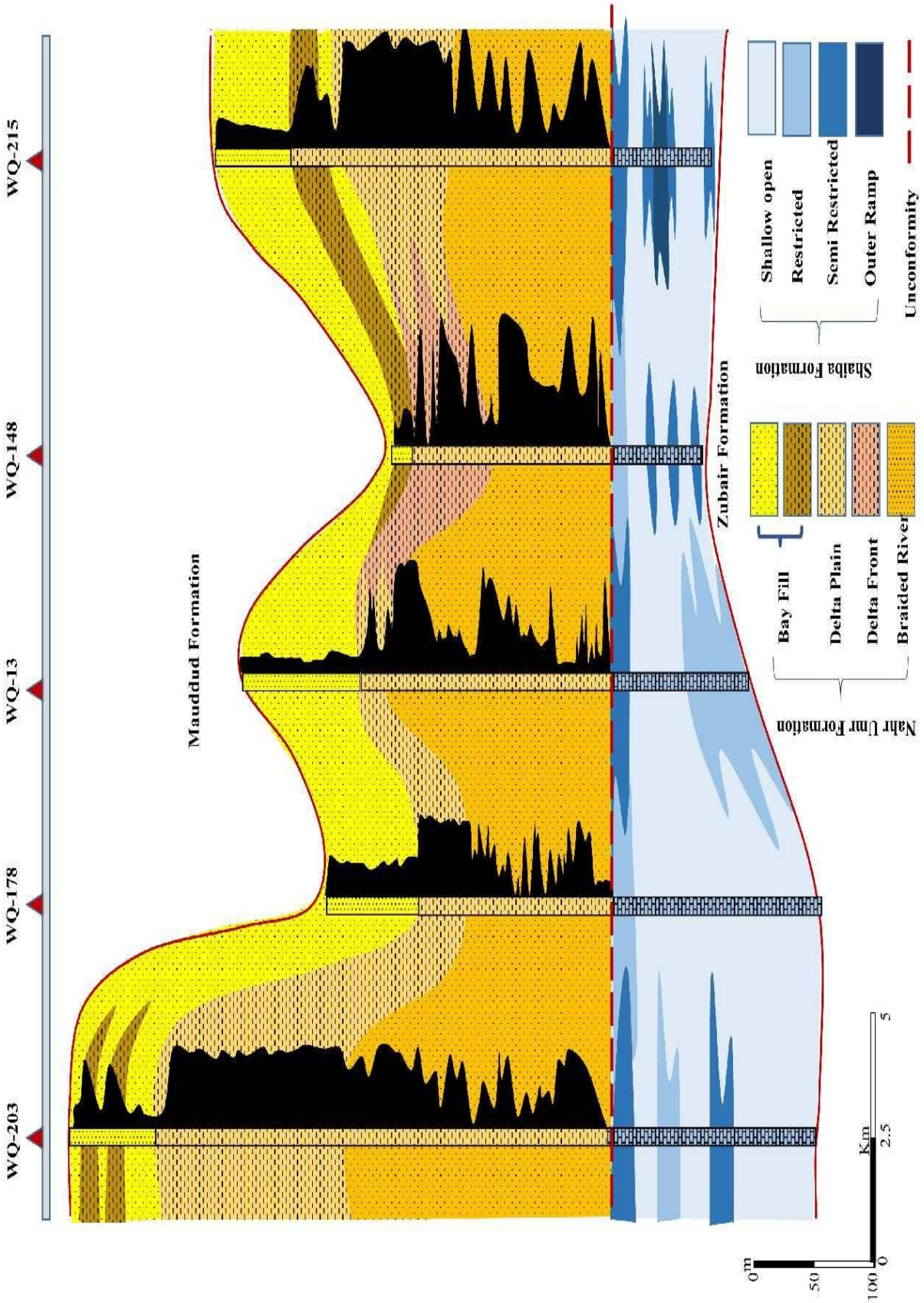


Figure 2- Stratigraphic cross section showing vertical and lateral facies changes.

Diagenesis

The term diagenesis is used to describe the processes by which unconsolidated sediment is transformed into a rock. So, diagenesis may involve all changes (textural, physical, chemical and biological) in sediments or sedimentary rocks which occur during and after deposition, but excluding processes involving high enough temperature and pressure to be called metamorphism [4].

The most common diagenetic features observed in the studied sections include Micritization, Cementation, Leaching (dissolution), Dolomitization and Compaction fabrics. The most effective diagenetic processes were cementation, dissolution and dolomitization processes which have direct effect upon the study sections.

Micritization

The micritization is represented by micrite envelope surrounding the skeletal whole organisms or the skeletal bioclast especially in wackestone and packstone texture [6]. This type of daigenesis processes is common in most study carbonate rocks Plt-3a.

Cementation

Cementation comprises processes leading to the precipitation of minerals in primary or secondary pores, these processes require the supersaturation of pore fluids with respect to the mineral [4]. Five types of cementation were identified in the Shuaiba carbonates but in the Nahr Umr Clastic four types were observed only:-

Isopachus marine cement it is an even thickness crust cement (uniform-thickness coating around grains). This type of cement is common in shallow open and semi-restricted Plt-3b. **Syntaxial rim cement** overgrowth cements on echinoderms are common in Shuaiba limestones Plt-3c., and overgrowth of quartz in of Nahr Umr Formation Plt-5a. This type of cementation is identified in most of succession parts. **Drusy mosaics cement** the drusy cement was observed mainly in Shoal grainstone and other Packstones as equant crystals cement, Plt-3d showing Drusy mosaics cement in Shuaiba limestones and Plt-5b showing Drusy mosaics cement in Nahr Umr Formation. **Granular cement** Plt-3e, showing Granular cement in Shuaiaba limestones and Plt-5c showing Granular cement in Nahr Umr Formation. **Blocky cement** Plt-3f, showing Blocky cement in Shuaiba limestones and Plt-5d, showing Blocky cement in Nahr Umr Formation.

Dissolution

Dissolution may occur at any point in the burial history of the carbonate sequence, after mineral stabilization, will generally be characterized by non-fabric-selective dissolution, where the resulting pores cut across all fabric elements such as grains, cement, and matrix [7]. The dissolution processes are controlled the porosity zones (secondary porosity), therefore it's the more important diagenetic processes in Shuaiba and Nahr Umr which are part of this study Plt-4a.

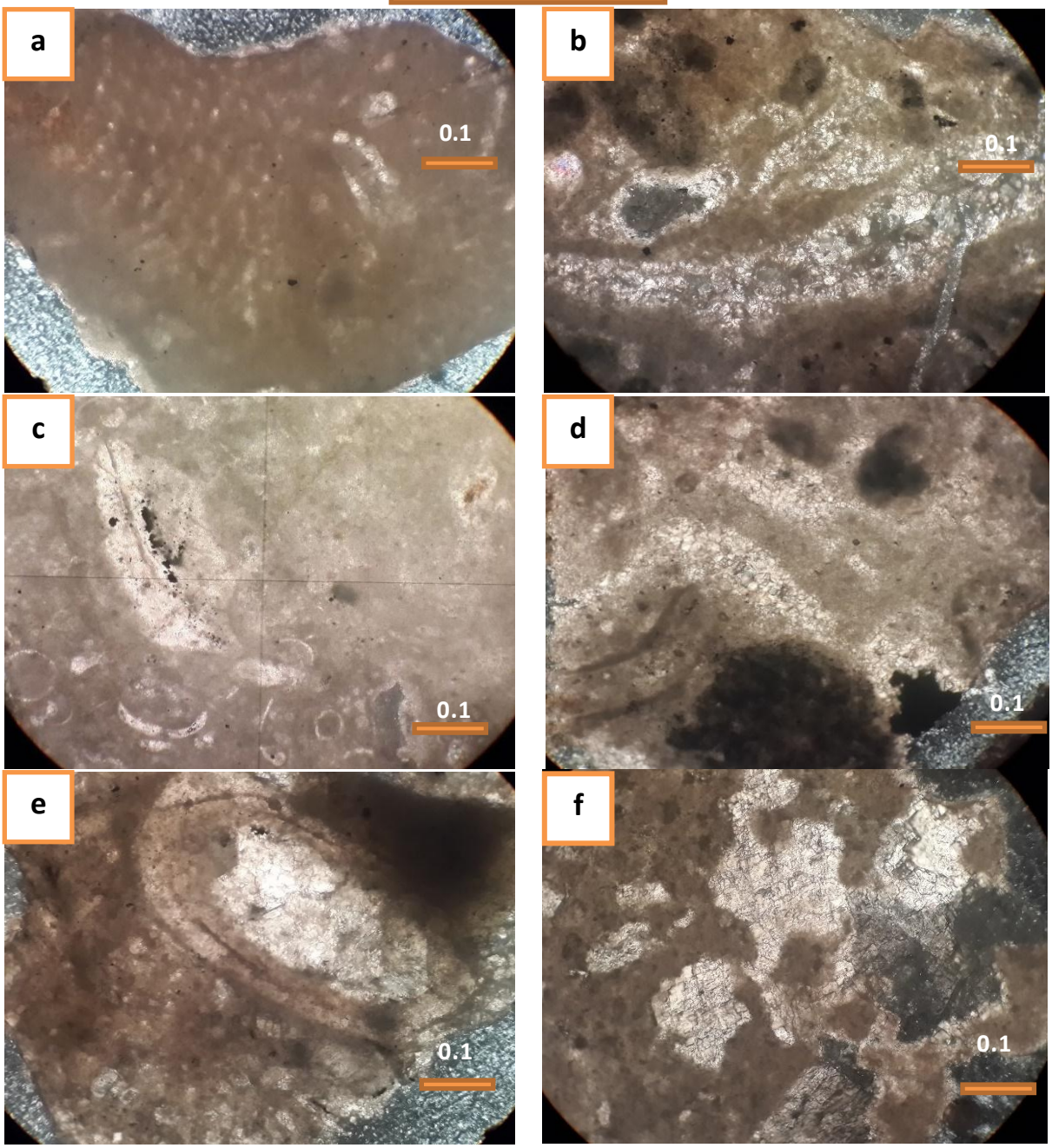
Dolomitizaition

Dolomitization is a diagenetic process that converts limestones to dolostones through a microchemical process of calcium carbonate dissolution and dolomite precipitation. According to [7] we can describe three general dolomite types in studied sections: - **Scattered**, coarse, euhedral dolomite rhombs with strong, often light crystal zone (cloudy center clear rimmed), generally associated with stylolites and pressure solution Plt-4b. **Pervasive** coarsely zoned crystalline dolomite (cloudy center clear rim) that may exhibit fabric selectivity and well-developed porosity, or may form dense interlocking mosaics and floating dolomite crystal Plt-4c. **Saddle dolomite**, which is common, as mentioned above, and generally occurs as very late pore-fill cement and characterized by cloudy coarse crystals Plt-4d.

Compaction

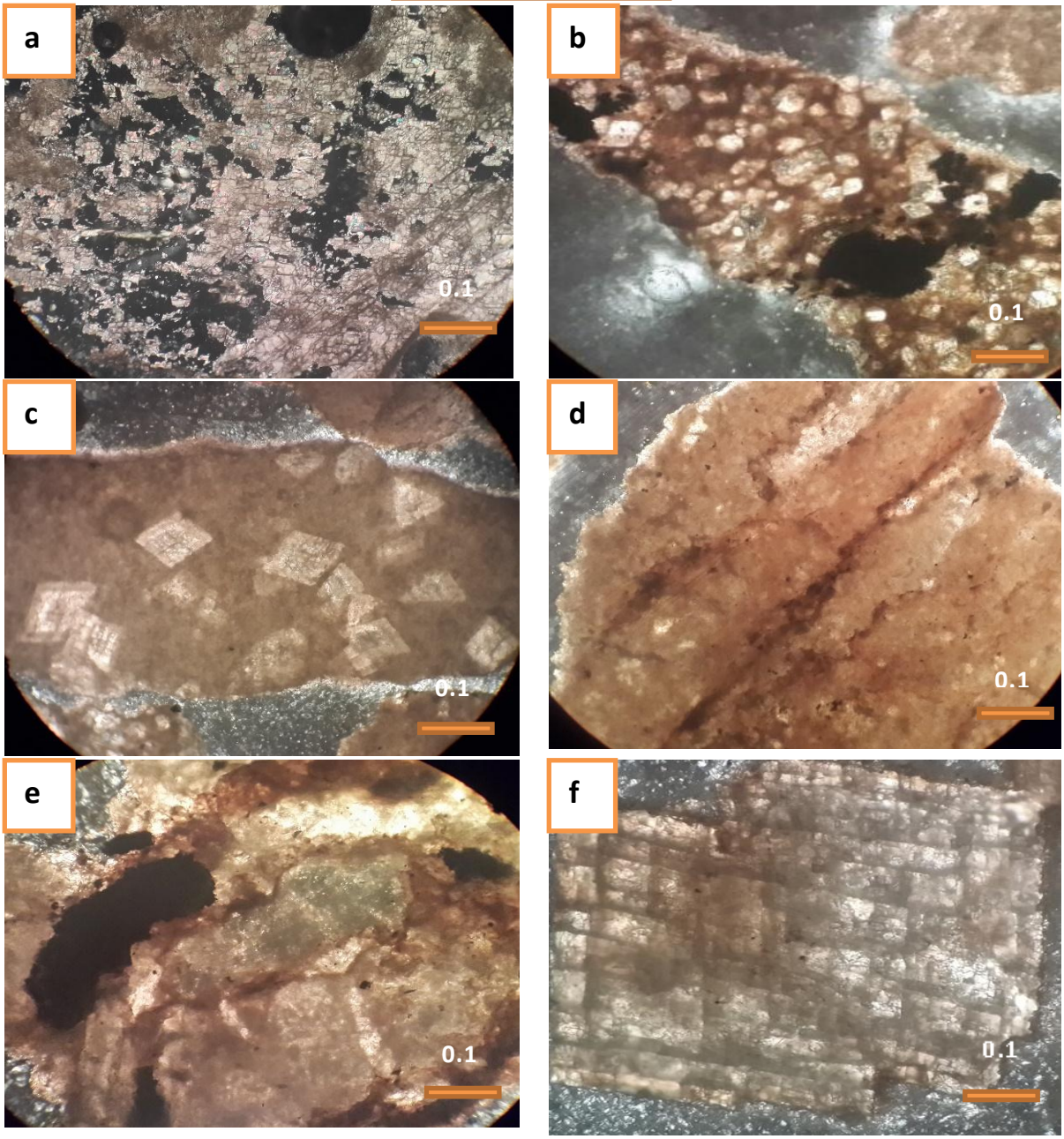
Compaction fabrics are related to burial diagenesis when the carbonate rock is buried under a thick sediment overburden, and it is one of the principal diagenetic mechanisms for porosity destruction. The compaction includes mechanical and chemical compaction, where the mechanical and chemical compactions are described in carbonate succession as deformation and Shattered micrite Plt-4e in mechanical type and styllolite Plt-4f, in chemical type, while in clastic succession as deformation of grains Plt-5e

Plate(3)



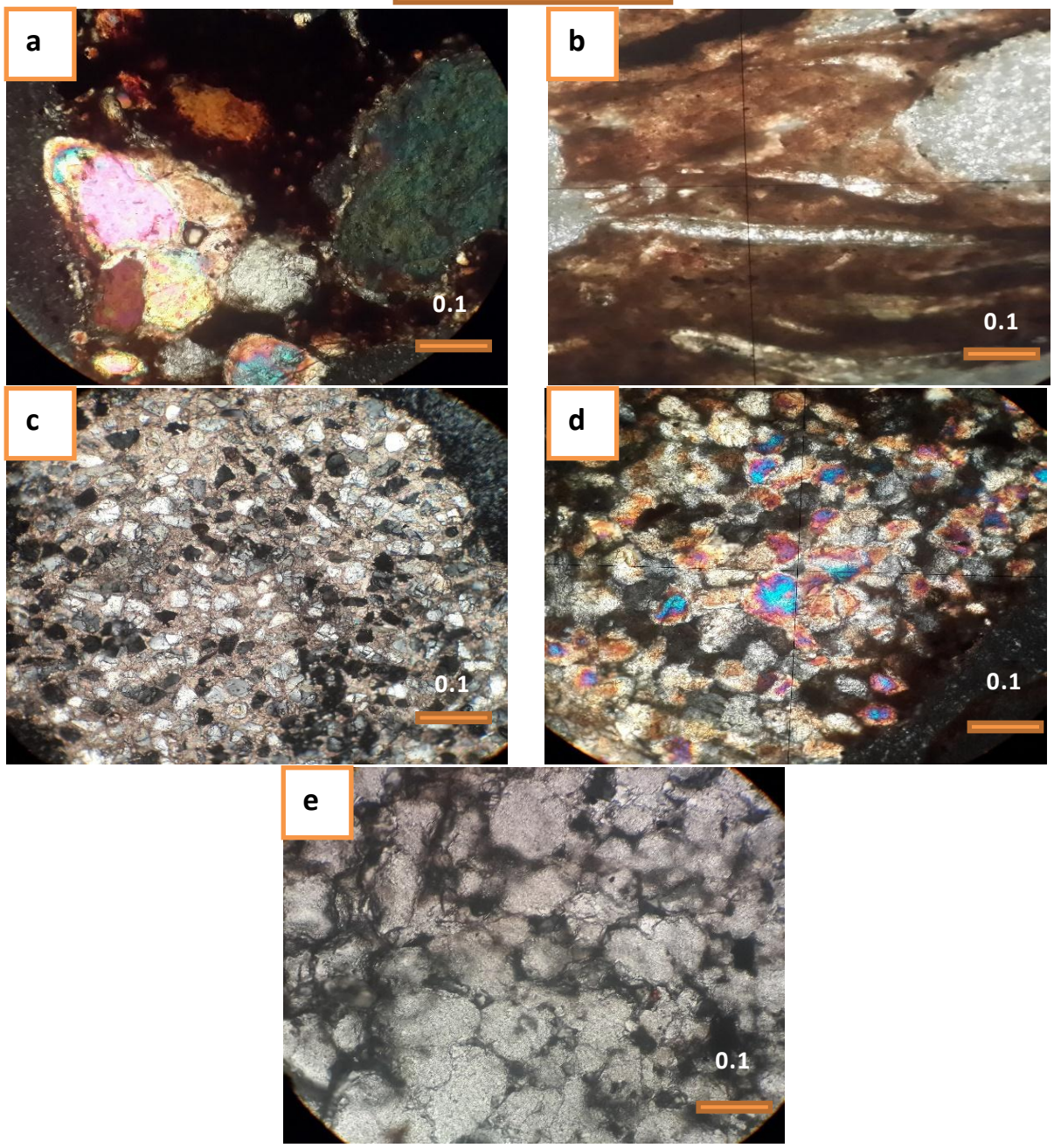
a. **Micritization of Orbitiolina skeletal fragments. (WQ-215 , depth 3390 m)**
b. **Isopachus marine cement. (WQ203, depth3334 m)**
c. **Syntaxial rim cement of the echinoderm fragmen. (WQ-148, depth4038m)**
d. **Drusy mosaics cement. (WQ-203, depth 3324 m)**
e. **Granular cement. (WQ-203, depth 3375 m)**
f. **Blocky cement. (WQ-178, depth 3443 m)**

Plate(4)



a. **Dissolution processes. (WQ178 , depth 3363m)**
b. **Scattered, euhedral dolomite rhombs. (WQ-148 , depth 3078 m)**
c. **Pervasive floating dolomite crystal. (WQ-178, depth 3383 m)**
d. **Saddle dolomite cloudy coarse crystals. (WQ-203, depth 3384 m)**
e. **Mechanical compaction. (WQ-148, depth 3088 m)**
f. **Chemical compaction (styllolite). (WQ-148, depth 3078 m)**

Plate(5)



a. **Syntaxial cement of in sandstone . (WQ-178 , depth 3353m)**
b. **Calcite mosaics cement in shale . (WQ-148 , depth 3015m)**
c. **Granular cement in sandstone . (WQ-215, depth 3070m)**
d. **Blocky quartz cement in sandstone (WQ-215 , depth 3130m).**
e. **Compaction as deformation of grains in sandstone.((WQ-178 , depth 3313m)**

Diagenitic development

Study of diagenitic features for the studied sections has shown the following:-

A. The carbonate rock characterized by high effect of late dolomitization at WQ-13, WQ-178 and WQ-203 Figures-3,-5,-6 with appeared the saddle type of dolomite. Addition to high cementation effects (Blocky cement) and less effect from the others diagenetic process.

At WQ-148 the dolomitization is a moderate stage with pervasive zoned dolomite type Figure-4, this indication upon the fluctuation effects of fresh water and freatic water respectively. The isopach

and syntaxial rimmed types of cement were appeared in this section. While at the WQ-215 was the early dolomitization effect which represented by scattered dolomite and low cement effects Figure-7. That indicates that the sea most quickly and completely receded from the northern region, and the central region remained under the influence of fluctuations in sea level, while the southern region least affected by this fluctuation.

B. The cementation is the more important diagenetic feature in the clastic rock because its affection upon the primary porosity for this type of rock. The cementation is high effects in the northern region at the WQ-13, WQ-178 and WQ-203, where the calcite cement is the more effect upon the lower part of Nahr Umr (braided river association lithofacies). While to the south area the quartz cement was the major effects.

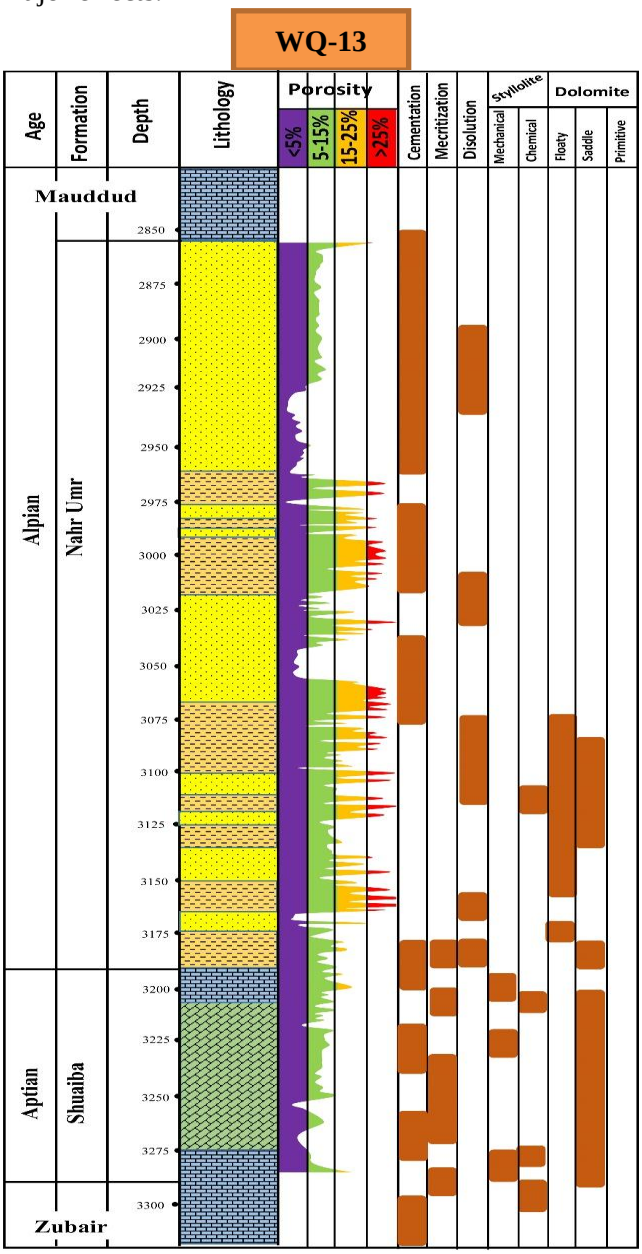


Figure 3-WQ-13 Columnr sections showing the diagenetic features and porosity percentage of Shuaiba and Nahr Umr Formations.

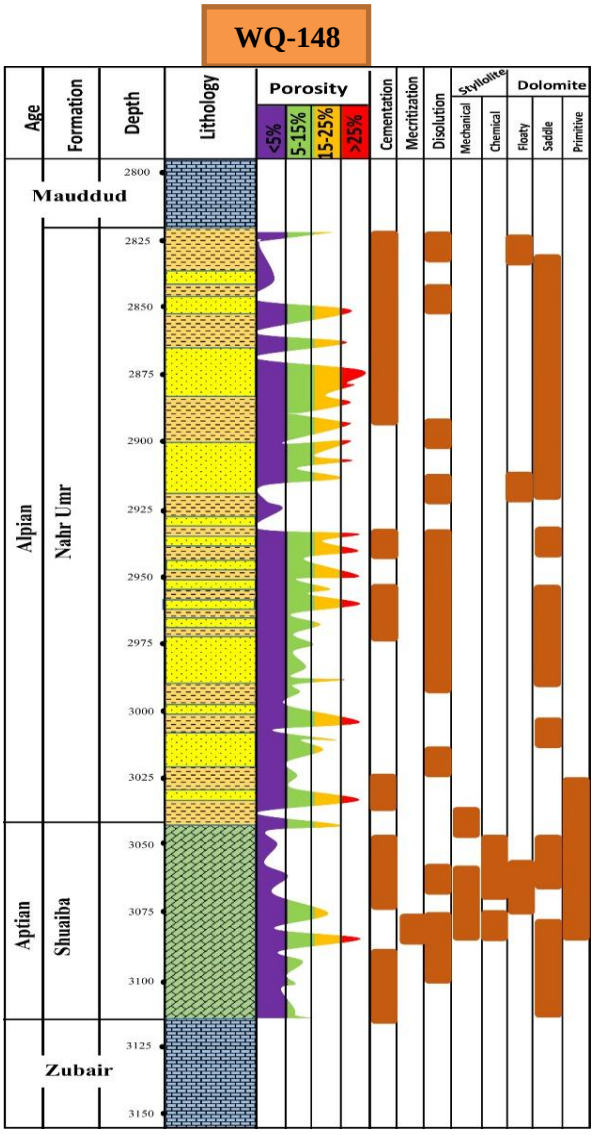


Figure 4- WQ-148 Columnr sections showing the diagenetic features and porosity percentage of Shuaiba and Nahr Umr Formations.

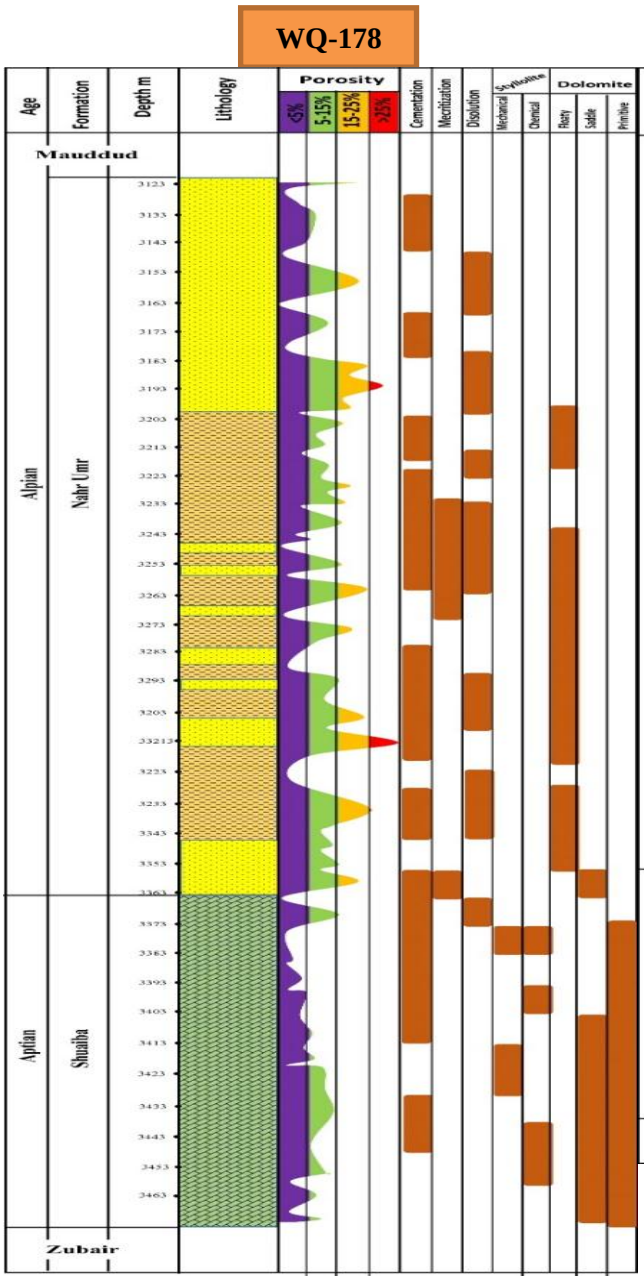


Figure 5-WQ-178 Columnr sections showing the diagenetic features and porosity percentage of Shuaiba and Nahr Umr Formations.

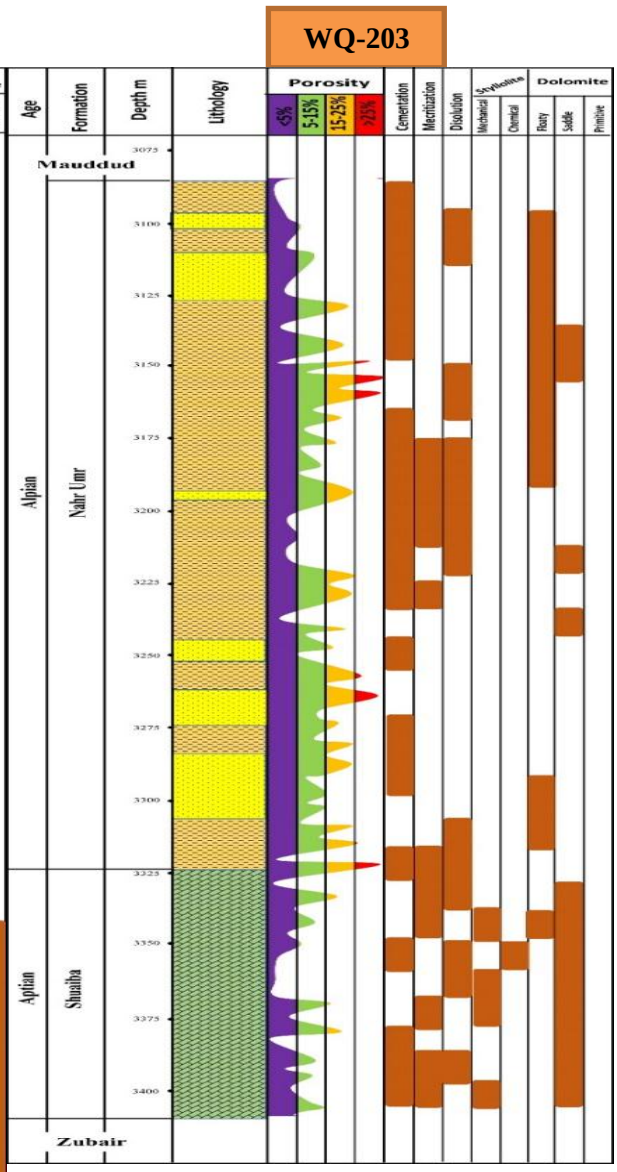


Figure 6- WQ-203 Columnr sections showing the diagenetic features and porosity percentage of Shuaiba and Nahr Umr Formations.

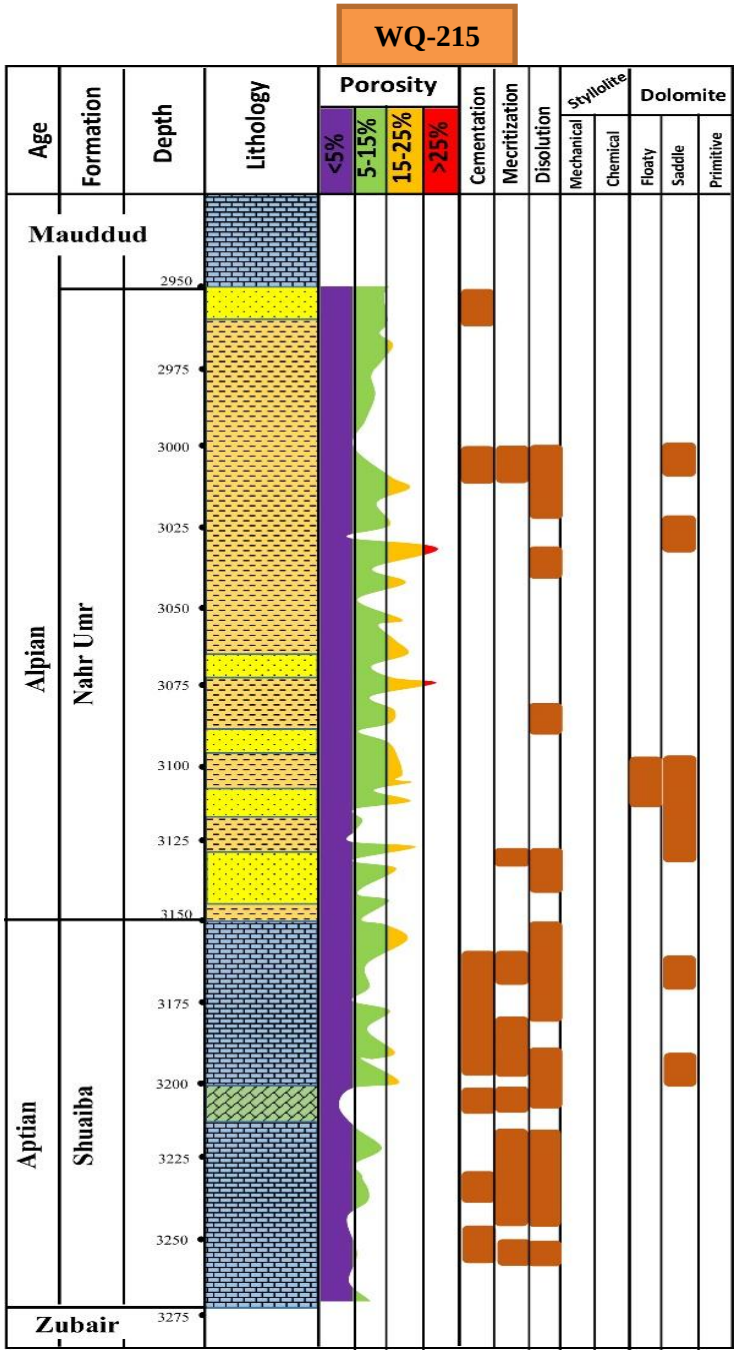


Figure 7- WQ-215 Columnr sections showing the diagenetic features and porosity percentage of Shuaiba and Nahr Umr Formations.

Conclusions

According to the type of studied succession there are two types of facies analysis:-

a. Carbonate facies analyses (microfacies):
Five major microfacies were recognized in the succession of the Shuaiba Formation, bioclastic mudstones to wackstone , *Orbitolina* wackestone to packstone, Miliolids wackestone, Peloidal wackestone to packstone and planktonic - small benthic mudstone to wackestone identified as open shelf toward deep basin.

b. Clastic facies analyses (petrography and well log facies):
Five major facies were recognized in the succession of the Nahr Umr Formation according to petrographic observation with gamma ray and spontaneous potential well logs recognize the paleoenvironment. There are Four major environments that can be recognized within the Nahr Umr Formation; bay fill, delta plain, delta front, and braided river.

The depositional history of the studied area started with sea level rise after still stand (when the Zubair Formation deposited). During the sea level rise the Shuaiba Formation was deposited within the ramp depositional setting then the first stage ended with the regional sea level fall during the late Aptian, where the depositional setting became transition to continental environments. Within the studied area the braided river recognizes the lower part of Nahr Umr Formation. This part is shown as two cycles in the north at WQ-13, WQ-178 and WQ-203. While to the south the lower part appears as one cycle and random trend to indicate the direction away from the braided river basin. The progress of the deltaic environment above the braided river system refers to the sea level rise and the shore face retrogradation.

The studied sequence was affected by five major diagenitic processes, these are: micritization, cementation, dissolution, dolomitization and compaction. The disparity in the distribution of the effect of diagenetic process in different studied sections indicates that the sea more quickly and completely receded from the northern region. And the central region remained under the influence of fluctuations in sea level, while the southern region least affected by this fluctuation.

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