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Stratigraphy Analysis of the Nahr Umr Formation in Zubair oil field, Southern Iraq

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Abstract
The Nahr Umr Formation is considered one of the main reservoirs produced in southern Iraq. It is one of the important siliciclastic deposits of the Cretaceous sequence of Iraq oilfields. Zubair oil fields ZB-190 and ZB-047 were chosen to study areas. This study depends on the available core and cutting samples to determine the facies analysis, depositional environments, petrographic characteristics and diagenesis processes. Based on the description of the core and the borehole, six types of facies were distinguished in the Nahr Umr Formation, resulting in an intercalated sandstone and shale with a thin layer of siltstone. The petrographic study of the clastic part of the Nahr Umr Formation showed that the sandstone is composed mainly of quartz arenite. Diagenesis processes affecting the Nahr Umr Formation are two types compaction and cementation processes. The sedimentary environment of the Nahr Umr Formation was represented by the deltaic fluvial environments. These environments appear in the central and southwestern parts of the study area. Sequence stratigraphy in the Nahr Umr Formation is beginning by sequence boundary type one (SB1) and sequence boundary type two (SB2) that appeared in the upper part of the formation. The other surfaces were represented by the end of the deposition of the Nahr Umr Formation and the emergence of the transgressive ravinement surface (TRS) within the transgressive system tract (TST)and The maximum flooding surface (MFS) was distinguished in the middle of the formation and each of these surfaces has a lateral extension along the study section.

Keywords: Albian; Nahr Umr Formation; Sequence stratigraphy; Microfacies; southern Iraq

التحليل الطباقي لتكوين نهر عمر في حقل الزبير النفطي جنوب العراق

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الخلاصة
يعتبر تكوين نهر عمر أحد المكامن الرئيسية المنتجة في جنوب العراق . والذي تكون خلال دورة الالبيان الثانوية .

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حيث تم اختيار بئرين في حقل الزبير ZB-190 و ZB-047 لعمل دراسة مستفيضه عن تكوين نهر عمر بالاعتماد على البيانات لتحديد الخصائص السحنيه والبيئات الترسيبية والخصائص البتروغرافية اضافة الى العمليات التحويرية .
وبالاعتماد على الصخارية تم تمييز سته انواع من السحنات لتكوين نهر عمر حيث ادى لوجود الحجر الرملي والسجيلي مع طبقة رقيقة من الغرين . اوضحت الدراسة البتروغرافية للجزء الفتاتي من تكوين نهر عمر ان الصخور الرملية له ناضحة معدنياً وان المكون الاساسي لها هو معدن المرو وهذه الصخور من نوع كوارتز أرينايت . وان اهم العمليات التحويرية المؤثرة على صخور تكوين نهر عمر هي عملية الانضغاط وعملية السمنتة. تمثلت البيئة الترسيبية لتكوين نهر عمر بالبيئة النهرية والدلتائية وتظهر هذه البيئات في الجزء الوسط والجنوبي الغربي من منطقة الدراسة.
ميزت في تتابعات تكوين نهر عمر أسطح طباقية تمثلت بحدود التتابع من النوع الأول(SB1) والذي يمثل بداية ترسيب تكوين نهرعمر وحد تتابع من النوع الثاني (SB2) ظهر في الجزء الأعلى من التكوين ، كما ميز سطحين اغماريين الأول ظهر في منتصف التكوين والسطح الأخر تمثل بنهاية ترسيب تكوين نهرعمر وظهور سطح الأنهيارالتقدمي (TRS) ضمن المسار الأغماري (TST) و ميز اقصى سطح فيضان (MFS) في وسط التكوين، ولكل من هذه الأسطح امتداداً جانبيا على طول مقطع الدراسه.

Introduction

The stratigraphic setting of the Nahr Umr Formation belongs to the Lower Cretaceous cycle, which extends from (Late Berriasian – Albian) [1].This cycle is subdivided into two secondary cycles, the first cycle from the Late Berriasian (the end of the Sulaiy Formation) and ending with the Aptian (the Shuaiba Formation) and the second cycle from the Aptian to the Albian (the Nahr Umr Formation) [1]. The upper contact of the formation with the Mauddud Formation is gradual. The limestone at the base of the Mauddud Formation may be on top of the black shale of the Nahr Umr Formation. This formation is bounded from below by the Shuaiba Formation in an unconformable. As well as plant residues, several researchers agreed that the Nahr Umr Formation was deposited in a shallow environment composed of several deltaic sequences and some calcareous layers.

The study area of the Zubair oil field is about 20 km west of Basrah. Its axis is parallel to the Rumaila oilfield, with an extension starting from the border Iraqi-Kuwait to the north of the marshes area (2-3) degrees. Considered an asymmetrical fold as the slope of its western end is more than the eastern end, the length of the fold ranges about 60 km, and its width is about 8 km dimensions are at a level of 11,000 feet below sea level. The location of Nahr Umr Formation in the Mesopotamian Zone southernmost unit within the Zubair Subzone. The study area is located in Zubair, South and North Rumaila oil fields, Southern Iraq (Figure 1). The study aims to evaluate the depositional environment through petrography and facies analysis. Well logs such as Gamma-ray (GR) and Spontaneous Potential (Sp) were performed as a primary need of stratigraphic analysis to show the Nahr Umr Formation sequence development.

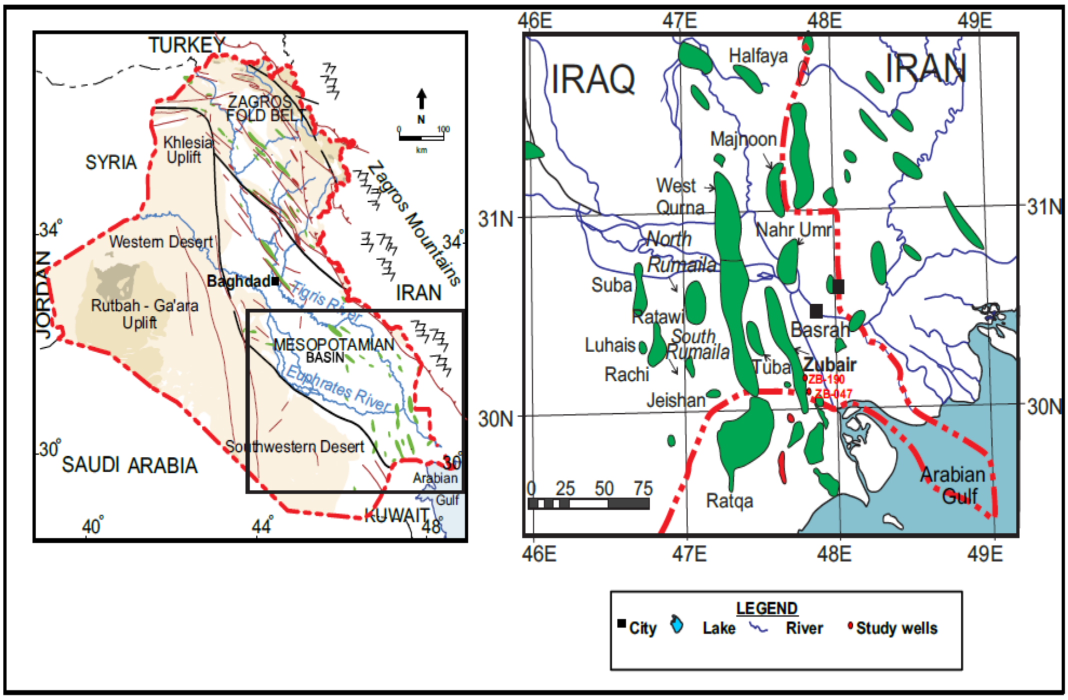

Figure 1: Location map of the study area, modified after(Al-Khafaji *et al*.,2021).

Methodology

The Basrah Oil Company supplied the core data and logs of the ZB-190 and ZB-047 wells (Zubair oilfield). Seventy-seven samples were used to create thin sections Department of Applied Geology laboratories, University of Babylon. Table 1 shows the coordinates of the two studied wells, with the top and bottom contacts of the Nahr Umr Formation at Zubair oil field in Southern Iraq. The core available for the selected wells has been described. The description included the nature of the formation rocks, whether they were sandstone, shale, or siltstone, and their facies characteristics such as color, hardness, and granular size. The spontaneous potential (SP) and gamma-ray (GR) logs were used to help determine the sedimentary facies and stratigraphy sequence of formation. The primary and minor lithofacies and diagenetic variables, porosity types, origins, and evolution were investigated. Logs such as gamma-ray (GR) and spontaneous potential (SP) were integrated with lithofacies. The lithological units, reservoir units, and sedimentary facies were predicted, as well as stratigraphic correlation.

- Creating thin sections from samples of cores and cuttings taken from studied wells.
- Examine thin sections of the cores to determine their petrography and lithofacies.

Table 1: The Coordinates of the two studied wells, with the top and bottom contacts of the Nahr Umr Formation at Zubair oil field in Southern Iraq.

Well no.	top (m)	Bottom (m)	Longitude	latitude
ZB - 047	2823	3291.5	648 523	3361 470
ZB -190	2930	3299.9	748 355.8	3381 641.8

Petrography

Many variables influence the mineral composition of sandstone, including the mineral composition of the source rock, the distance of carrying debris before it reaches the final deposition sites, the climate in the source area and the diagenetic effect once the deposition is complete[3]. The sandstones of the Nahr Umr Formation are classified as quartz arenite[2]. Which formed after long-distance transport from the source area.

Quartz is the primary component of sandstone in the study area, as it constitutes a very high percentage of about %95 in the Nahr Umr Formation. The main reason for this ratio is that quartz is caused by weathering tropical, long-distance transportation, and recycling [4] .Quartz grains range in size from medium to very fine, according to [5]. Most of the quartz grains are monocrystalline (Figure 2a) as the monocrystalline quartz may be derived from a plutonic source or another type of source[6]. The size of the granules ranges from fine to medium, the roundness ranges from semi-rectangular to round, and some are very round (Figure 2f&g). Polycrystalline quartz is a group of quartz grains assemblage in different directions of light[7] (Figure 2b). The reason is due to the absence of polycrystalline quartz makes it unstable when transported over long distances, as well as its absence in parent rocks. According to[8], increased pressure and temperature can cause polycrystalline quartz to transform into monocrystalline quartz.

Feldspar was found in less than 5% of the mineral components of the studied samples of Nahr Umr Formation and the reason for this is that it is less stable and sensitive to chemical reactions during weathering and long-distance transportation[4].Feldspar is deried from coarse-grained plutonic rocks with less extension than the volcanic sources[4]. In general, it includes orthoclase, microcline and plagioclase (Figure 2c).

A rock fragment thay are piece that contains various mineral components that are present in little or not found during long-distance transportation[4]. The rock fragments in sediments are more essential because they provide detailed information on the nature of the parent rocks [4]. The particle size of the source rock is connected to the size of the rock fragments. It includes chert and carbonate rock fragments (Figure 2d & e).

Diagenetic processes are described as all chemical and physical changes that occur in sediments or sedimentary rocks during and after deposition. Diagenetic processes affect porosity and permeability. It can be divided into two types: the physical diagenesis processes which include compaction and chemical diagenesis processes which include cementation.

Compaction Under the influence of the sedimentary cover, there are a set of processes that occur to reduce the primary porosity of the sediments and reduce the size of the rocks through the exit of fluids that are trapped between the grains of sandstone. The act of compaction was distinguished from the shattering, crushing, and expansion of the surface area of the grains (Pl. 2-c). It was found that the effect of compression is great in the Nahr Umr Formation and the reason for this is the high content of clay. The compaction increases by increasing the clay content and fine granules [4] and it decreases by increasing the structural components and the two named processes (early cementation and dolomitization) (Figure 2i).

Cementation: The cementing process reduces the porosity that was present at the time of sedimentation because cement is formed around the edges of the grains and its growth outward in the pores leads to partially or filling the pores, which leads to a decrease in the porosity[4]. More than one type of cement was found in the Nahr Umr Formation rocks: silica cement constitutes a greater proportion than other types of cement, which takes the shape of (Quartz overgrowth) (pl.2h) it is optically continuous with the quartz grain and appears partially or completely and it may be detected in many situations by spotting a ring. The original quartz grain is separated from the cement by iron oxides or clays and this is known as the dust line[4]. Silica cement may be formed from the processes of pressure solution, which leads to the dissolution of silica at the areas of contact with the grains, as with the increase in the burial process, the contact between the quartz grains increases, and the solubility of the silica increases in the areas of contact, and then it is re-deposition between the voids[4] . Calcite cement was also found in smaller quantities than silica cement, which is either microcrystalline calcite or spary calcite cement also available in the shape of spots, also, some quartz grains appeared floating in the calcite cement, resulting in the (Poikililotopic texture) [4] .It is known as inconsistent cement because its chemical structure differs from the chemical structure of the granules that make up the rock.It is believed that the most important sources of this type are the solutions saturated with calcium carbonate, resulting from the dissolution of granular and lime structures within the Nahr Umr Formation, as well as the dissolution of some lime layers located below and above the formation at the borders of contact with the Shuaiba and Mauddud formations, and then deposited in the form of cement in other sites within the Nahr Umr Formation

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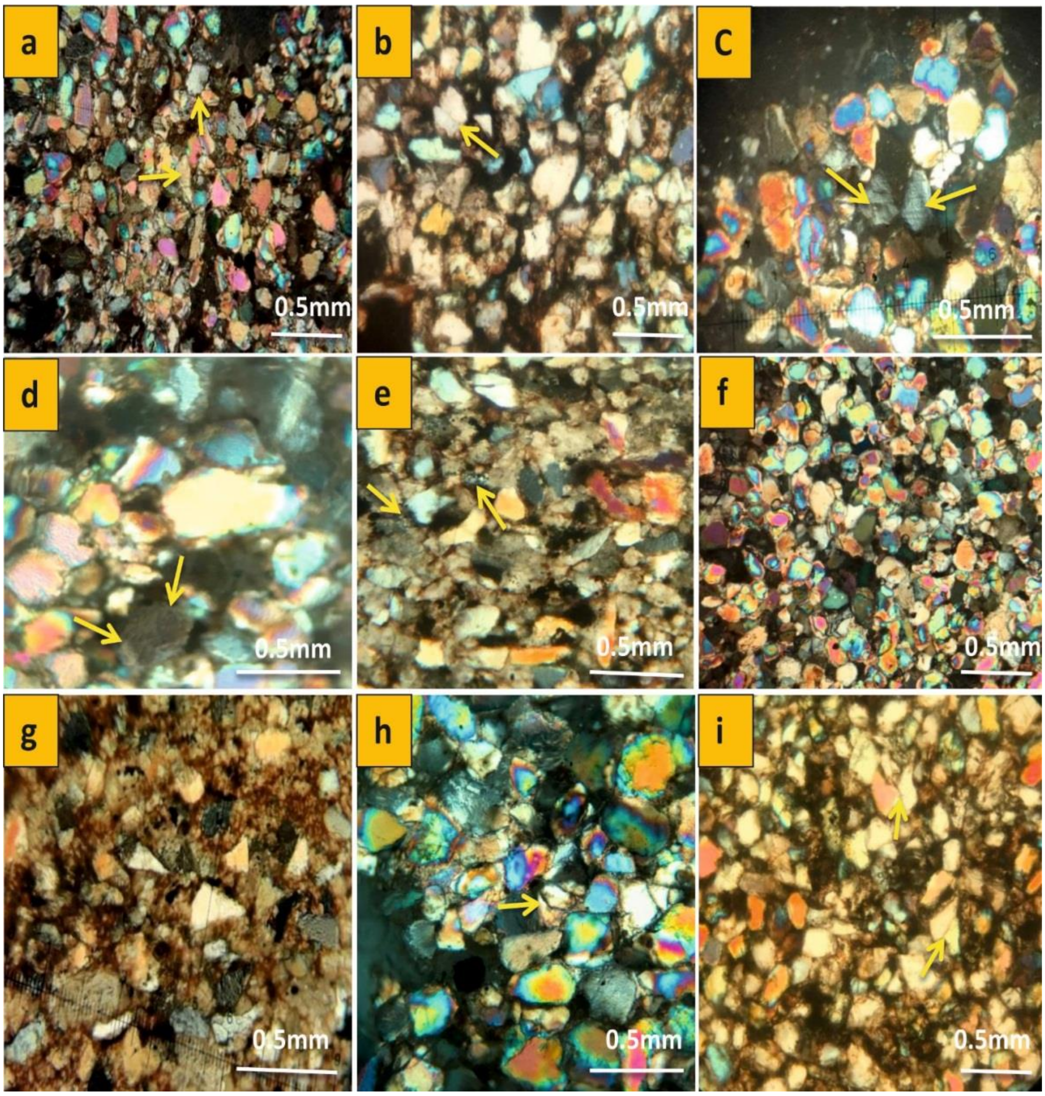


Figure 2: a**.** Monocrystalline quartz (ZB-190, 2556m). b**.** Polycrystalline quartz (ZB-047, 2820m) .c**.** Orthoclase feldspar (ZB-190, 2556m) d**.** carbonate fragments (ZB-190, 2656m). e**.** Chert fragment (ZB-047, 2546m) .f. Well-sorted quartz arenite. Sandstone (ZB-190, 2606m). g. Poorly sorted quartz arenite sandstone (ZB-047, 2556m). h. Quartz overgrowths (ZB-190, 2776m). i. Compaction to a grain of quartz contract relation between grain (ZB-047, 2786m).

Lithofacies of Nahr Umr Formation

One of the primary discoveries of the description based on the thickness of the layer, the kind of rocky type, the color, the sedimentary structures, and the contents is the division of the core into lithofacies, which is one of the essential phases in the facies study of the clastic reservoirs. [14] defined it and explained that it represents a group of microscopic fossil and petrographic characteristics and characteristics in addition to the data that result from the diagenesis processes that come after the sedimentation processes. The following is a list of the lithofacies in the Nahr Umr Formation sequence.

- Shale lithofacies

These (F.1) are shale rocks that have high organic content and a black or dark lead color (vegetation residues) (Figure 3a). The main distinguishing feature of these facies is their high density, which is combined with a large shale volume (high Gamma-ray). The lower section of the Nahr Umr Formation is dominated by shale and its facies reflect that. Thickness of this facies in ZB-190 is (2590m – 2591m).

- Lenticular bedded sandstone-mudstone lithofacies

These facies consists of soft sandy rocks in the form of ventricular sandstone that overlap with shale rocks of gray color, non-foliation (Figure 3b). This sandstone can develop into a sedimentary structure of the kind of wavy sand in one area due to energy fluctuations. This kind of rock was discovered towards the top and bottom of the Nahr Umr Formation, which is characterized by clay rocks.Thickness of these facies in ZB-047 is (2600 m / 2601 m).

-Falser Bedded Sandstone –Mudstone lithofacies

These facies are composed of simple and falser layers with a thickness of less than one meter and a restricted distribution that may not be present in all, where it comprises falser bedding and fine-grained medium-sized sedimentary cycles of the investigated wells. Sandstone is interlaced with a shale-shaped structure in a calm maritime environment. When mud is caught between layers of sand that are not linked and separated, wave activity occurs because the mud was created as a result of alternating wave currents (Figure 3e). (More deceptive bedding) (Serrated shape gamma-ray). When sand is deposited in stagnant water when the sedimentation energy is high and the clay stays suspended, it is deposited on the peaks created in the early phases of the period when the sedimentation energy is low. When the strong currents return, they will deposit sand and wash away the mud that has accumulated on the tops of the ripples. As a result, the mud in the ripple depressions will remain stuck. As a result, these facies emerge in alternating energy settings [4] .Thickness of these facies in ZB-190 is 2500 m / 2501 m.

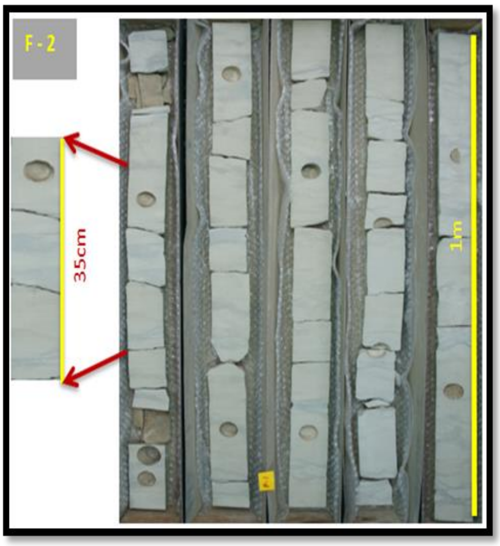
- Siltstone–shale lithofacies

This facies is composed of shale rocks containing silt and fine sand as well as plant fragments. Because the proportion of shale in the Nahr Umr Formation is lower than in the shale lithofacies, this structure formed in the upper section of the Nahr Umr Formation which is dominated by shale (Figure 3d). The quantity of shale here is smaller than the amount compared with the other shale lithofacies, resulting in rapid reductions in gamma-ray log values. Thickness of these facies in ZB-047 is 2666 m / 2667m

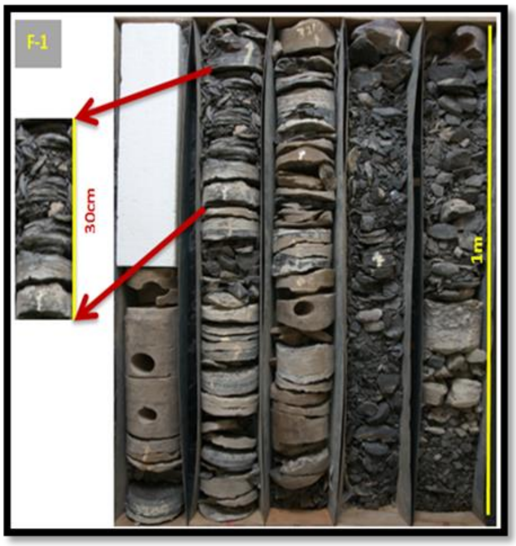
- Cross-bedded sandstone lithofacies

These facies are composed of medium- coarse sandstone that is well-sorted and vary in color from pale to dark brown due to a rise in oil evidence(Figure 3e). Two types of sedimentary structures have been observed: trough cross-bedding and planar cross-bedding.The red color on sandstone might occasionally indicate the influence of the oxidation process on the rocks. The facies of sandstone with parallel and cross-bedded are considered one of the most prevalent facies in the Nahr Umr Formation especially in the lower part of it, where these sand show two types of sequences, one of the fining to the upward and coarsening bottom sequences less and the first is less widespread than the second and may not appear different it is granular in size or difficult to distinguish.Thickness of these facies in ZB-047 is 2820m /2821 m.

- Parallel and Cross Lamination Sandstone lithofacies: It is a facies that consists of fine to medium foliated sand grains inclined at different angles from well-sorted sandstones(Figure 3f). The cross lamination facies are mostly of the medium-sized type, with an inclination angle of 20°, in addition to a cross lamination of a lesser degree with an inclination angle between (5-10°) degrees. Calm tides, banks and dams [9] . While the existence of the bioturbation as a mottled structure indicates an active deposition in river channels and prodelta [9] .Thickness of these facies in ZB-047 is 2710 m / 2711 m.



(a)



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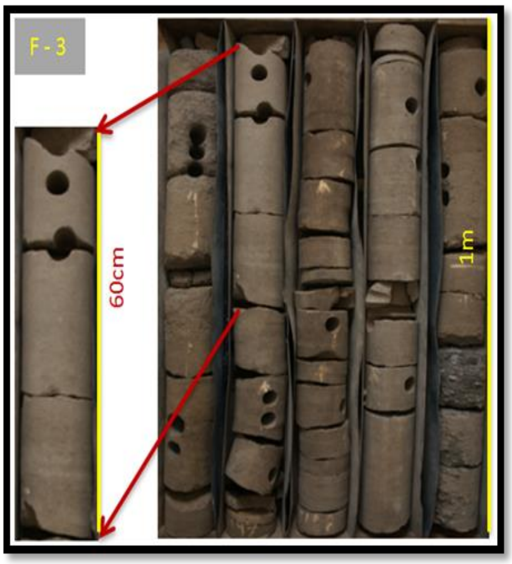
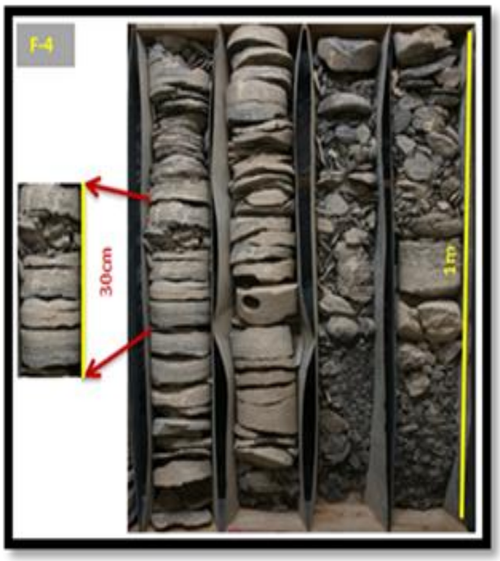


(c)



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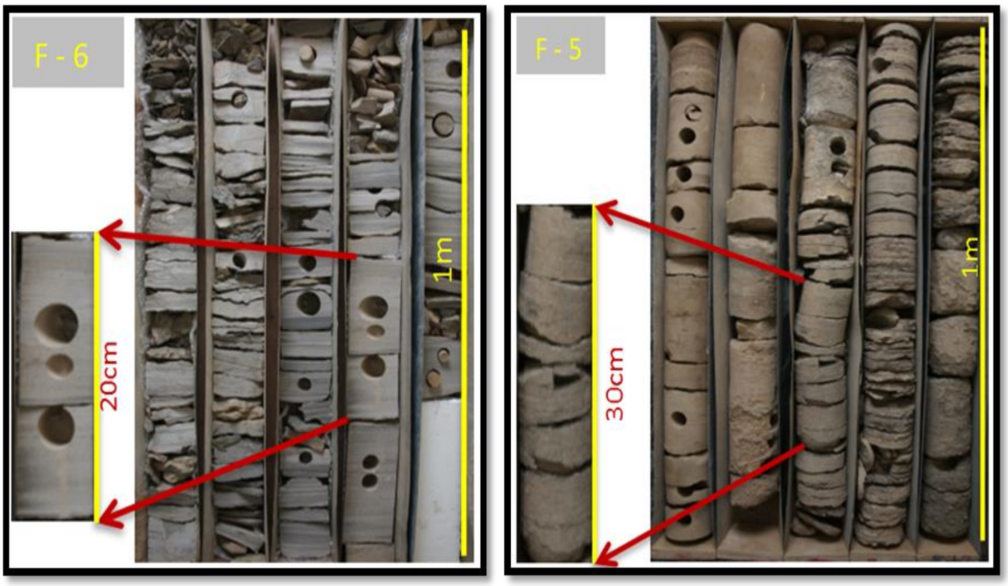

Figure 3: Nahr Umr lithofacies **a**. Shale lithofacies (F.1) (ZB-190, 2590m / 2591m). **b**. Lenticular bedded sandstone-mudstone lithofacies (F.2) (ZB-047, 2600 m / 2601 m) **c**. Falser Bedded Sandstone –Mudstone lithofacies (F.3) (ZB-190, 2500 m / 2501 m). **d**. Siltstone–shale lithofacies (F.4) (ZB-047, 2666 m / 2667m) **e**. Cross-bedded sandstone lithofacies (F.5) (ZB-190, 2820 m / 2821 m.) **f**. Parallel and Cross Lamination Sandstone lithofacies (F.6) (ZB-047, 2710 m / 2711 m.).

Sedimentary environment

Modern stratigraphic research tries to determine the sedimentary environments and attempts to construct a sedimentary model for the studied region using information gathered from sedimentary facies, electrofacies and microfacies. The sedimentary environment is defined as a geographically defined part of the earth's surface where sediments accumulate and can be described from a geomorphological and it is characterized by complex physical, chemical and biological conditions that distinguish it from its surroundings [10] .The facies are one of the smallest units of the environment and [11] is the first to establish a link between the sedimentary facies and the sedimentary environment, which became known as Walther's Law. The facies association is defined by the vertical succession of facies, which is determined by the sedimentary environment. It is thought to be a key to the environmental explanation; the succession is caused by a change in the sedimentary environment,which is caused by a change in sea level. It is clear from the preceding that it was possible to determine the sedimentary environment for the Nahr Umr Formation based on the availability and collection of sedimentary evidence including the study of microfacies, sedimentary structures and rock components available in the facies and linking them with the logs study and ths it was possible to determine the sedimentary environment for the Nahr Umr Formation .

Fluvial Environment

This environment has been characterized by fining upwards and the prevalence of high-energy sedimentary structures below these facies is represented by the cross-bedded and planer cross-bedded, respectively, which transform into the low energy structures, represented by the parallel and cross lamination at the top, which indicates the gradual low in the energy of sedimentation.The study of modern rivers indicated that there are two types of sediments formed in the riverine environment, one of which represents coarse sediments at the bottom of the channel that moves as a bed load or as a (suspension load). The suspension load in the stages of high or normal flow [12],while the second of them represents sediments above the banks represented by soft and transported sediments as a suspension load in the stages of floods, and thus the riverine environment can be divided into:

-Channel Lag Deposits This deposit consists of cross-bedded sandstone lithofacies (F.5) (Figure 3e), including coarse-grain sandstone, which is very rough sands resulting from very high energy flows transmitted as a bottom stratigraphic load. Erosion and transport occur in such an environment due to the high energy of the current, and when this energy of the current is reduced, this facies is deposited in the middle of the river channel, which is known as sediments. As a result (lateral accretion), which in turn leads to a decrease in the energy of the rivers responsible for the transport process, a decrease in the grain size occurs at the top, and its facies are (Parallel and Cross Lamination Sandstone lithofacies (F.6) (Figure 3f)., respectively, forming sediments fining upwards.

-Natural Levee Deposits This subenvironment's sediments are deposited near river channels in the form of longitudinal bodies that reach over. The river's two sides are distinguished by a sharp slope towards the channel and a little inclination towards the flood plain. It is more noticeable on concave banks than on convex banks. It has cross-bedded sandstone lithofacies (F.5) (Figure 3e), sandstone–mudstone lithofacies, and siltstone–shale lithofacies (F.4). The higher sections of these facies exhibit a beautiful succession towards the top and these facies (F.5) (Figure s. 3e and 4) (Figure 3d) appear in succession,and finally, towards the top, the facies(F.6) (Figure 3f) and (F.4) (Figure 3d) appear in succession(F.4) (Figure 3d). As the quantity of water carrying suspended materials and the restricted interior increases, so does the energy of this water, which forms horizontal surfing under conditions of heavy run-off at the beginning of the flood stage.

-Flood Plain Deposits Floodplains are large and flat basins positioned along the river's two sides and sediments build in them when water flows through them water crosses into the floodplains. these facies are sometimes distinguished, especially the siltstone–shale lithofacies (F.4)(Figure 3d).

Deltaic Environment

This environment has been distinguished by the appearance of the coarsing sequences upward and the presence of organic materials, plant remains, and amber, which is found in the marshes and swamps environment within the deltaic environment, as well as the response of the spontaneous potential (SP) that shows the funnel shape, which indicates the cycles of coarsing upwards, and these deltas can be counted as the type dominated by the river, through the number of high sediments entering it and the large grain size of sandy grains and the prevalence of sedimentary structures of high energy represented by intermittent stratification and the emergence of shale rocks and the spontaneous potential log tends to resemble the shape electrofacies of the deltaic environment controlled by the river according to [9]. It was feasible to identify it from the south and north Rumaila oil fields and its gradient upwards to a deltaic environment dominated by tides, as evidenced by the spread of sedimentation of channels and tidal flats in the well (ZB-047) and the upper section of the well (ZB-190). This deltaic habitat was developed at the boundary of the seam between the development of Nahr Umr and Mauddud formations, it was formed during the drop in sea level, generating a gradual delta.

-Delta plain Deposits. This environment has cross-bedded sandstone lithofacies(F.5) (Figure 3e). The grain size of the sands in this environment varies consistently (uniform in grain size). Carbonized flakes are abundant at weak stratified levels of stratification are common and spontaneous potential (SP). These facies can be counted with in the sub-aerial part of the deltaic deposits.The subaerial part of the delta represents the sediments of the secondary deltaic channels.

-Distributary Mouth Bar Deposits. This environment's sediments are mostly made up of cross-bedded sandstone lithofacies (F.5) (Figure 3e). This shows coarse sequences towards the top due to the increase in sedimentation energy towards the top, this exhibits coarse sequences near the top. These facies are laid down on top of the prodelta sediments. And such a sequence is explained by the fact that it was deposited in the environment of the developing delta region (Prograding delta front). This may be observed through the behavior of the spontaneous potential, which shows the funnel shape and these represent the underwater part of the deltaic deposits. (subaqueous part of the delta) it represents the environment of the delta front affected by rivers (river-dominated delta front). The effect of the riverine action is evident through the prevalence of discontinuous stratification structures and coarse granular size.

-Distal Bar Deposits The lithofacies of this habitat are false-bedded sandstone–mudstone (Figure 3c). Furthermore, the sand of these facies is fine size due to the presence of thin layers of siltstone–shale lithofacies (F.4) (Figure 3d) and shale lithofacies (F.1) (Figure 3a). This environment's facies display coarse sequences towards the top, which is compatible with the SP log reaction. It demonstrates the funnel shape and the rise in thickness of this environment in the center of the research area. It represents a transitional environment between the prodelta environment from below and the river mouth barrier from the bottom. The upper section is the sloping edge towards the sea, and it is distinguished by an increase in sedimentation pace and grain size towards the top.

-Prodelta Deposits. The environment is characterized by shale lithofacies (F.1) (Figure 3a) and siltstone–shale lithofacies (F.4) (Figure 3d) which exhibit the phenomena of coarseness towards the top. This ecosystem is distinguished by fine sediments, which result from slow accumulation of sediments in a calm environment. We infer from the types of rocks and sedimentary structures indicate that these facies correspond to the underwater component of the deltaic deposits lying inside the environment of the delta front.

-Tidal Channel & Tidal Flat: The presence of facies in this setting demonstrates the delta change from a river-dominated delta. Several signs were found in the core in the study wells, particularly in the well (ZB -047). It gradually fines in granular size towards the top, reflecting the phenomenon of fining towards the top the gradation in sedimentary structures towards the top, from high energy sedimentary structures at the bottom to distinctive low energy sedimentary structures (flasher and lenticular stratification) at the top. The presence of the latter is one of the important indications of the sedimentation of mixed intertidal flats, with the presence of mudstone and sandstone and bioturbation in the upper part of these sequences. The following describes each of these sedimentary structures. In the lower part of this core, sandstone facies were observed. This type of application results from the effect of displacement of sand waves or large ripples marks, due to the currents of the flood and island cities. Then it is topped by the basin stratification of the same previous facies [13]. This type of structure results from the displacement of the large ripples marks under the influence of tidal currents at the bottom of the tidal channels (subtidal sub environments). It is also called the lower tidal flat [13] then it grades upwards, revealing the facies of the falser bedded sandstone–mudstone lithofacies (F.3) and facies of the lenticular bedded sandstone-mudstone(F.2). Widespread in this part and finally the facies of shale lithofacies (F.1) all these environments and facies appear in the lower member of the mixed unite(Figures 4 and 5)

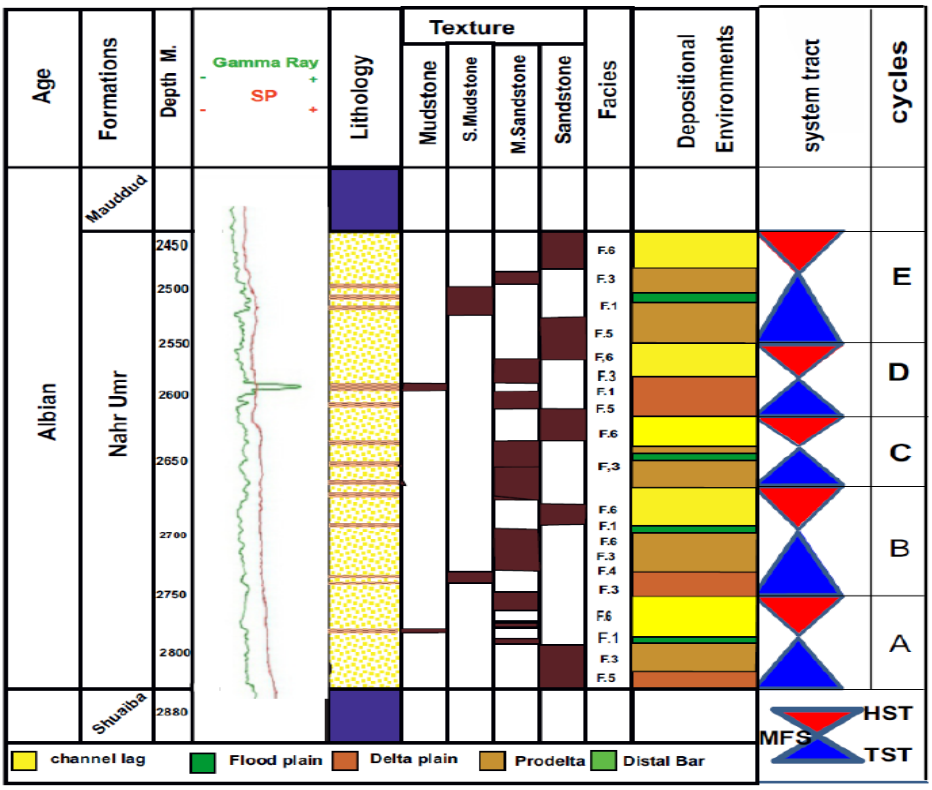

Figure 4: Sequence stratigraphy and depositional environment of Nahr Umr Formation at ZB-190.

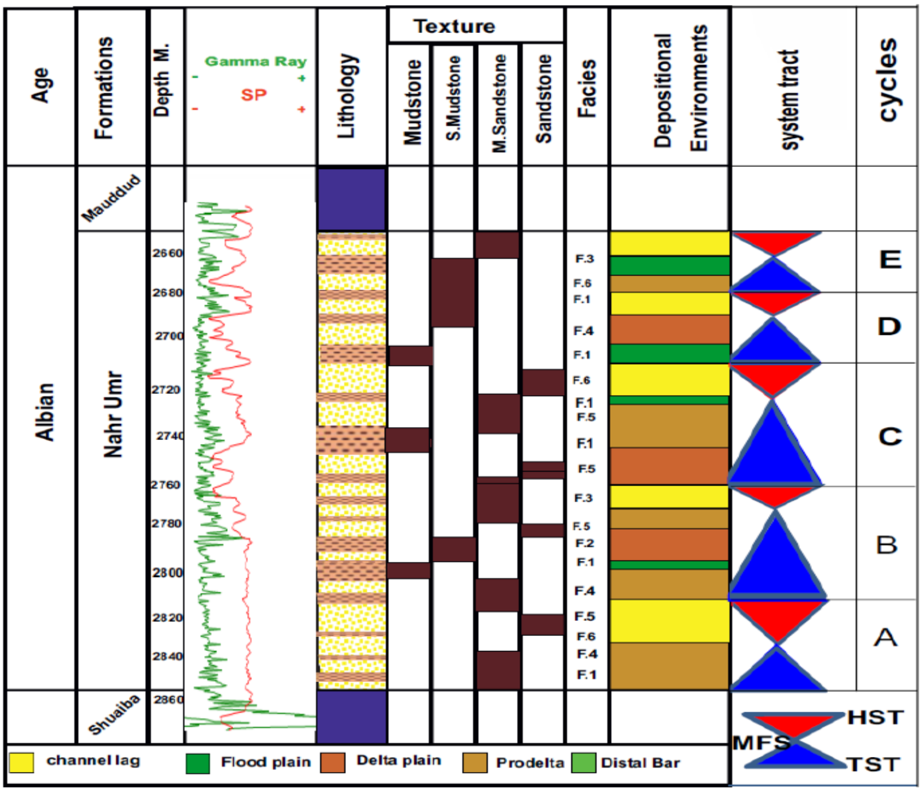

Figure 5 : Sequence stratigraphy and depositional environment of Nahr Umr Formation at ZB-047.

Sequence Development of the Nahr Umr Formation

The sequence analysis of the Nahr Umr Formation under study indicates that the formation includes an integrated sedimentary cycle with part of a second cycle, as the facies were distributed within the sedimentary systems according to two successive cycles as the facies were distributed within the sedimentary systems according to two successive cycles of sea-level variations. Sequence of the first cycle begins with a surface of erosion, which represents the boundary of the sequence type one (SB1) .As the result of the significant drop in the relative sea level during the stage of the marine retreat(regressive), causing the erosion of the old sediments by the river drilling operationsand controlling the amount of drilling in general, the presence of plant texture resistant to the river erosion processes and this limit is the beginning of the deposition of the Nahr Umr Formation. Then deposited on the surface of erosion sediments of river channels within the valleys dug within the course of the lowstand system tract (LST). These sediments are characterized by high thicknesses of sandy bodies with lateral and vertical extensions, forming vertical patterns of aggradation. Its thickness varies mainly depending on the depth of erosion within the valley (the size of the generated accommodation space) this was evident in the study wells. The increase in the rate of relative sea-level rise and the lack of preparation contributes to the deposition of layers of shale, represented by the marine flooding surface within the sediments of this tract.

In the early stages of sea-level rise, the deposition of the sands of the deltaic channels begins, indicating the beginning of the deposition of the transgressive system tract (TST), which is separated from the lowstand system tract (LST) by a layer of shale rocks represented by the swamp shale or the floodplain, which represents the transgressive surface (TS). With the increase in the rate of rising the relative sea level, the size of the accommodation space increases, which contributes to finning the channels upwards, forming sediments from Gulfs with sedimentation continues within the transgressive system tract (TST) as a result of the increase in the influence of tidal processes, the sediments of mixed tidal flats are deposited in a regressive staking pattern towards.With the continuous rise in the relative sea level, there is an increase in the deposition of layers of lamination shale represented by the shallow sea shale with the deposition of coastal sandstone, (transgressive ravinment surface) appearing within the course of the transgressive system tract (TST) separating the tidal deposits from the shallow sea shale with the continuation of the increase in sea level rise reflects an increase in the depth of water and an increase in the thickness of the shale deposits to reach its maximum height when sediments of the shallow, this records the highest reading of the gamma ray log continuously horizontally in study wells at the middle of the formation and this reflects the maximum flooding surface (MFS) which separates the transgressive system tract (TST) from the highstand system tract (HST). Deposition of the sandstone of the marine shelf begins with a decrease in the sedimentation of the shale layers forming cumulative staking patterns (aggradational) within the highstand system tract (HST) and then continues decreasing at the relative sea level transforming into progradation patterns and this is reflected by the logs curves (GR, SP) which indicate (coarsening-shallowing upwards) and with continuous decreasing, a sequence boundary of type two (SB2) is formed at the end of this tract to end there the first sequence and the thickness of this tract increases in the north and south of the field.The sequence boundary of type two (SB2) represents the decrease in sea level indicating the beginning of the second stratigraphic sequence, which shows the deposition of sandstone of the river channels as it reflects progressive staking patterns towards the basin represented by the shelf margin system tract (MFST) then the sediments begin to finning and the shale layer appears at the top of the Nahr Umr Formation, which reflects the regional marine progress and marked the sedimentation of the Mauddud Formation that separates it from the Nahr Umr Formation on the regional transgressive surface (TS) and that supports and confirms the deposition of this surface at the top of the Nahr Umr Formation the presence of this surface at the top of the Burgan Formation in Kuwait is represented by the shale facies of dark black color with little biological influence caused by the sedimentary environments of lakes (Lagoon) [13], (Figures 4 and 5).

Conclusions

The Nahr Umr Formation in the Zubair oilfields is composed of sandstone and shale with a thin layer of siltstone . The sandstone in the Nahr Umr Formation is classified (Quartz arenite) at about 95% with a small percentage of rock fragment and feldspar .

The Nahr Umr Formation was deposited within a fluvial and deltaic environment and consisted of six lithofacies: shale, lenticular bedded sandstone–mudstone, false bedded sandstone–mudstone, siltstone–shale, cross-bedded sandstone, and parallel and cross-lamination sandstone. Nahr Umr Formation was affected by many diagenesis processes which are: compaction and cementation. The stratigraphic surfaces were distinguished in sequences of the Nahr Umr Formation, represented by the sequence boundaries type one (SB1), which indicates the beginning of the sedimentation of the Nahr Umr Formation, and the sequence boundaries type two (SB2) that appeared in the upper part of the formation. The other surface was represented by the end of the deposition of the Nahr Umr Formation and the emergence of the transgressive ravinement surface (TRS) within the transgressive system tract (TST), and the maximum flood surface (MFS) was distinguished in the middle of the formation, and each of these surfaces had a lateral extension along the study sections.

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