

Facies analysis and stratigraphic development of the Albian Succession in Nasiriyah Oil Field, Southern Iraq

Aiad Ali Al-Zaidy, Marwah Hatem Khudhair

University of Baghdad, College of Science, Department of Geology

Abstract— The Carbonate - Clastic succession in this study is represented by the Nahr Umr and Mauddud Formations deposited during the Albian Sequence. This study includes facies analysis and stratigraphic development for this succession in 5 boreholes within Nasiriyah oil field.

There are several types of microfacies were recognized in the succession of the Mauddud Formation. Their characteristic grain types and depositional texture enabled the recognition of six facies associations (depositional environments) were distinguished in the Mauddud Formation, they are: shallow open marine, restricted, reef, slope, deep open marine and basinal.

Two types of rocks are observed within the Nahr Umr Formation; the first is the upper part which characterized by shale dominated rocks and the second (lower part) is characterized by sand dominated rocks. Four facies associations (depositional environments) were distinguished in the Nahr Umr Formation, they are: delta plain, prodelta, bay fill, and distributary channels.

The microfacies analysis and reconstructed the paleoenvironments of the Albian basin in the studied area; there are three stages of the deposition: - during the first stage the sea level was rise which led to progress prodelta facies (retrogradation) and onlapping the unconformity. This part is represented by TST stage in all studied boreholes. The prodelta facies was changed to distributary channel facies up-ward to mark the mfs between these two facies. This refers to deposition during the high stand period as two cycles. The sea level was reactivated to progress after the last step of Nahr Umr deposition, to start the Mauddud Formation deposition.

At second stage the facies change was shown three steps of the sea level rise (TST) to deposition the restricted, reef-back reef and shallow open marine/slope. Overlying the slope facies to the shallow marine and then deposited the shallow marine refer to maximum flooding surfaces after deposition the last ones. Therefore, the shallowing up-ward succession which deposition later was represented the high stand stage (HST).

The final stage is represented by reactivated the sea level rise to deposition the basinal facies within the Mauddud Formation. The continued rise in sea level during the period of transgression (TST) is a preparation for the Ahmadi basin, which is characterized by deposition in a deep environment and conformable lower contact with the Mauddud Formation.

Keywords— *Petrophysical Properties, Reservoir development, Albian Succession and Nasiriyah Oil Field.*

I. INTRODUCTION

Clastic-carbonate succession which including the Nahr Umr and Mauddud Formations are represented a part of Albian-Early Turonian Sequence (Wasi'a Group), (Cretaceous period). The present study includes five boreholes (Ns-1, 2, 3, 4 and 5) within the Nasiriyah oil field. The study area is located in the South of Iraq. This field is representing a subsurface anticline with Northwest to Southeast direction axis within the Mesopotamian Zone, figure (1).

The Nahr Umr Formation was defined by Glynn Jones in 1948^[1] from the Nahr Umr structure in South Iraq. The two major depocentres in central and South Iraq correspond to areas which received clastics from the Rutba Uplift and the Arabian Shield. In its type area in Southern Iraq, the Nahr Umr Formation comprises black shale bedded with medium to fine grained sandstones with lignite, amber, and pyrite ^[1]. The proportion of sand in the formation increases towards the Salman Zone.

The Mauddud Formation includes the Upper part of Qamchuqa Formation and is the most widespread Lower Cretaceous formation in Iraq. Its thickness varies due to lateral facies changes and erosional truncation. At outcrop in NE Iraq the Qamchuqa Formation comprises organodetrital, detrital and locally argillaceous limestones with variable degrees of dolomitization. In some areas fresh- or brackish-water limestone beds were reported ^[1]. In Southern Iraq, the Mauddud Formation comprises frequently dolomitised organodetrital limestone.

The present study involves petrophysical properties of the Nahr Umr and Mauddud Formations, and the effects of

diagenetic development on reservoir properties, with construction of a reservoir model for these formations.

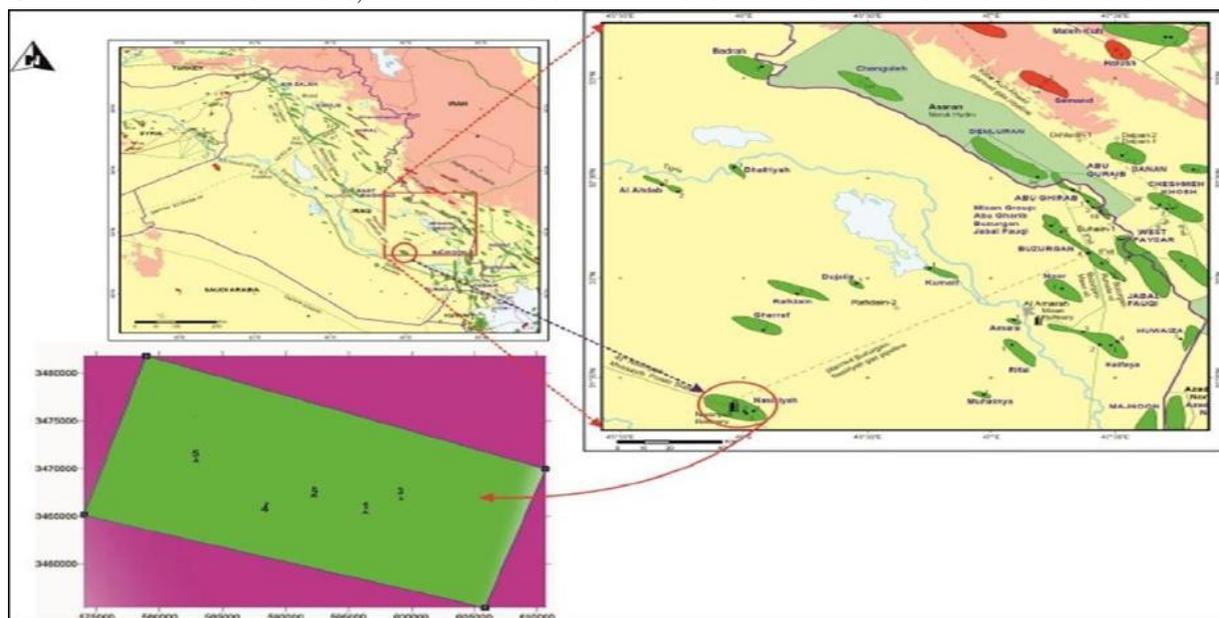


Fig.1: Location map of Study area

II. FACIES ANALYSIS OF MAUDDUD FORMATION

The textures and fabric of the carbonate rocks for Mauddud Formation are classified according to Embry and Klovan's classification [2] modified from Dunham [3]. The approach of Burchette and Brittens [4] in grouping facies types as "association" rather than a single type or class was followed. The facies associations were compared with the models of standard microfacies and depositional environment belt of carbonates proposed by Wilson [5] and Flugel [6].

There are several types of microfacies were recognized in the succession of the Mauddud Formation; their characteristic grain types and depositional texture enabled the recognition of paleoenvironment.

Microfacies (A):- Orbitolina - wackestone to packstone
This facies is mainly composed of Orbitolina and shell fragments (mollusk), echinoderms, pellets and calcareous algae (Plt 1.a). Such microfacies reflect a shallow open marine.

Microfacies (B):- Textularia/hedenbergella wackestone
The second most common microfacies is the textularia, and hedenbergella limestone. With echinoderm and calcareous algae (Plt 1.b). This may reflect an open marine.

Microfacies (C):- Globigerina wackestone to packstone
The main constituents are Globigerina and small benthic foraminifera with few red algae (Plt 1.c). This microfacies reflects a deep open marine 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 rounded grains are inferred, from their biform size, ovoid shape where the dominance of relatively coarse to fine (sand sized) and moderate sorted peloids (Plt 1.d).
- pelletal wackestone to packstone is characterized by the abundance of the uniformly of small particle size and consistent shape of these grains (silt sized well sorted pellets) (Plt 1.e).

Microfacies (E):- Intraclasts packstone

Two types of this microfacies were distinguished in the succession Bioclats (Rudist and other shell fragments) (Plt 1.f), and Mudstone to wackstone shell fragment packstone with micro convolute structure (Plt 1.g). This may reflect to brecciated slope deposits.

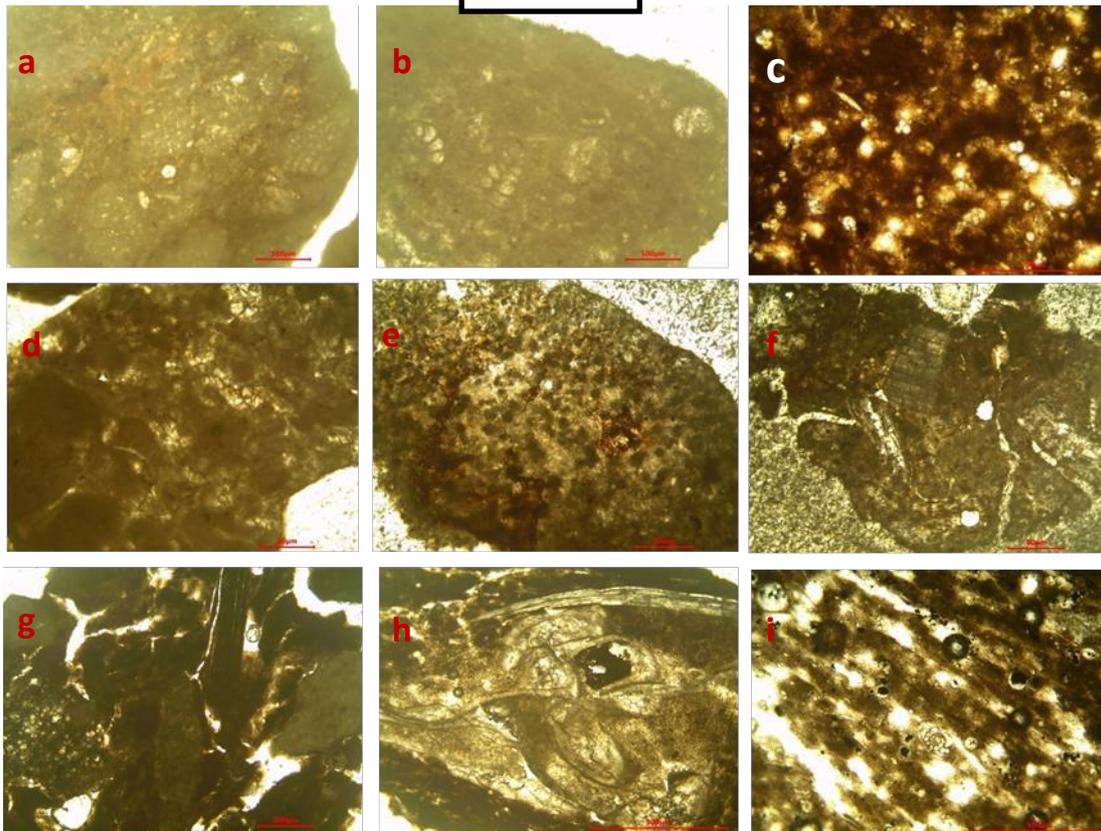
Microfacies (F):- Rudist boundstone to rudstone .

This is a less common microfacies distinguished in most wells. It is composed of rudist fragments and other shell fragments (gastropod and mollusk) (Plt 1.h). This microfacies is identified as backreef to reef environment.

Microfacies (G):- Basinal green shale

These facies is appeared in the upper part of Mauddud Formation as Globigerinal and calcisphere shale and shaly limestone. This facies is observed in the reflected by gamma ray log response addition to thin section diagnostic (Plt 1.i).

Plate- 1



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|----|--------------------------------------|----|--|
| a. | Orbitolina - wackestone to packstone | f. | Rudist intraclasts packstone |
| b. | Textularia/hedenbergella wackestone | g. | Mudstone to wackestone intraclasts packstone |
| c. | Globigerina wackestone to packstone | h. | Rudist boundstone to rudstone. |
| d. | Peloidal wackestone to packstone | i. | Basinal marl to marly limestone |
| e. | Pelletal wackestone to packstone | | |

III. PALEOENVIRONMENTS OF MAUDDUD FORMATION

Six facies associations (depositional environments) were distinguished in the Mauddud Formation, they are: shallow open marine, restricted, reef, slope, deep open marine and basinal (Fig.2).

- Facies association 1:- shallow open marine
The Orbitolina wackestone to packstone is the main microfacies which reflect the open marine conditions. It is characterized by high diversity in components where contained upon the Orbitolina as major component addition to Echinoderms, gastropods fragments, small benthic foraminifera and lithothamnium algae.
- Facies association 2:- restricted shallow marine
The restricted shallow marine facies association is largely consisting of peloidal and pelletal wackestone-packstone. Other important compounds are rudist fragments, and mollusk, echinoderm and green algae.
- Facies association 3: reef and back reef environment

This associated is represented by Rudist boundstone to rudstone which composed of rudist as a main compound. Also consists of Mollusca (pelecypoda and gastropoda) and algae.

- Facies association 4: slope environment
This is the less common facies association in the Mauddud Formation. It is characterized by various microfacies such as Intraclasts packstone - wackestone, bioclastic-Orbitolinid- packstone, and foraminiferal - rudistid wackestone - packstone. The main components of these environments are intraclasts rudist fragments, and Mollusc fragments.
- Facies association 5: deep open marine
The planktonic mudstone to wackestone with abundant Globigerina sp. With few small benthic foraminifera reflects deposition in a deep marine environment of the outer ramp.

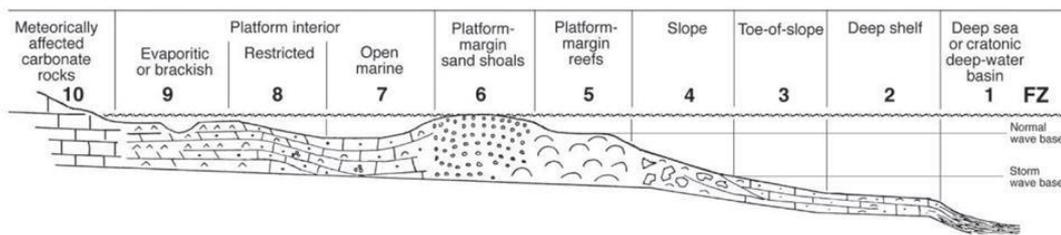


Fig. 2: Rimmed carbonate platform: The Standard Facies Zones of the modified Wilson model^[7].

- Facies association 6: basinal environment

This facies association is represented by planktonic foraminifera and calcisphere marl and marly limestone. This facies is reflected to deposition in the basinal environment. The high value of gamma ray log response referred to clay compound in this facies.

IV. FACIES ANALYSIS AND PALEOENVIRONMENTS OF NAHR UMR FORMATION

Two types of rocks are observed within the Nahr Umr Formation; the first is the upper part which characterized by shale dominated rocks and the second (lower part) is characterized by sand dominated rocks. Five major lithofacies were recognized in the succession of the Nahr Umr Formation according to the petrographic observation with gamma ray and spontaneous potential well logs to determine the paleoenvironment.

- Well sorted Quartz arenite Lithofacies (1):- Its represents the fine grained sandstone dominated rocks of Nahr Umr Formation. This characterized by well sorted quartz arenite, with very low gamma ray values with box shape of GR log (Plt 2.a).
- Poorly sorted Quartz arenite Lithofacies (2):- Its represents wide range of grain size of sandstone (fine-coarse), within the sandstone dominated rocks of Nahr Umr Formation. This characterized by poorly sorted quartz arenite, with very low gamma ray values with box shape of GR log (Plt 2.b).
- Poorly sorted graywacke Lithofacies (3):- This lithofacies represents the upper part of the sandstone member, and characterized by poorly sorted graywacke sandstone with moderate values of gamma ray (funnel shape) (Plt 2.c).
- Sandy shale Lithofacies (4):-This facies is appeared in the lower part of the shale member of Nahr Umr Formation, which characterized by high gamma ray values with funnel shape and sand lenses. high gamma ray values with box shape (Plt 2.d).
- Shale Lithofacies (5):- This facies represent the lower part of Nahr Umr Formation. Its characterized by high gamma ray values with bell to funnel shape (Plt 2.e).

V. PALEOENVIRONMENTS OF NAHR UMR FORMATION

In the present study, four facies associations (depositional environments) were distinguished in the Nahr Umr Formation, they are: delta plain, prodelta, bay fill, and distributary channels. This distinguished was according to Coleman, and Prior (1981), Emery (1996), Kindall (2003) and Rachmawati (2011).

1. Delta plain

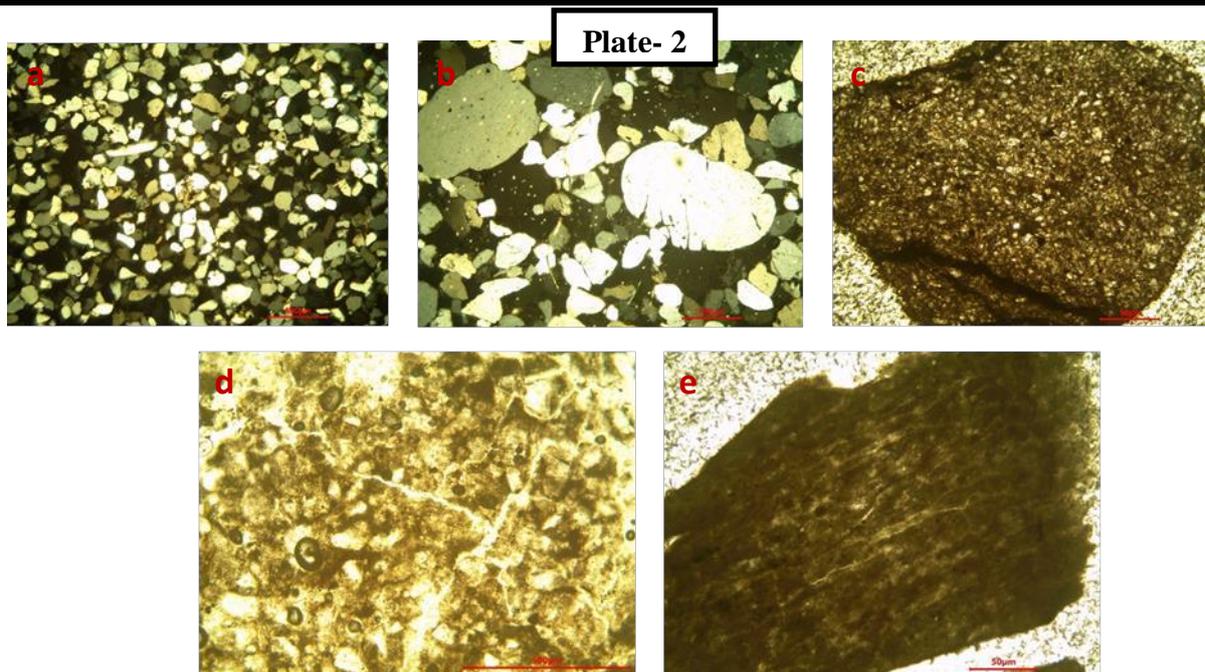
These shallow inland-restricted inter distributary lakes constitute an important environment in many upper delta plains and occur in all climatic settings. The delta-fill forms a wedge of coarse clastics within an overall deposit consisting of fine-grained organic-rich clays from lacustrine and back swamp deposits, which normally displays a coarsening-upward trend.

2. Delta front

Prodelta silts and clays grade landward and upward vertically into the coarser silts and sands of distal bar. Directly at the mouths of the active distributaries lie the coarsest sand deposits. These deposits are commonly referred to as the distributary-mouth bar. If sediments deposited seaward of the river mouth accumulates faster than subsidence or removal of sediments by marine processes occurs, deltaic progradation will take place and the subaerial deltaic deposits will overlie the uppermost parts of the subaqueous delta, forming a complete delta sequence^[8].

3. Bay fill

Bay-fill sequence and variations in log response that can occur within such a sand body. The sand body generally displays a fan-shaped wedge, with the thickest sands generally being found near the initial break in the distributary channel. Often, sands in this vicinity display a sharp base scoured into the underlying inter distributary bay and marsh deposits (Coleman, and Prior, 1981). Away from the initial break, however, the typical coarsening-upward sequence (or inverted bell-shaped logs) becomes clearly the type of log response.



- a. Well sorted Quartz arenite Lithofacies
- b. Poorly sorted Quartz arenite Lithofacies
- c. Poorly sorted graywacke Lithofacies
- d. Sandy shale Lithofacies
- e. Shale Lithofacies

4. Distributary channels

Braided Rivers exhibit numerous channels that split off and rejoin each other to give a braided appearance. They typically carry fairly coarse-grained sediments down a fairly steep gradient. Deposits of Braided Rivers tend to be coarse-grained and contain abundant amalgamated channels. The vertical sequence shows a fining-upward grain size relationship; a few coarser layers are found near the upper one-third of the sand body. The sand body has a scoured base, and often coarse, organic trash (logs, limbs and clay clasts) is found intercalated with the sandy units. Thin clay and silt layers often separate coarse.

VI. BASIN DEVELOPMENT

The studied succession was deposited during the Albian age, after the sea level was made the unconformable surface between the Shuaiba Formation and Nahr Umr Formation. The microfacies analysis and reconstructed the paleoenvironments of the Albain basin in the studied area; there are three stages of the deposition: -

- The first stage: During this stage the sea level was rise which led to progress prodelta facies (retrogradation) and onlapping the unconformity. This part is represented by TST stage in all studied boreholes. The prodelta facies was changed to distributary channel facies up-ward to mark the mfs between these two facies. This refers to deposition during the high stand period as two cycles (Fig. 4).

The sea level was reactivated to progress after the last step of Nahr Umr deposition, to start the Mauddud Formation deposition.

- The second stage: the facies change during this stage was shown three steps of the sea level rise (TST) to deposition the restricted, reef-back reef and shallow open marine/slope.

Overlying the slope facies to the shallow marine and then deposited the shallow marine refer to maximum flooding surfaces after deposition the last ones. Therefore, the shallowing up-ward succession which deposition later was represented the high stand stage (HST).

- The third stage: This stage is represented by reactivated the sea level rise to deposition the basinal facies within the Mauddud Formation. The continued rise in sea level during the period of transgression (TST) is a preparation for the Ahmadi basin, which is characterized by deposition in a deep environment and conformable lower contact with the Mauddud Formation.

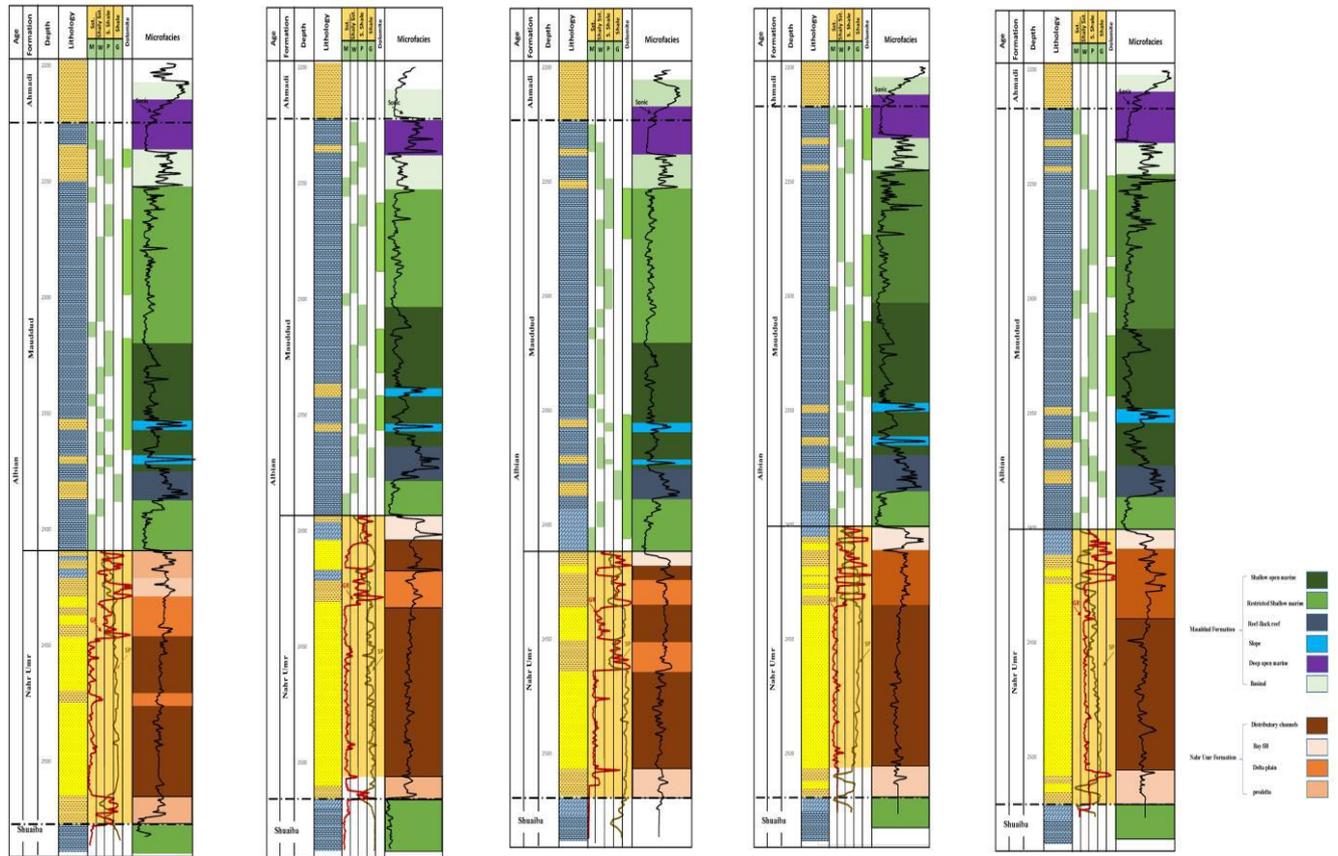


Fig. 3: Lithology and Microfacies of the five wells Ns-1, 2, 3, 4, and 5.

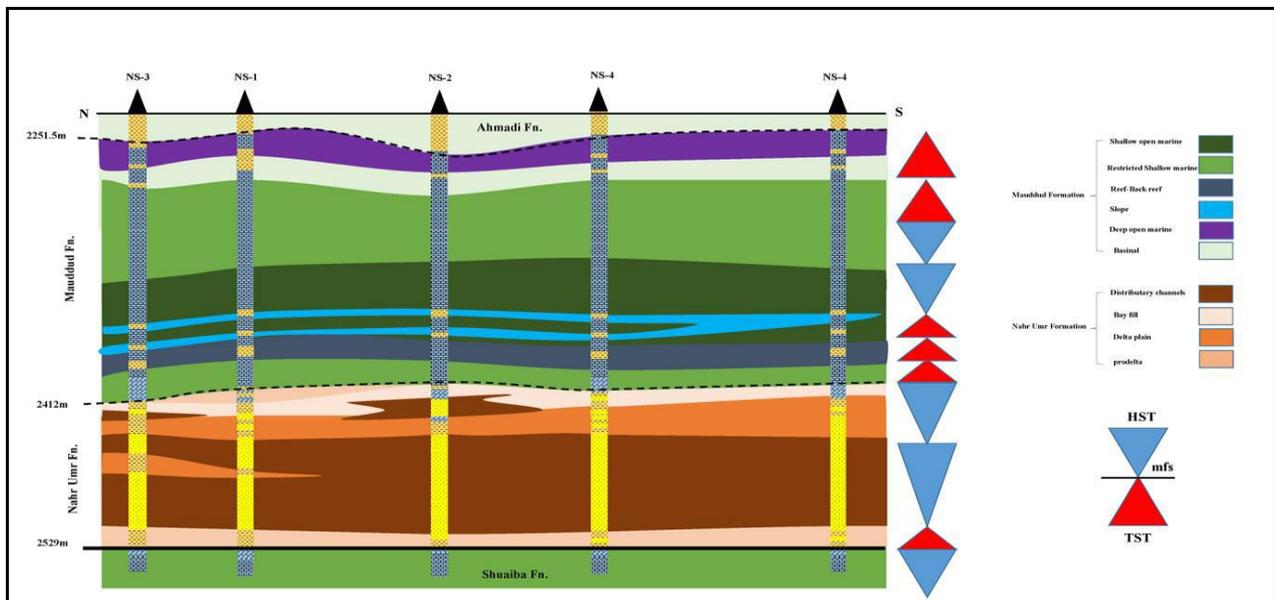


Fig. 4: Depositional model of the studied section

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