Facies Analysis of Abu Roash (G) Member and Upper Bahariya Formation of Asala-Samra Oil Fields, North Western Desert, Egypt

Mohamed Fathy[1], Mahmoud Bekhit[1], Momen Mohamed [2]

[1.] Department of Geology, Al-Azhar University, Cairo, Egypt
[2.] Qarun Petroleum Company, Cairo, Egypt
Geomomen1987@gmail.com

Abstract: The main producible reservoirs in Asala-Samra oil fields are Abo Roash G member as a primary target and Upper Bahariya Formation as a secondary target. These reservoirs is divided into seven facies, which were described from total 4 wells on the basis of the sedimentological description using wireline logs and borehole images with ditch cuttings and core descriptions from reports that showed different depositional settings. These facies are of marginal marine and are interpreted as: (1) open coast tidal flat where sand ridges rests on prograding mudstone (2) distributary mouth bar of fluvial dominated delta indicated by the prograding gamma ray log trend, however, this facies showed minor tidal effect indicated by mud drapes, (3) distributary channel of deltaic settings that showed cutting into underlain strata, (4) distal mouth bar of deltaic settings where sandy fringe is in front of the active mouth bar, (5) tidal bars of tide dominated estuary facies where indications of facies deepening up, (6) intertidal flats of estuary settings that showed heterolithic bedding with facies shallowing upward, and (7) intertidal channel cutting into intertidal flats with shallowing upward facies.
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1. Introduction

1.1. Location

The area selected for the study is located in Asala, Samra fields, East Bahariya concession in the Kattaniya inverted basin, North Western Desert, Egypt (Fig.1). The study area lies in the North-Eastern portion of the Western Desert of Egypt, between latitudes 29° 27' 29" N- 29° 25' 44" N and longitudes 29° 30' 47" E - 29° 27' 17" E.

The Western Desert, occupies an area approximately 700,000 km2, of the total area. It comprises the area west of the Nile River and Delta. It extends 600 to 800 km2 from the Nile Valley to the Libyan border in the West, and 1000 km2 from the Mediterranean Sea to the Sudanese border in the South.

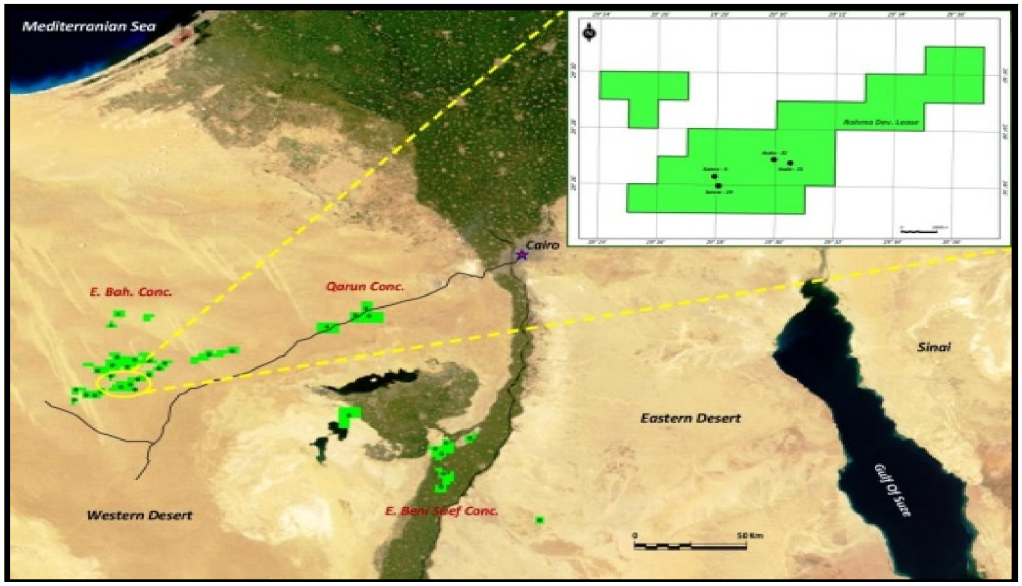

Fig.1: Location map of Asala-Samra oil fields, East Bahariya concession, Western Desert, Egypt.

1.2. Aim of study

The main objective of this study is to highlight on the facies analysis to delineate the reservoirs distribution of the producible zones in the study area. The study mainly based on the analysis extracted from borehole with core and ditch cutting reports. The borehole data consists of wireline logs of 4 wells comprising Gamma ray, resistivity and neutron/density logs with borehole image. The facies analysis requires describing the lithology on basis of sedimentary structure, accessories, gamma rays trends, ichnofacies, etc., then interpreting these descriptions on the basis of knowledge of its indications and how it relates to the depositional environments. The shapes of gamma gay log represents certain depositional environment, however description based on well logs should be supported by other tools such as the above mentioned tools.

1.3. Stratigraphy

The total stratigraphic thickness, despite some anomalies increases progressively from about 600 ft. in the south to reach about 25,000 ft. to the north and northeast along the coastal area. The main part of the North Western Desert is covered by thin blanket deposits of Miocene rocks which unconformable overlie old strata (Said, 1962). The stratigraphic section of the North Western Desert is thick and includes most of the sedimentary succession from recent to Pre-Cambrian basement complex (Moustafa, 2003) (Fig.2). The sedimentary sequence of the study area based on deepest well ranges in age from the Early Jurassic Ras Qattara Formation to Miocene Moghra Formation. The Cretaceous mega-sequence is divided into Lower and Upper sequences, the Lower Cretaceous includes Alam El Bueib, Alamein, Dahab and Kharita formations while the Upper Cretaceous sequence incorporates Bahariya, Abu Roash and Khoman formations (Hantar, 1990). The Late Cretaceous Abu Roash "G" Member and Upper Bahariya Member represent the main reservoirs in the study area. In the study area Abu Roash "G" consist of shale, sandstone, limestone with siltstone streaks.

2. Material and Methods:

The key to the interpretation of facies is to combine observations made on their spatial relations and internal characteristics (lithology and sedimentary structures) with comparative information from other well studied stratigraphic units, Facies successions represent distinctive log curve patterns. The shape of well log curves can be related to certain facies successions, which resemble their grain size succession (Selley, 1978) (Fig.3), However, description based on well logs should be supported by other tools. In this study (as mentioned before) the available tools for the stratigraphic description are the borehole images, ditch-cutting, and cores reports.

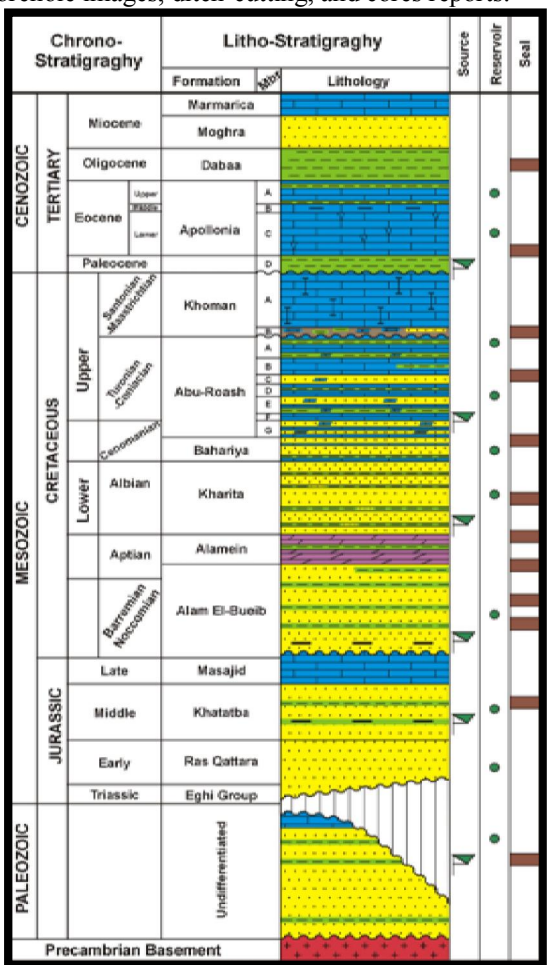

Fig.2: Generalized Stratigraphic column of the North Western Desert of Egypt. (Moustafa, 2003)

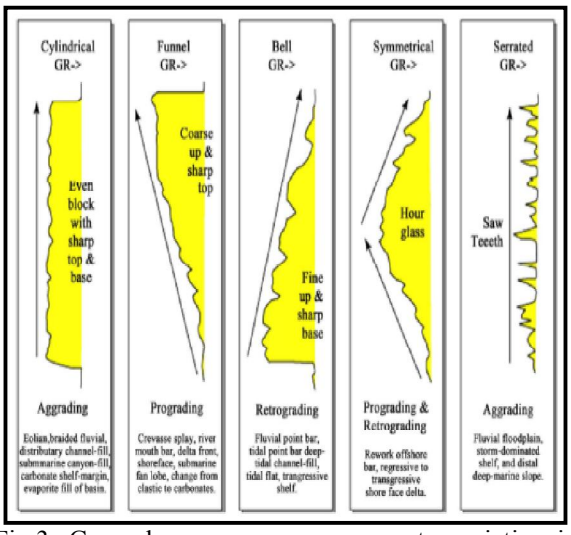

Fig.3: General gamma ray responses to variation in grain size (Selley, 1978)

3. Results:

3.1. Facies Analysis

3.1.1. Facies (1):

Facies description:

This facies consists of shale which is of greyish to greenish color sub-flakey, moderately firm, with traces of glauconite and pyrite. In Well (Z) the shale overlain by sandstone of fine- to medium- grained sandstone, grading to silt size, with sub-rounded to rounded, sub spherical and moderately sorted. This sandstone had facies change to siltstone in well (W). On gamma ray log, this facies showed slight fining upward at the lower interval and coarsening upward at the upper interval. Also the borehole image showed for Well (Z) cross bedded sandstone of low angel and mud drapes of darker colors.

Facies interpretation:

According to the available wireline and ditch cuttings data with absence of core data this facies is suggested to be of open coast tidal flat (chenier plains) (Fig-4-6). Those are widely separated, sub-parallel beach ridges termed cheniers. These are commonly composed of sand, but may be formed of shells or vegetative matter. They rest on a silt or clay substrate and are isolated from the shore by a belt of tidal mudflats sandy ridges that lie above prograding muddy deltaic sediments (Reading, 1996), the sand ridges sit above a muddy substrate deposited by shoreline progradation; the sandy ridges were suggested to be formed by minor transgression and reworking (Reading, 1996). This facies is represented in well (Z) by Upper Abo Roash (G) sandstone interval (Fig.4).

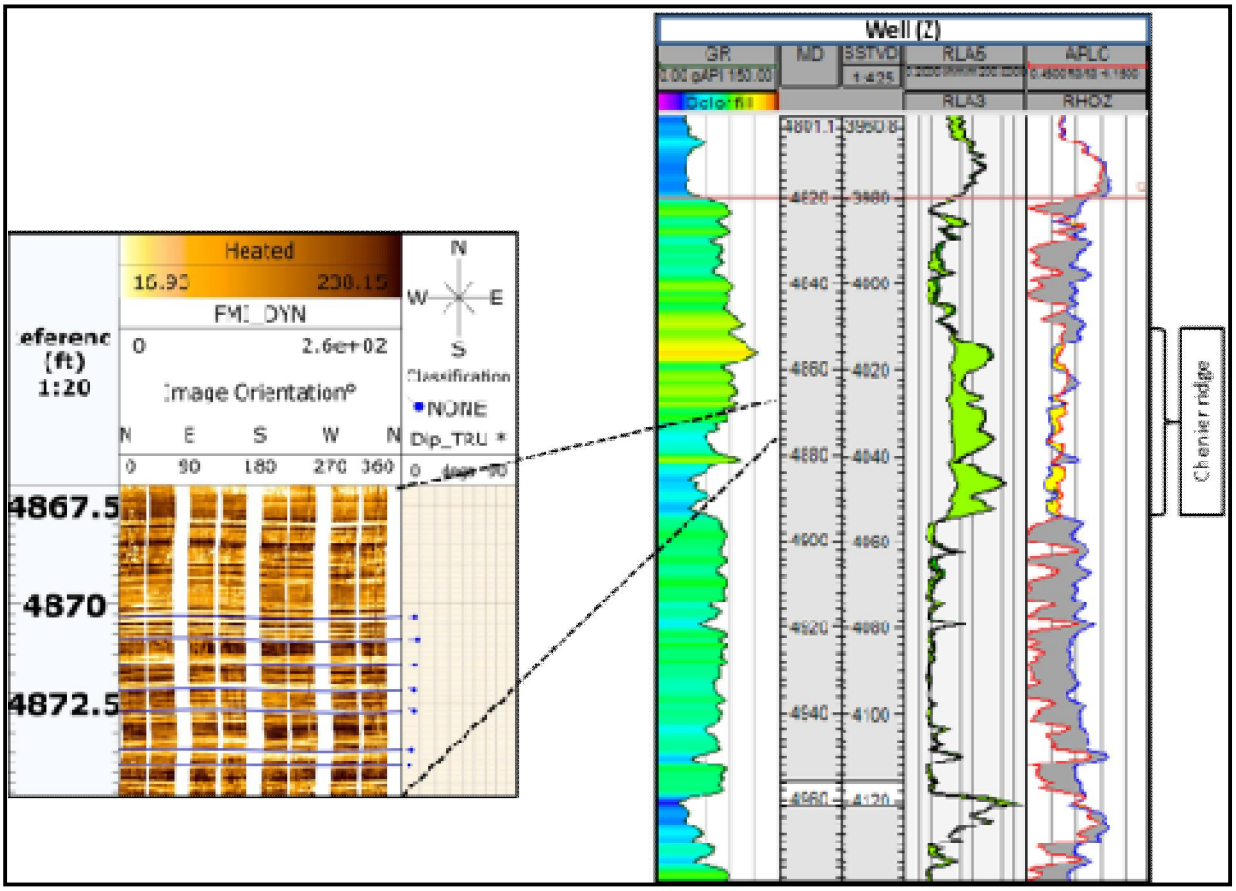

Fig.4: U. ARG in Wireline log and borehole image Well (Z)

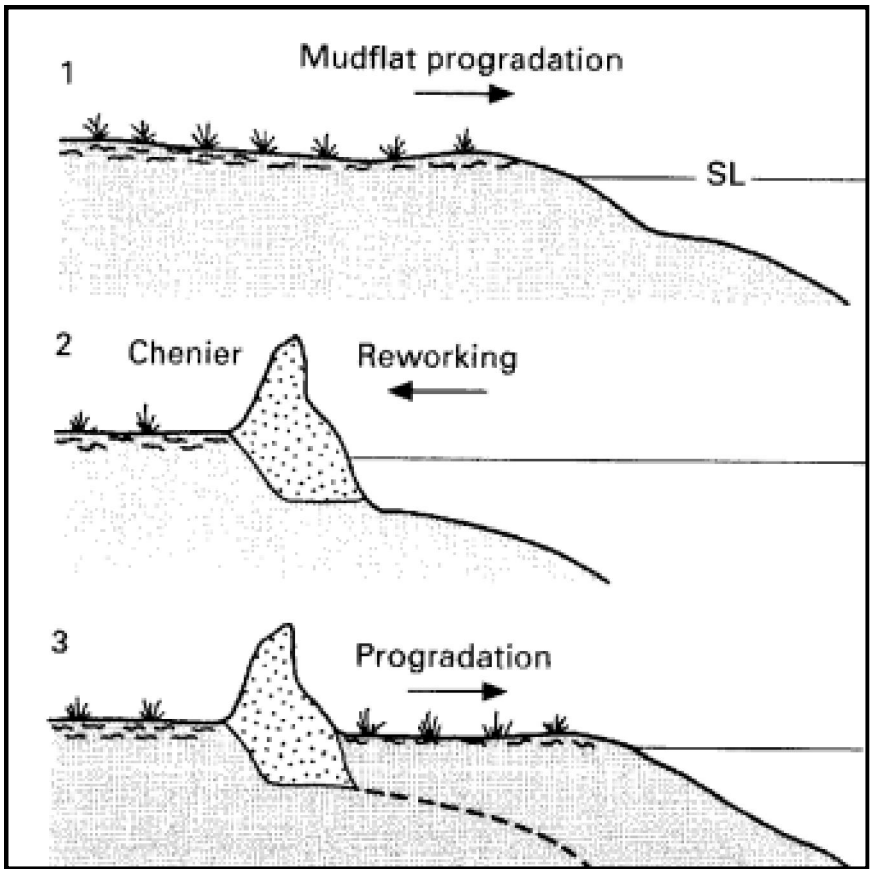

Fig.5: Chenier formation by means of alternating mudflat progradation and wave reworking (Reading H.G., 1996)

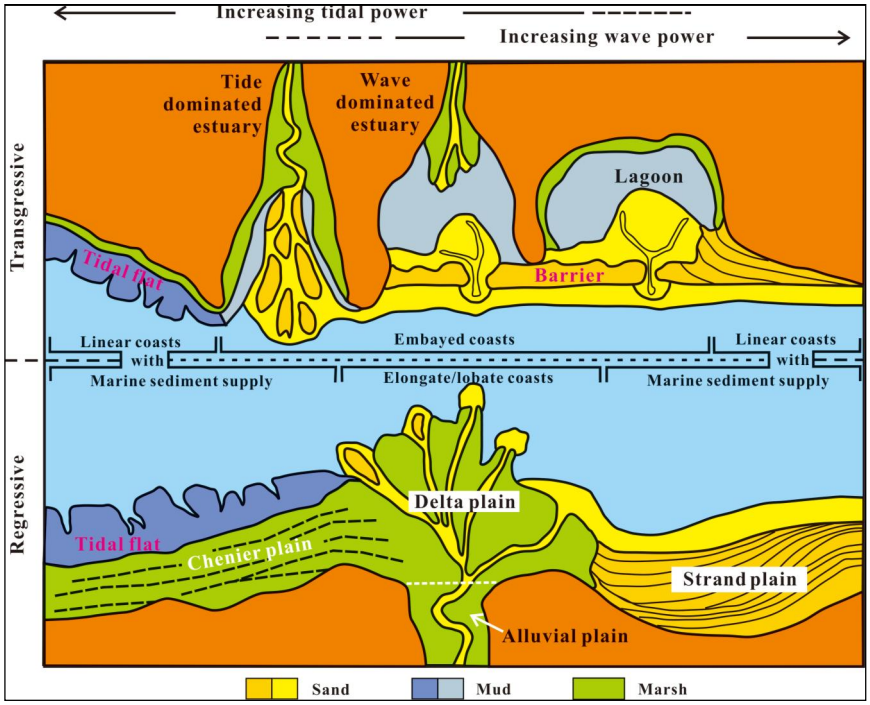

Fig.6: The distribution of major coastal depositional features (after Boyd et al., 1992).

1.1.1. Facies (2)

Facies description:

This facies consists of shale which of greyish color sub-flakey, moderately firm, with traces of glauconite and pyrite overlain by sandstone of fine- to medium- grained sandstone, grading to silt size, with sub-rounded to rounded, moderately to well sorted. This sand could be divided according to gamma ray trend into two intervals; the lower body of box shape (no trend) and upper with funnel shape (coarsening upward). The borehole image showed two behaviors of sedimentary structure; as shown in (Fi.7) the internal sedimentary structure of the sandstone is cross-bedding of very low angle, and also it showed (in parts) high angle cross-bedded and massive sandstone.

Facies interpretation:

This facies suggested to be interpreted as a distributary mouth bar (Fig.6, 7, 10) that partially cut by distributary channel. Also Another scenario for this interval is a complete distributary channel cutting the mouth bar reaching the prodelta; that indicated by the abrupt change from the prodelta shale to the upper sandstone that missed the normal grading from shale through siltstone to sandstone as it appeared in the surrounding wells, this facies is represented by Middle Abo Roash (G) Sandstone interval in Well (W) (Fig.7).

1.1.2. Facies (3):

Facies description:

This facies consists of shale which is characterized by greyish green color, sub flakey, moderately firm, with traces of glauconite and pyrite, those are overlain by siltstone of brownish color, grading to very fine-grained sandstone, sub blocky and moderately hard in which it was overlain by sandstone of fine- to medium-grained, sub rounded to rounded, moderately sorted. The sandstone is characterized by coarsening upward trend on gamma ray and porosity logs. The borehole image showed the internal sedimentary features as very low angle cross bedded sandstone with intercalation of sandstone, siltstone and shale layers and mud drapes. Also a coal seam was detected at the top of the interval at depth 5183 ft.

Facies interpretation:

The coarsening upward gamma ray pattern indicated deltaic facies especially with the absence of the faunal content in addition to the sedimentary structure from the image log that illustrated unidirectional flow of the fluvial dominant deltaic settings (Fig.6, 10). The delta facies is regarded as river dominated with minor tidal influence that was indicated by mud drapes. The interval showed transition from marine conditions to a subaerial setting. The marine conditions indicated by the presence of pyrite and glauconite in the shale which interpreted as prodelta. The subaerial settings at the top indicated by absence of the marine faunal content and presence of coal seam. This succession indicated progradational coarsening upward pattern from fine-grained sediment of prodelta to coarser-grained sediments of mouth bar, this facies is represented by Middle Abo Roash (G) Sandstone interval in well (X) (Fig.8).

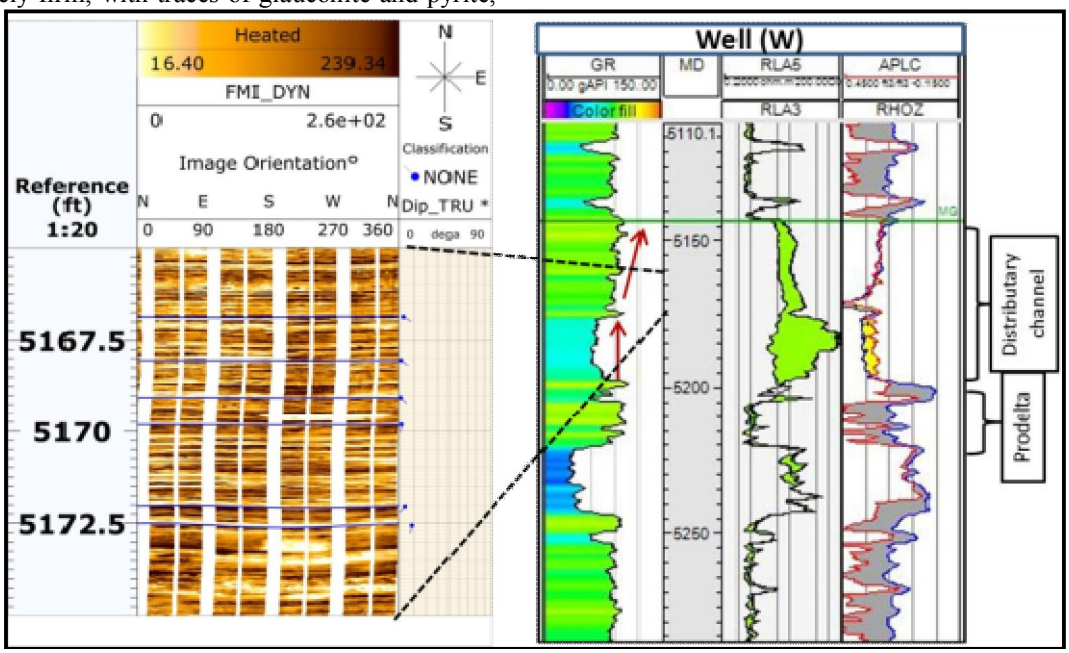

Fig.7: M. ARG in Wireline log and borehole image of Well (W)

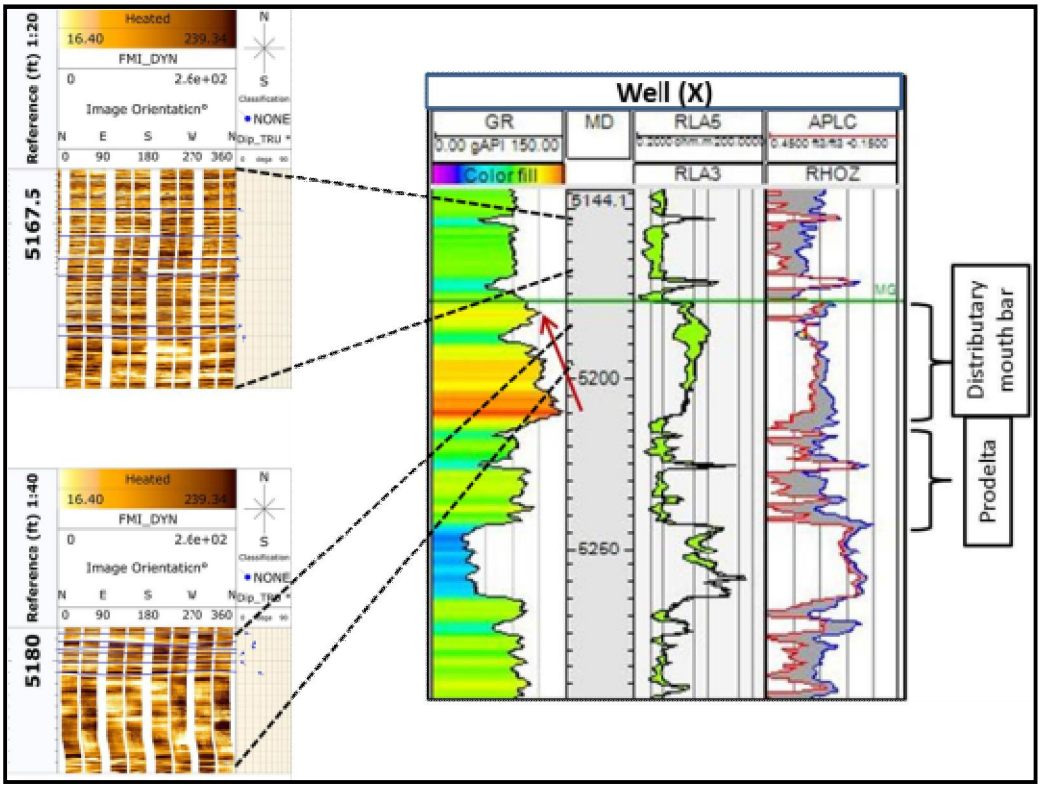

Fig.8: M. ARG in Wireline log and borehole image of Well (X)

3.1.2. Facies (4)

Facies description:

This facies comprised of shale which characterized by greyish color sub-flakey, moderately firm, with traces of Glauconite and Pyrite, Overlain by intercalation between shale and very fine sandstone grading to silt size with coarsening upward trend on gamma ray log.

Facies interpretation:

Those are the characteristics of the distal place to distributary mouth bar in which is referred as the distal delta front (Fig.10) and can form a relatively continuous sandy fringe in front of the active mouth bar or it could be related to the interdistributary bay which is the sheltered area of shallow water characterized by finer grains due to the low energy sedimentation. This facies is represented by Middle Abo Roash (G) Interval in well (Y) (Fig.9).

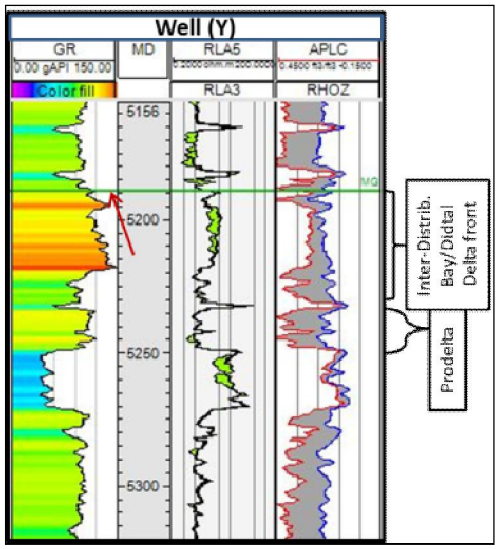

Fig.9: M. ARG in Wireline log of Well (Y)

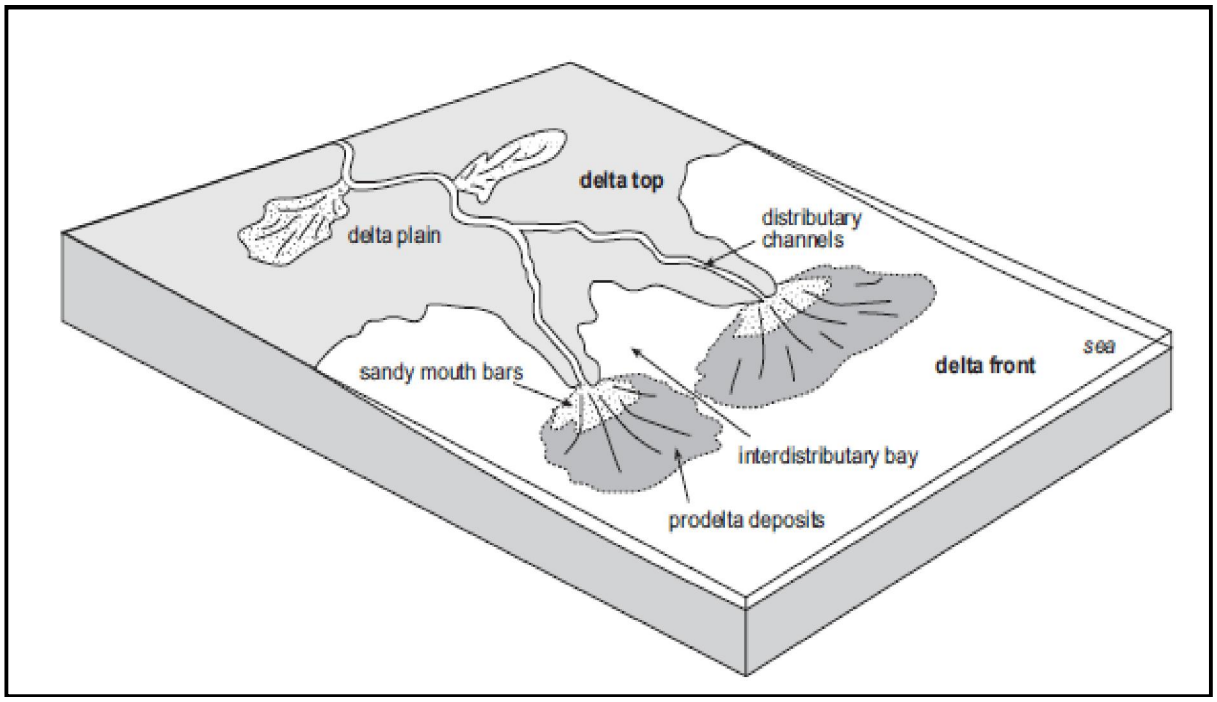

Fig.10: Flurival dominated delta subenvironments (Nichols, 2009)

3.1.3. Facies (5)

Facies description

This interval divided into three zones; from bellow (Zone-1) which comprised of shale of greyish color, moderately firm, flakey to sub-flakey, overlain by sandstone of very fine- to fine-grain size, sub rounded to rounded. The zone characterized by abrupt change from shale to sandstone with coarsening upward trend on gamma ray and porosity logs in sandstone.

As shown on borehole image the zone was highly bioturbated and characterized by scour base between the sandstone and the underlying shale.

Going upward the overlain (Zone-2) comprises shale of dark grey color, sub blocky to sub flakey, overlain by sandstone of very fine grained to silt size, sub rounded to sub angular moderately sorted, The zone characterized by coarsening upward trend on gamma ray and porosity logs. The borehole image showed highly bioturbation which destroyed the internal sedimentary structure. Upward from the last zone is (Zone-3) in which is comprised of shale of dark grey color sub blocky to sub flakey, occasionally interbedded with siltstone, also comprises small beds of sandstone. the sandstone to the mudstone ratio changes from one well to another. The borehole image showed decrease in bioturbation compared to other zones.

The upper zone is (Zone-4) which comprises siltstone of green and brown color, highly glauconitic, interbedded with limestone of greyish white color, and high marine fossil content.

Overall, the facies showed decrease in grain size and a decrease in bioturbation intensity from the lower zones to the upper zone.

Facies interpretation

All above is suggested to be tide dominated estuarine environment (Fig.11, 12) which indicated by the facies deepening upward from sand to shale to limestone of marine condition, and each sandstone body suggested to be tidal bar indicated by the coarsening upward trend on gamma ray of each sandstone body, scour base of the lower zone which believed to be due to macrotidal current, as the currents of macrotidal regions are strong enough to cause local scouring (Nichols, 2009), also the tidal influence was indicated by the mud drapes as shown on borehole image and core images. Each tidal bar is overlain by intertidal mudflats that are covered at high tide and exposed at low tide. Water flooding over these areas with the rising tide spreads out and loses energy quickly: only suspended load is carried across the tidal flats, and this is deposited when the water becomes still at high tide. (Nichols, 2009). This facies is found in the 4 wells and is represented by Lower Abo Roash (G) intervals (Fig.11).

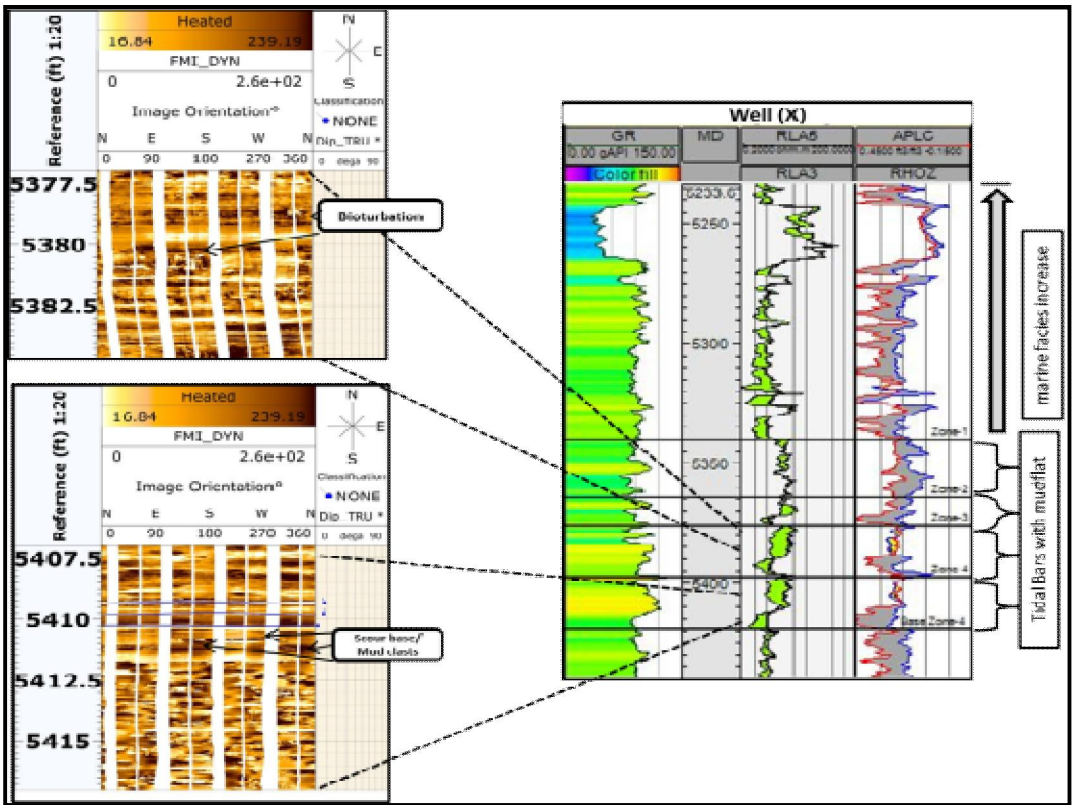

Fig.11: L. ARG in Wireline log and borehole image of Well (X)

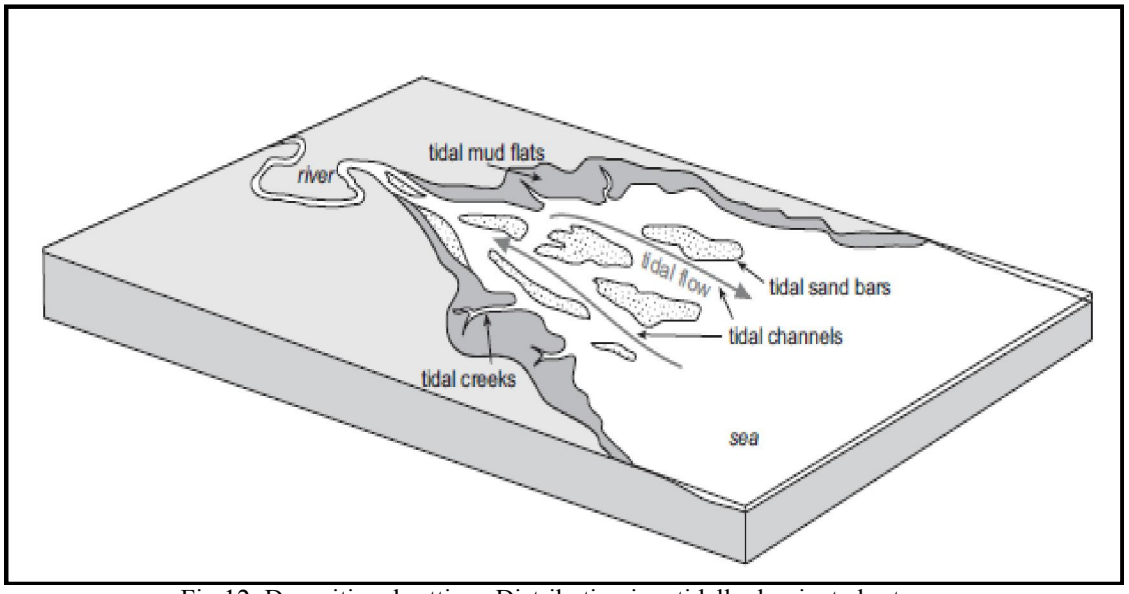

Fig.12: Depositional settings Distribution in a tidally dominated estuary

3.1.4. Facies (6)

Facies description:

This facies comprised of sandstone of white to off-white fine-to very fine-grained grading to silt size, sub rounded moderately sorted sandstone with traces of glauconite and pyrite. The sandstone is intercalated with siltstone and shale in which the siltstone is of brownish and greyish color soft to moderately hard, glauconitic in parts, and contains pyrite. The shale is of green, grey, brown color with Sub-blocky, sub-flakey and contains free glauconite and pyrite. These facies were overlain by offshore marine facies of shale and carbonate. The facies showed intercalation between sandstone, siltstone and mudstone that of

heterolithic bedding, in places the sandstones is dominated and in other places the ratio is equal and in other places the mudstone is dominated. From the gamma ray log (Fig.13) the facies showed coarsening upward with serrated trend. From the borehole image the facies showed in Well (X) a cross bedding with some features which could be discriped as bioturbation or soft sediment deformation (Fig.13).

Facies interpretation:

According to the facies described above, the facies was suggested to be of intertidal flats due to the heterolithic bedding indicated by the intercalation between Sandstone and Mudstone as it represents tidal flow periods (Sandstone) and slack-water periods of mud drapes (Mudstone), also the tidal influence indicated by the bioturbation which in parts destroyed the internal structure like mud drapes and cross bedding. Although the tidal flats are characterized by the fining upward trend but these facies showed coarsening upward trend which represent transgressive tide dominated estuary setting indicated by landward shift of the depositional settings from mud dominated through mixed dominated to sand dominated in which all of it is overlain by offshore marine facies of shale and carbonate. This facies is represented by U. Bahariya interval in well (X) (Fig.13).

3.1.5. Facies (7)

Facies description:

The facies consists of interval dominated by shale overlain by interval dominated by sandstone, the shale is of green, grey and brown color with sub blocky, sub flakey and contains free glauconite and pyrite, the overlain sandstone is of off white color, fine- to very fine-grained size, grading to silt size, sub-rounded, sub-spherical, moderately sorted.

The borehole image in parts showed bioturbation in sandstone interval which destroyed its internal structure, also it showed scour base (Fig.14).

Facies interpretation:

The sandstone facies is related to the previous facies of intertidal flats as it is suggested to be intertidal channel indicated by the scour base as described above and resting directly on shale of mudflat without going through mixed facies. This facies is represented by Upper Bahariya interval in well (Z) (Fig.14).

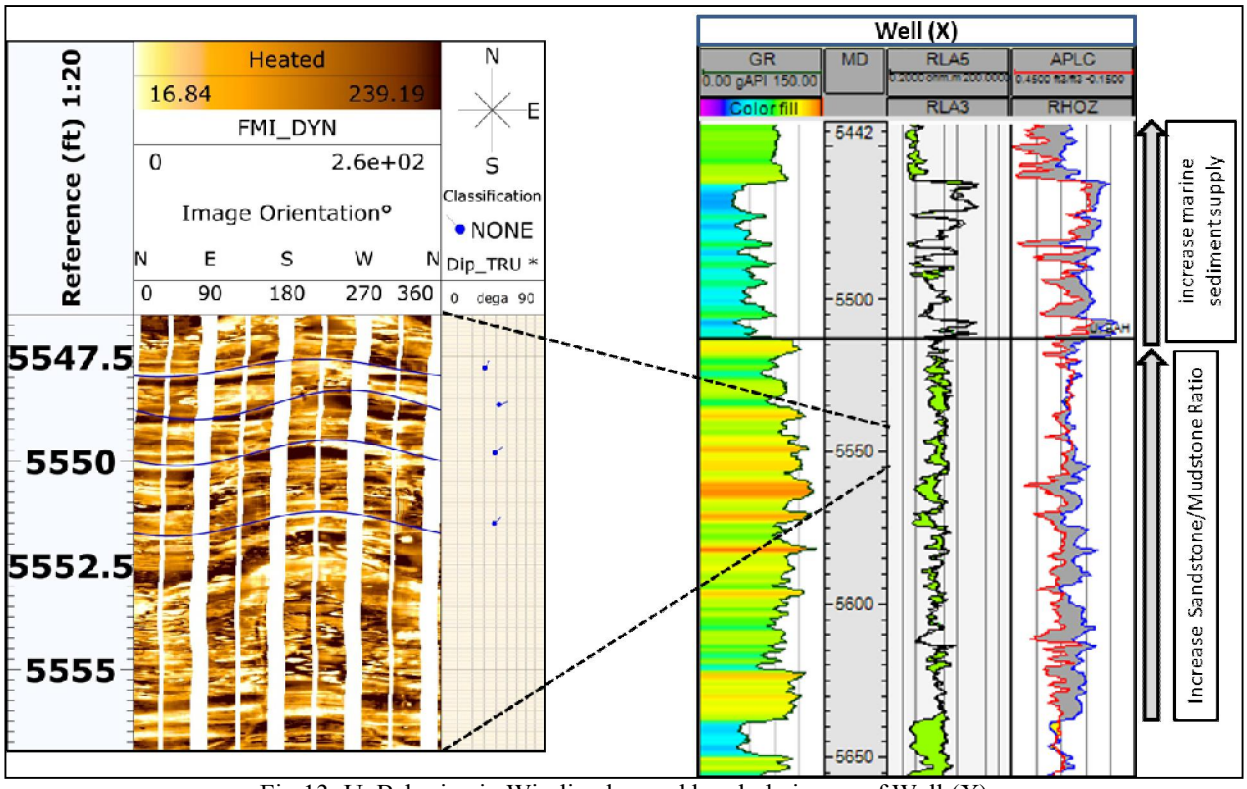

Fig.13: U. Bahariya in Wireline log and borehole image of Well (X)

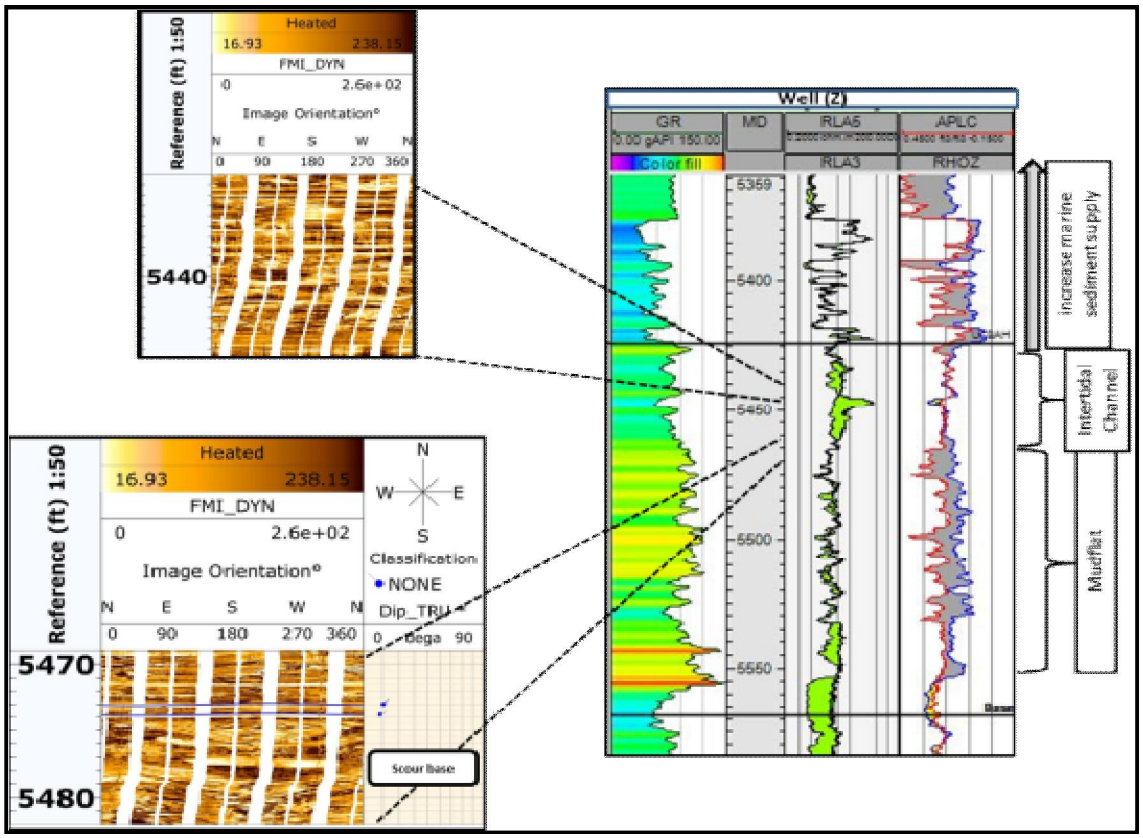

Fig.14: U. Bahariya in Wireline log and borehole image of Well (Z)

4. Summary and Conclusion

Integrating sedimentological knowledge of sedimentary structure and sedimentation process with the study of modern environment allows knowledge of distribution of paleoenvironments, that was done by describing the facies in a sedimentological frameword using wireline logs, borehole image, core image reports, and mud logs of 4 wells to interpret these facies in a depositional environment context, That displayed seven facies represents seven subenvironment varying between open coast tidal flat that characterized Upper Abo Roash (G), river dominated deltaic environment that characterized Middle Abo Roash (G), and tide dominated estuary environment that Characterized Lower Abo roash (G) and Upper Bahariya. These facies are as follow:

1. Open coast tidal flat that was represented in U. Abo Roash (G).
2. Distributary channel of fluvial dominated delta that was represented in M. Abo Roash (G).
3. Distributary mouth bar of fluvial dominated delta which was represented in M. Abo Roash (G).
4. Interdistributary bay or distal delta front which was represented in M. Abo Roash (G).
5. Tidal bar of tide dominated estuary, that was represented in L. Abo Roash (G).
6. Intertidal flat that was represented in U. Bahariya
7. Intertidal Channel that was represented in U. Bahariya

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