International Journal of Scientific & Engineering Research Volume 8, Issue 7, July-2017
ISSN 2229-5518

Characterizations of the Late Cenomanian Reservoirs in Asala Field, East Bahariya Concession, Northern Western Desert, Egypt.

Tharwat M. Abd Elhafeez[1], Mohamed Fathy[1], Hany H. Abd Elaal[2] and Ahmed Abd Ellatief[3],

Abstract— The study aimed to combine the different available data to understand the subsurface system and the characteristic of reservoirs in Asala Field to represent the vertical and lateral heterogeneity at the well, multi-well, and field scale, which could be used as a tool for reservoir management. Seismic interpretation was conducted on the seismic sections that concerned the study area to make a detailed structural interpretation to determine the structural geometry of the horizons. Petrophysical well log analysis of the reservoir rock of Lower and Middle zones of Abu Roash "G" member have been done and mapped. The estimated volume of Original Hydrocarbon in Place of Lower and Middle zones of Abu Roash "G" member have been calculated.

Index Terms— Reservoir, effective Porosity, hydrocarbon saturation, payzones, shale volume, Tectonic setting, and structure.

1 Introduction

The Western Desert of Egypt covers an area of approximately 700, 000 km2, which represents two thirds of the total area of the country (EGPC, 1992). Oil fields in these areas exploit oil mainly from siliciclastic and carbonate rocks and rarely from fractured basement rocks. These areas exploit oil mainly from siliciclastic and carbonate rocks and rarely from fractured basement rocks. The Northern Basins of the Western Desert were initially formed as a single rift, probably during the Permo-Triassic, which had been developed into a pull-apart structure. Marine conditions are recorded in the Jurassic. The East Bahariya concession study area lies in the north-eastern portion of the western Desert of Egypt (around 170 kilometres south west of Cairo), between latitudes 29° 20' N- 29° 40' N and longitudes 29° 20' E- 29° 40' E (Fig.1). The study area encompasses the Asala Field (seven wells; AS-4, AS-13, AS-19, AS-20, AS-22, AS-27 & AS-40 distributed in the field as shown on the base map). In the eastern part of the region, where the area under investigation is situated, there are some of these features such as the Abu Roash positive structural and topographic element, the Wadi El-Natrun and the Birket Qarun negative elements. Such elements offer some of the prominent topographical or geological features. The East Bahariya concession was awarded to Apache and Repsol (operator) on March 19th, 1996. The original area was 5600 Km2, reduced presently to 2848Km2 after the second relinquishment (Fig. 1.1). The original operator, Repsol acquired a total of 2350Km2 of 2D seismic data. The practical work of this research will focus in the Asala Field located in the southern part from East Bahariya concession. The main oil producing horizons are some sandstones of the Coniacian-Santonian to Cenomanian Abu Roash Formation (units C, E and G), and the upper part of Cenomanian Bahariya Formation.

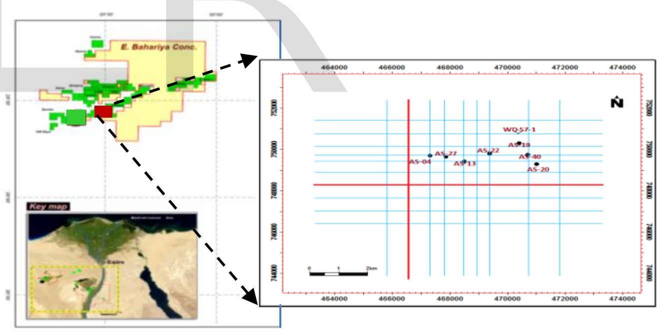


Fig.1. Location Map of Asala Field, East Bahariya Concession, North Western Desert.

2 MATERIALS AND METHODS

Interpretation was conducted on seismic lines and (SP, GR, Resistivity, Density, Neutron and caliper) logs of seven wells extracted from Asala Field (Fig.1). Integrated methods involving seismic interpretation and petrophysical data analysis were employed to meet the objectives of this study. Interpretations of seismic sections were done, Lower and Middle zones of Abu Roash "G" member were identified and evaluated by generating various maps such as structural, net reservoir isopach, arithmetic average water saturation, arithmetic average effective porosity maps, and arithmetic average Shale Content.

3 Geological Setting

3.1 Stratigraphic setting

The stratigraphic section of the North Western Desert is thick and includes most of the sedimentary succession from recent to Pre-Cambrian basement complex [1] (Fig.2).The sedimentary sequence of the study area based on deepest drilled well ranges in age from Precambrian Basement relief to Miocene Moghra Formation at surface (WD57-1 well). 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 [2]. The Late Cretaceous Abu Roash "G" Member represent the main reservoirs in the study area, it is a Late Cenomanian in age [3]. It is heterogeneous both vertically and laterally, and becomes sandy through Abu Gharadig basin [4]. In the study area Abu Roash "G" Member consist of shale, limestone, sandstone, with siltstone streaks.

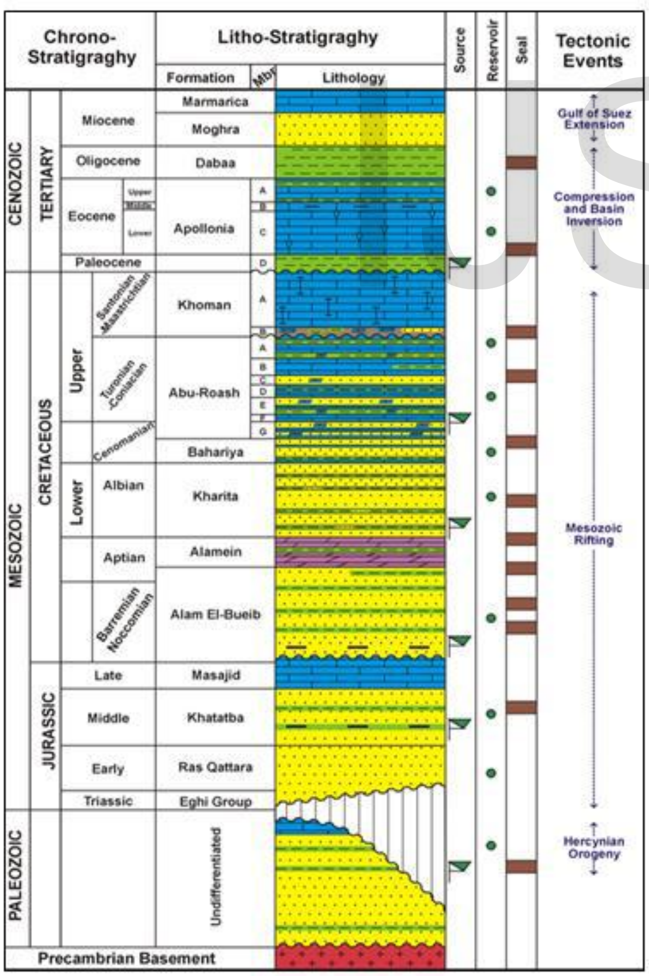


Fig. 2. Generalized Stratigraphic column of Northern Western Desert [5].

3.2 Tectonic setting

The structural patterns in northern Western Desert from the Precambrian to Early Tertiary appear to have been influenced significantly by two primary tectonic forces related to Tethyan plate tectonics: (1) the sinistral shear during the Late Jurassic to Early Cretaceous and (2) the dextral shear during the Late Cretaceous to Paleocene time [6]. Interpreted seismic section (x-line 5530) was selected in order to illustrate the picking of horizons and structure features in the study area. This section shows ten seismic reflectors were picked (Basement relief, Khatatba, Alamein, Upper Bahariya Formations, Abu Roash "G", Abu Roash "C", Abu Roash "A", members, Khoman, Apollonia and Dabaa formations).

3.2.1 North-South trending seismic section (x-line 5530)

This seismic section was oriented to the N-S direction of the study area (Fig. 3) passing through Asala-4 well. Late Cretaceous reflectors seem to be parallel, semi parallel and gradually dipping toward the north. A set of normal faults affect the sequence especially the Late Cretaceous sequence (Upper Bahariya and Abu Roash formations) and older unites. These faults also influences on top of Khoman and Apollonia formations which less deformed than the older Bahariya and Abu Roash formations, the effect of these faults terminates at base Dabaa Formation.

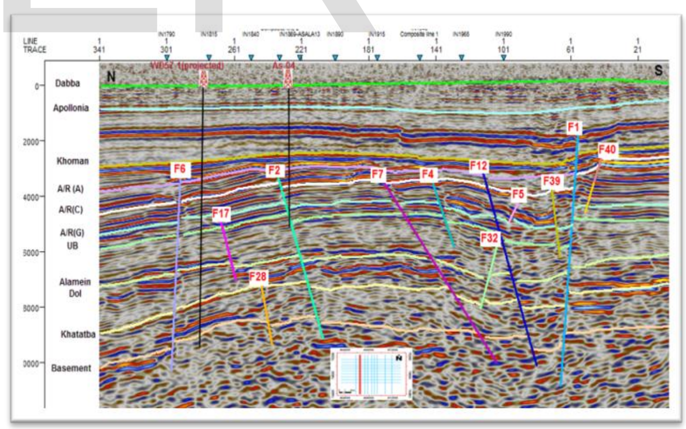


Fig.3. N-S trending seismic section (x-line 5530) passing through Asala-4 well.

4 Structure Contour Maps

Structure contour maps constructed on top Abu Roash "G" member, (Fig.4) shows that the structurally low areas exist in the north part along the major NE-SW fault and in the northwestern part of the study area recording depth values between 5000 ft. to 5700 ft. and structurally high recording depth values in the central area and northeastern part from 4000 ft. to 4500 ft.. Both faults trends related to dextral convergence between Africa and Eurasia, Africa and Eurasia

International Journal of Scientific & Engineering Research, Volume 8, Issue 1, July-2017
ISSN 2229-5518

changed from sinistral divergence to dextral convergence until the Late Cretaceous ([7]; [8]). The movement formed some basins grabens and half-grabens, each bounded by a major fault on its down dip side. Away from this fault, the dip angle of the rocks within the basin decreases and at the extreme up dip edge of the basin, they have a very gentle dip and are usually referred to as platforms and these constructed high area at the south and in the central part in the trend NW formed closures making trapping to hydrocarbon at this main target reservoir rock level in the study area and the basin increasing to the northern part of the study area.

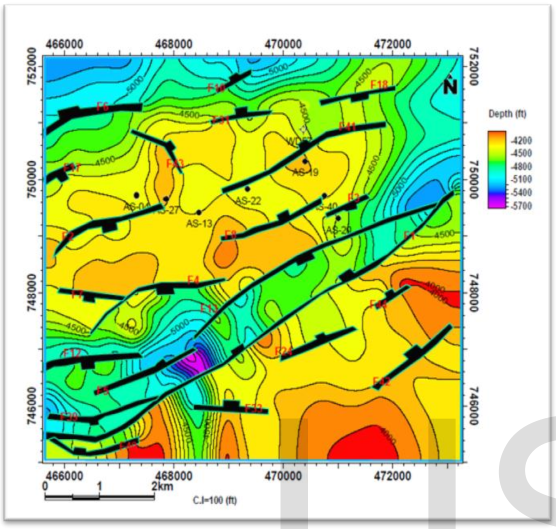


Fig. 4. Depth Structure Map of Top Abu Roash "G" Member.

5 ISOPACHMAPS BASED ON 2D EXTRACTED FROM 3D SEISMIC DATA:

5.1 Late Cretaceous

(Fig. 5) is an isopach map (based on 2D seismic data) of the Upper Cretaceous A/R "G" Member (between top Bahariya and top A/R'G'). This sequence exhibits maximum thickness to the central, western and southeastern parts of the study area. It also shows thinning of this unit in southern and southwestern parts of the mapped area. The change in the thickness of the A/R"G" ranges from 400 ft. to 1050 ft.. From the depth structure map and isopach map of the A/R 'G', the main basin is trending in the northwestern part of the study area.

6 WELL LOGGING ANALYSIS

6.1 Neutron Density crossplot

Middle Abu Roash "G" zone represent the middle clastic reservoir zone of Abu Roash "G" Member, (Fig. 6) shows the neutron density crossplots that have been applied on the Middle Abu Roash "G" zone. It is observed that, the reservoir sandstone plotted points are scattered and lay between sandstone and limestone lines with average grain density

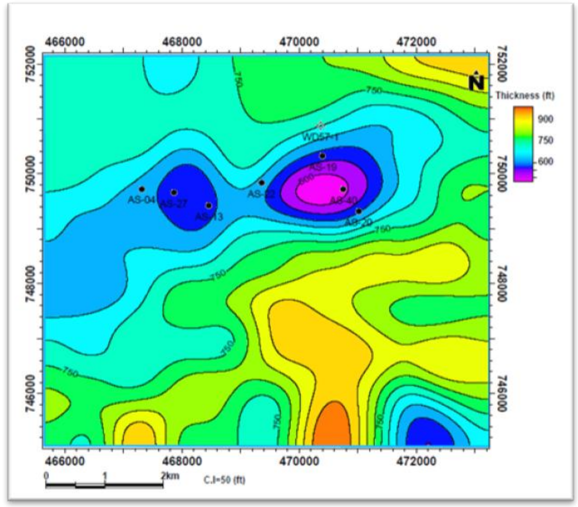


Fig. 5. Isopach Map (Based on 2D Seismic) Showing the Thickness Variations from Upper Bahariya top to A/R "G" top.

(pma) is 2.66 gm/cc and neutron porosity ΦN is 20% (in AS-40 as example). The zone is mainly reservoir sandstone with non-reservoir siltstone scattered and lays between limestone and dolomite lines. (Fig.7) shows the neutron density crossplots that have been applied on the Lower Abu Roash "G" zone. It is observed that, the major plotted points are scattered and lay between sandstone and limestone lines with average grain density (pma) is 2.67 gm/cc and neutron porosity is 24% (in AS-40 as example).

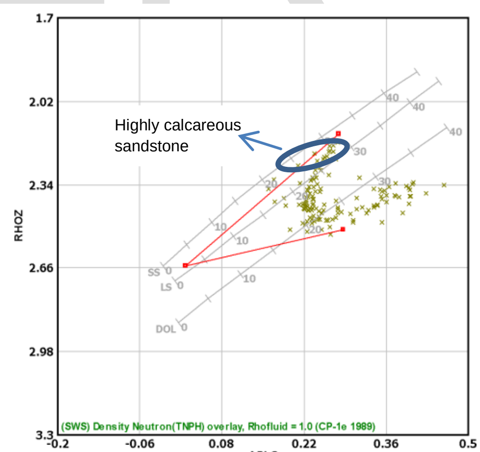


Fig. 6. Neutron-Density Cross-plot showing the Lithological Components of Middle Abu Roash "G" zone.

6.2. Well log analysis results

Table 1 summarize reservoir and pay zones resulted from the petrophysical analysis.

6.3. Lateral variation of reservoir properties

After calculating the values of the log- parameters, the values have been averaged and mapped to represent their general distribution.

International Journal of Scientific & Engineering Research, Volume 8, Issue 1, July-2017
ISSN 2229-5518

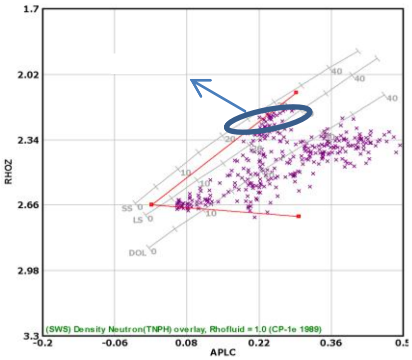


Fig. 7. Neutron-Density Cross-plot showing the Lithological Components of Lower Abu Roash "G" zone.

6.3.1. Middle Abu Roash "G" zone

Middle Abu Roash "G" sandstones were deposited in prograding deltaic distributary environment and exhibit coarsening-upward profile with related increase in reservoir quality upwards [9]. The net reservoir sandstone isopach map of the Middle Abu Roash "G" zone is shown in Fig. 8. Its thickness varies from 4 ft in Asala-27 well to maximum value 18 ft in Asala-20 well. The highest calculated net pay is restricted in the eastern part. This distribution pattern indicates that the hydrocarbon potential of Middle Abu Roash "G" Member is promising in the eastern part of the study area. The neutron –density cross over shows a dominant sand section in Middle Abu Roash "G" Member. The high gamma ray against that sand may be due to the high shale content or argillaceous sandstone interval. The shale content generally increases in the center part of Middle Abu Roash "G" Member.The resistivity values in the pay zone indicate the presence of hydrocarbon accumulation where there is a good separation between deep and shallow resistivity; the deep resistivity values range from 4 to 24 ohm.m. (Fig. 12A & B). On other hand the area of low values of sandstone might represent interdistributary fine sandstone and siltstone. The effective porosity distribution of the Middle Abu Roash "G" is shown in (Fig.9). It reaches the maximum value (25%) at the mouth bar facies (in Asala-20 well) and the minimum (7%) toward the inter-distributary fine sandstone and siltstone facies (in Asala-27 well). The general trend of average porosity distribution increases toward the eastern part of the area, whereas it decreases toward the interdistributary fine sandstone and siltstone to the west. Distribution of the Shale volume (Fig.10) shows an increase of shale volume toward the interdistributary fine sandstone and siltstone which reflects that Shale volume was controlled by facies distribution. The iso-shaliness map of Middle Abu Roash "G" Member (Fig.10) shows a relatively intermediate content of shale ranging from 3% at Asala-20 well to 15% at Asala-27 well. The general trend of shale content in the study area increases toward northern west part, whereas it decreases towards south and east directions. The water saturation distribution map of the Middle Abu Roash "G" zone (Fig.11) shows the water saturation attains a minimum value of 30% in Asala-20 well and a maximum value of 48% in Asala-27 well. It generally increases in the study area toward northwest, whereas it decreases toward south and west directions. Both facies and structure elements controlled the water saturation distribution of Middle Abu Roash "G" zone. It generally increases toward west and south directions, whereas it decreases toward northern west parts of the study area.

Pay Summary for M A\R "G" Member

Well Names	Gross Interval (feet)	Net Res-ervoir (feet)	Average Phi Eff. (%)	Average SW (%)	Average Shr (%)	Average Vsh (%)
As-04	164	9	14	40	60	8
AS-13	151	7	11	42	58	10
AS-40	65	14	20	39	61	6
AS-19	162	14	21	37	63	4
AS-20	165	18	25	30	70	3
AS-22	162	5	9	46	54	12
AS-27	158	4	7	48	52	15

Pay Summary for L A\R "G" Member

Well Names	Gross Interval (feet)	Net Res-ervoir (feet)	Average Phi Eff. (%)	Average SW (%)	Average Shr (%)	Average Vcl (%)
As-04	172	10	15	48	52	7
AS-13	130	9	12	60	40	12
AS-40	172	34	24	44	56	6
AS-19	178	0	7	100	0	14
AS-20	180	30	22	33	67	5
AS-22	174	6	10	57	43	9
AS-27	169	4	8	56	44	8

Table. 1. Reservoir and pay summaries resulted from the petro-physical analysis.

6.3.2. Lower Abu Roash "G" zone

Lower Abu Roash "G" was deposited entirely in shallow marine environments where the sands exhibit strong linear trends. These sands were apparently deposited in sub-tidal bars within a marine embayment. This interval contains no evidence of incision at the base of the sands and the best sand facies exhibit current ripple cross bedding, presumably from tidal currents [9]. Lower Abu Roash "G" represents the lower clastic reservoir zone of Abu Roash" Member, this zone represented by reservoir sandstone and siltstone. The net reservoir sandstone isopach map of the Lower Abu Roash "G" (Fig.13) shows a variation from 4 ft in Asala-27 well to maximum value 34 ft at sandstone body (in Asala-40 well). The highest calculated net pay is restricted to the southeastern part of the area, whereas it decreases toward the northern-western part, rapidly to zero in the well Asala-19. This distribution pattern indicates that the hydrocarbon potential of Lower Abu Roash "G" Member is promising in the south part of the study area. The neutron –density cross-

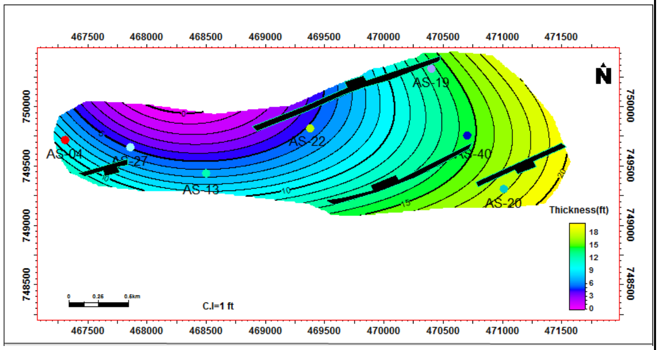


Fig. 8. Net reservoir isopach map for Middle Abu Roash"G" zone.

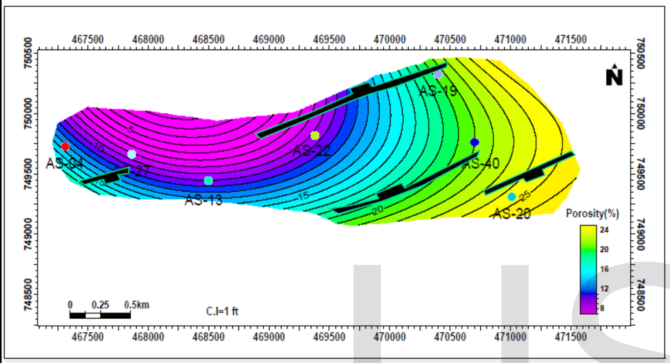


Fig. 9. Average effective porosity map for Middle Abu Roash"G" zone.

over shows a dominant sand section in Lower Abu Roash "G" Member. The high gamma ray against that sand may be due to the high shale content or argillaceous sandstone interval (Fig. 14 A & B). The shale content generally increases in the center part and higher part of Lower Abu Roash "G" Member. The resistivity values in the pay zone indicate the presence of hydrocarbon accumulation where there is a good separation between deep and shallow resistivity; the deep resistivity values range from 5 to 55 ohm.m.

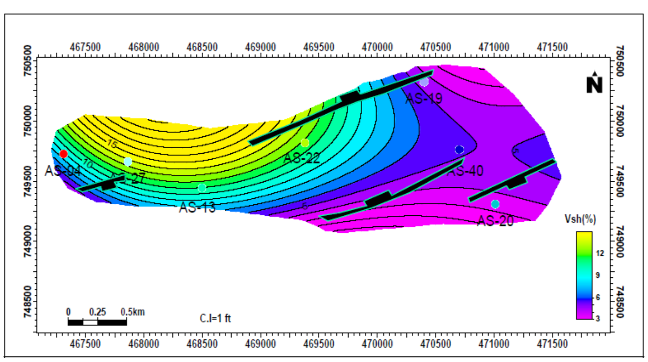


Fig. 10. Average shale volume distribution map for Middle Abu Roash"G" zone

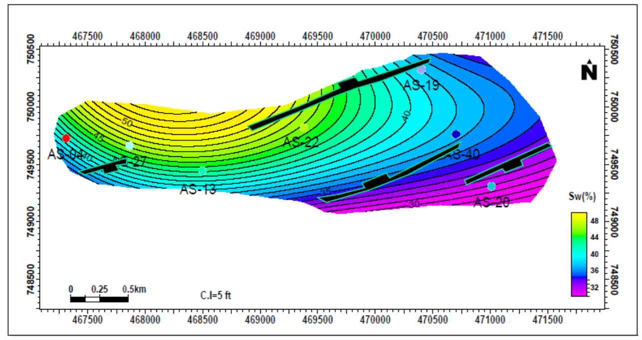


Fig. 11. Water saturation map for Middle Abu Roash"G" zone.

The effective porosity distribution map (Fig.15) ranges from 7% to 24% in Asala-19 and Asala-40 wells, respectively. The general trend of average porosity distribution increases toward the south east part of the area (toward tidal creek facies), whereas it decreases toward northwest. That reflects the influences of facies distribution on effective porosity. The Shale volume distribution map (Fig.16) shows a relatively intermediate content of shale ranging from 5% at Asala-20 well to 14% at Asala-19 well. The general trend of shale content in the study area increases towards (northeast and southwest), whereas it decreases towards northwest and southeast. The water saturation distribution map (Fig.17) shows that the water saturation attains a minimum value of 33% in Asala-20 well and a maximum value of 100% in Asala-19 well. It generally increases in the study area towards northeast, whereas it decreases towards southern part. The water saturation is decreasing toward the up-dip of the normal fault and increasing toward the down-dip of the normal fault. Water saturation distribution was controlled by the structure elements.

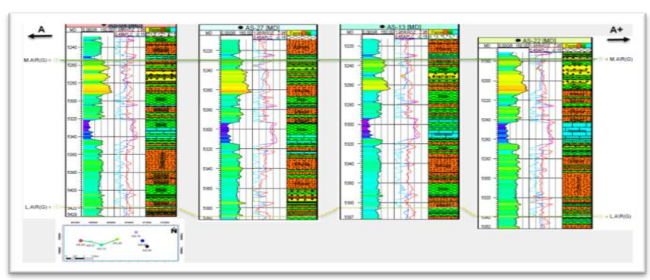


Fig.12 A. Stratigraphic correlation for Middle A/R(G) Member passing through AS-04, AS-27, AS-13 and AS-22 in the study area (A-A+)

7 HYDROCARBON VOLUME CALCULATIONS

Preliminary hydrocarbon volumes have been estimated for Abu Roash "G" Member. The reservoir input parameters were based on the sums and averages from seven drilled wells penetrating the reservoir section. These estimation were calculated based upon the following formula expressed in terms of original oil in place (OOIP): OOIP (MMSTB)= 7758 * A * h * Φeff * (1-Sw) * 1/Bo Where, A= reservoir area in acre, h= net pay thickness in feet, Φeff =effective porosity in fraction, (1-Sw) = hydrocarbon saturation in fraction, N/G = net to gross reservoir ratio, Bo = formation volume factor and 7758 is an acre feet conversion for oil.

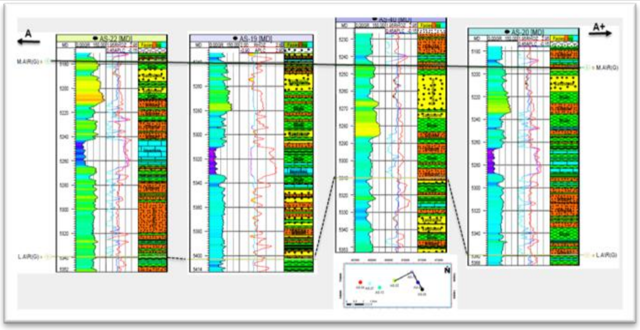


Fig. 12 B. Stratigraphic correlation for Middle A/R(G) Member passing through AS-22, AS-19, AS-40 and AS-20 in the study area (A-A+).

8 SUMMARY AND CONCLUSION

The principal structure responsible for hydrocarbon entrapment in the study area was a structural high which correspond to the three way dip closure of NW-SE major normal fault (F1) and other normal fault of Asala Field. Middle Abu Roash "G" zone consist of sandstone were deposited as distributary river mouth bar and interdistributary fine sandstone graded to siltstone with net reservoir thickness between (max. 18 feet - min. 4 feet),effective porosity reaches (max. 25% - min. 7%) at the mouth bar facies and the interdistributary fine sandstone and siltstone respectively, water saturation values ranging between (max. 48% - min. 30%), water saturation was controlled by structural and facies elements while effective porosity and shale volume were controlled mainly by facies distribution. Lower Abu Roash "G" consist of sandstone deposited at tidal flat environment with net reservoir thickness between (max. 34 feet - min. 4 feet), effective porosity reaches (max. 24% - min. 7%) at tidal creek sandstone facies and fine tidal flat sandstone respectively. Water saturation values ranging between (max. 100% - min. 33%). The original oil in place (OOIP) estimated for the Abu Roash "G" zone is 13.308945 Million Stock Tank Barrel. Figures 12. A&B and 14. A&B showed that the increase in thickness is toward north and showed a decrease in thickness toward the south.

APPENDIX

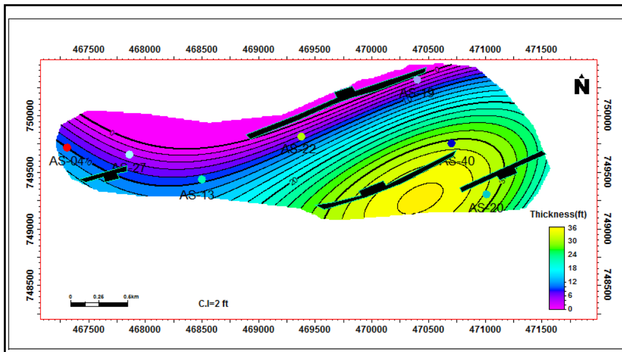


Fig. 13. Net reservoir isopach map for Lower Abu Roash "G" zone.

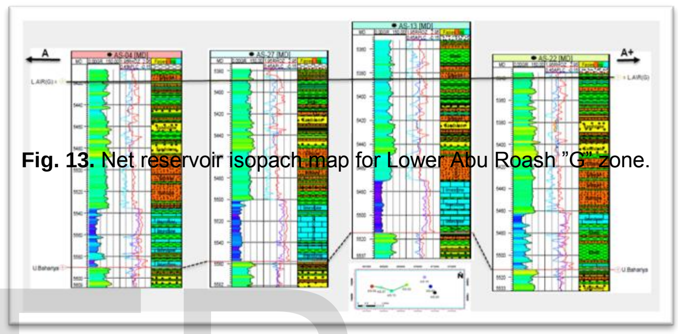
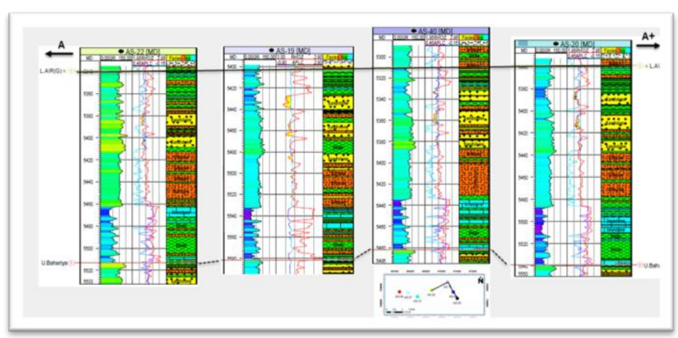
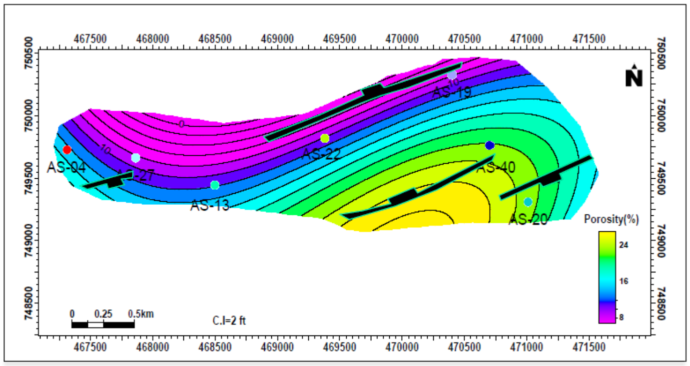


Fig. 13. Net reservoir isopach map for Lower Abu Roash "G" zone.

Fig.14 A. Stratigraphic correlation for Lower A/R(G) Member-passing through AS-04, AS-27, AS-13 and AS-22 inthe study area (A-A+).



(Fig.14 B): Stratigraphic correlation for Lower A/R(G) Member passing through AS-22, AS-19, AS-40 and AS-20 in the study area (A-A+).



(Fig. 15): Average effective porosity map for Lower Abu Roash"G" zone.

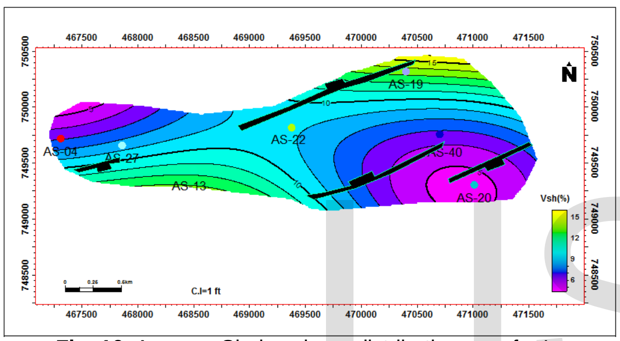


Fig. 16. Average Shale volume distribution map for Lower Abu Roash"G" zone.

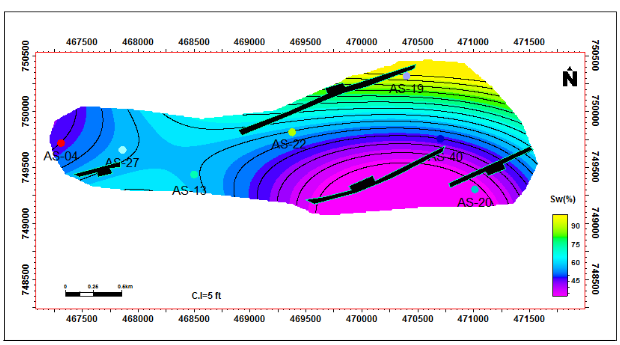


Fig.17. Water saturation map for Lower Abu Roash"G" zone.

Element	Average
Area, acres	623
Net pay, feet	20
PHI.	27
So.	51
Bo	1.015
OOIP (MMSTB)	13.308945

Table. 2. The volumetric estimations using the parameters of Asala Field for A/R (G) Member reservoir

ACKNOWLEDGEMENT

A word of gratitude is extended to the Egyptian Petroleum Corporation (EGPC), Qarun Petroleum Company (QPC). Sincere thanks to all the staff of Al-Azhar University.

REFERENCES

[1]. Schlumberger, Geology of Egypt Paper presented at the Well Evaluation Conference, Schlumberger, Cairo. (1995), pp. 58-66.

[2]. Hantar, G, North Western Desert, In Said, R. (1990), Geology of Egypt, (A.A. Balkema, Rotterdam, Brookfiled, 1990) pp.293-320.

[3]. Abdel Aal, A, Subsurface study of the Abu Gharadig basin,Western Desert, Egypt, Msc. Thesis, Ain Shams University,(1990).

[4] Fawzy, A., and Dahi, M, Regional geological evaluation of the Western Desert, Egypt: Paper presented at the Geology of the Arab World, Cairo University, 1992, pp.111-149.

[5] Moustafa.A. R.,Mesozoic-Cenozoic Basin Evolution in the Northern Western Desert of Egypt. Geology of East Libya, vol. 3, 2008, pp. 35-42.

[6] W. M. Meshref, Tectonic framework of Egypt. In Said, R. (Ed.), Geology of Egypt,1990, 113-156, Balkema, Rotterdam.

[7] Savostin, L.A., Sibuet, J.-C., Zonenshain, L.P., Le Pichon, X., and Roulet, M.-J., "Kinematic evolution of the Tethys belt from the Atlantic Ocean to the Pamirs since the Triassic Tectonophysics", v. 123, (1986).

[8] Smith, A.G, Alpine deformation and the oceanic area of Tethys, Mediterranean and Atlantic.Bull.Geol.Soc.Am.82, 1971, 2039- 2070.

[9] Pasley, M.A., Gabe Artigas, and Nassef, Osama and Joe Comisky, Depositional Facies Control on Reservoir Characteristics in the Middle and Lower Abu Roash "G" Sandstones, Western Desert, Egypt. Adapted from oral presentation at AAPG International Conference and Exhibition, Cape Town, South Africa, October 26-29, 2008.

[10] Cant, D.J., Subsurface facies analysis, in Walker,

International Journal of Scientific & Engineering Research, Volume 8, Issue 1, July-2017
ISSN 2229-5518

R,G., and James, N. P. eds., facies models:response to sea level change, Geological association of Canada, st. Johns, new-foundland, 1992, P 27-45.

[11] Coleman, J.M., & prior, D.B, Deltaic environment in sandstone depostional environments. AAPG, Mem. 31, (1982).