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Reservoir Characterization for Bahariya Formation, Aman Field, North Western Desert, Egypt, Africa.

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ABSTRACT

Seismic data and well logging data indicate that hydrocarbon fields of Aman in Bahariya formation, Shushan basin, northern Western Desert, Egypt, this area lying mostly to the north of latitude 30°N. These basins results from its location along the northern unstable shelf of Africa during different episodes of large scale tectonic movements. The movement between Africa and adjacent sub-plates changed through geologic time, providing different-structural patterns that have been superimposed. Some fault systems were reactivated during different tectonic episodes.

This sub-basin is the eastern end of the coastal basin. It was rapidly subsided during Jurassic time was more than 9000 feet of shallow marine- deltaic sediments were deposited. It is overlained to the north and northeast by the Nile Delta and to the south by the Kattaniya Horst.

INTRODUCTION

The Western desert of Egypt covers two thirds of the whole area of Egypt. The coastal basins (Matruh, Shushan, Alamein and Natrun) located in the northern half of the western desert 75 kilometers to the southwest of Matruh city, covering an area of about 3800 km2 which forms the major part of the unstable shelf as defined by Said (1990). It is located northeast-southwest trending basin. This basin characterizes by its high oil and gas accumulations and its oil production.The subject field is located Shushan in the northerly half of the Western Desert between latitudes 30 ^{O}47’38'' N to 30 ^{O}82’74'' N and longitudes 27^{O}09’50" E to 27^{O}13’94’’E Figure (1).

ISSN 2348 – 7968

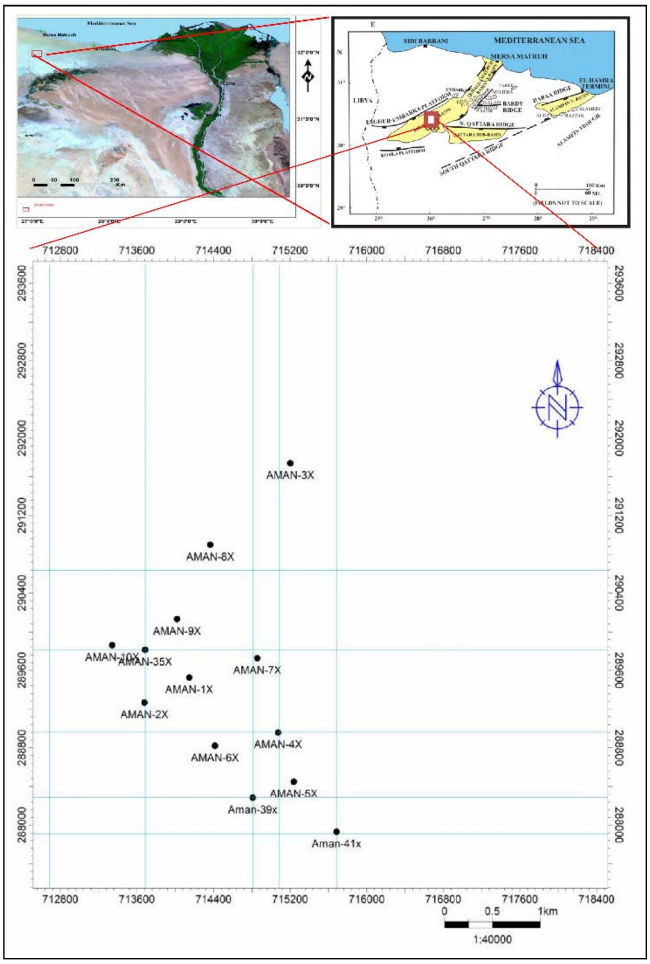

Figure 1: Location map of the study area.

1.1: STRATIGRAPHY

A complete stratigraphic section exists in the Study area and includes a variably eroded Palaeozoic sedimentary section overlying Precambrian basement rocks of continental affinity. A thick Mesozoic-Cenozoic sedimentary section, in turn, overlies this Palaeozoic section Figure (2).

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ISSN 2348 – 7968

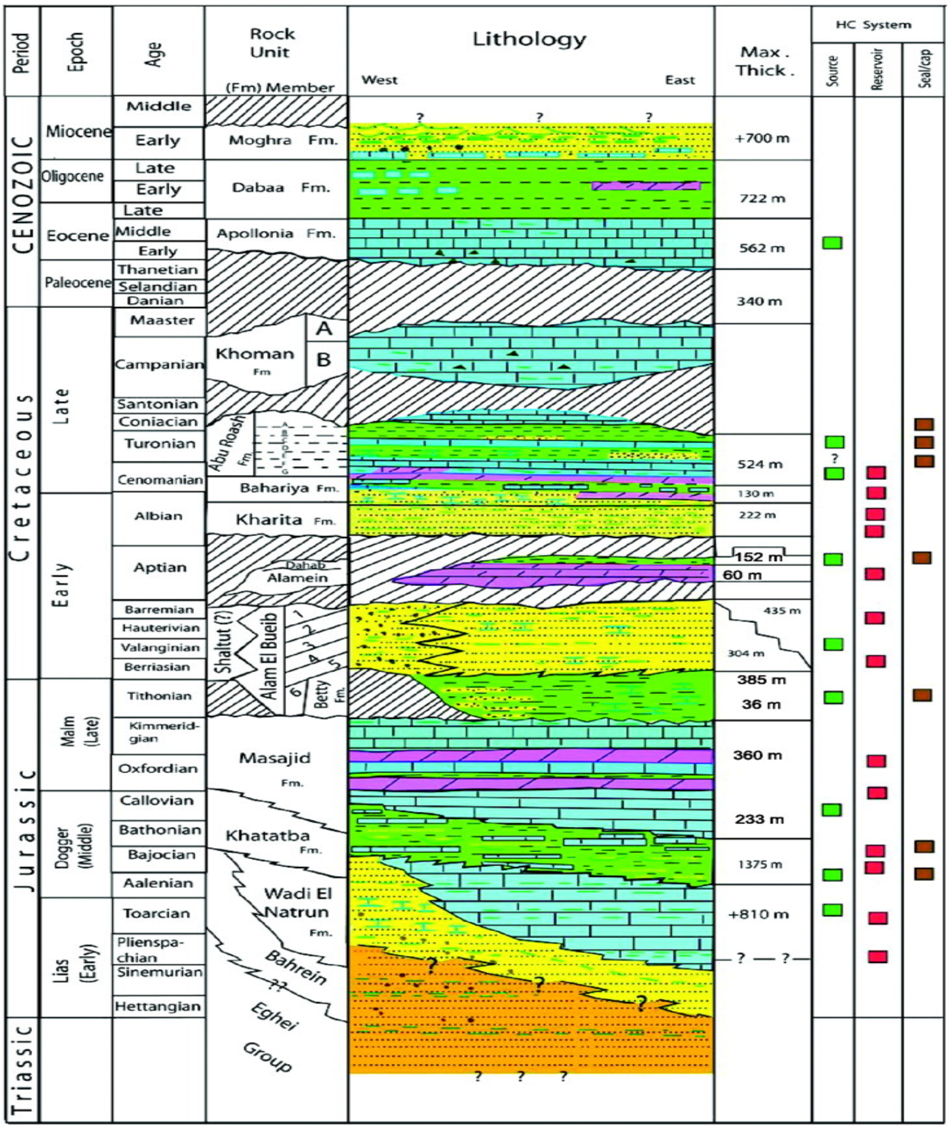

Figure 2: Lithostratigraphic section in the Northern Western Desert, after the compilation of Schlumberger (1995)

1.2:Bahariya Formation

Range in thickness from 550ft to 400ft, increase to south and southeast as in Isopach map Figure (3), correlation chart A-A\ (NE-SW) showing a decrease in thickness of Bahariya to word south-west and contain mainly of sandstone and shale.

Shushan Basin lies to the South of Matruh Basin and shows the effect of ENE-WSW and WNW-ESE oriented faults on the basin architecture. Like Matruh Basin, Shushan Basin witnessed Jurassic and Early Cretaceous extension followed by Late Cretaceous early Tertiary inversion (El Awdan et al., 2002). NE-SW and NNE-SSW oriented inversion anticlines as well as tilted fault blocks bounded by WNW-ESE and NW-SE oriented normal faults from

ISSN 2348 – 7968

the main structural traps in the basin. Many oil and gas fields which were charged by source rocks of Jurassic age have been discovered in Shoushan Basin e.g. Nakhaw, Umbarka, Kahraman, El-Qasr, Khepri, Sethos, Renpet, Kalabsha, Buchis, Heqet,Shams, Qamar, Amoun, Falak, Dorra, Meleiha, Emry,Aman, Lotus, Tut, Salam, Hayat, Yasser, Zahra, Bardy, Safir, and Bassel. The sedimentary cover within the Shushan Basin is about 25000 ft. As interpreted from gravity, magnetic and seismic. Shushan basin is considered as a collapsed crest of a regional high that was developed during Late Kirnmerian Orogeny.

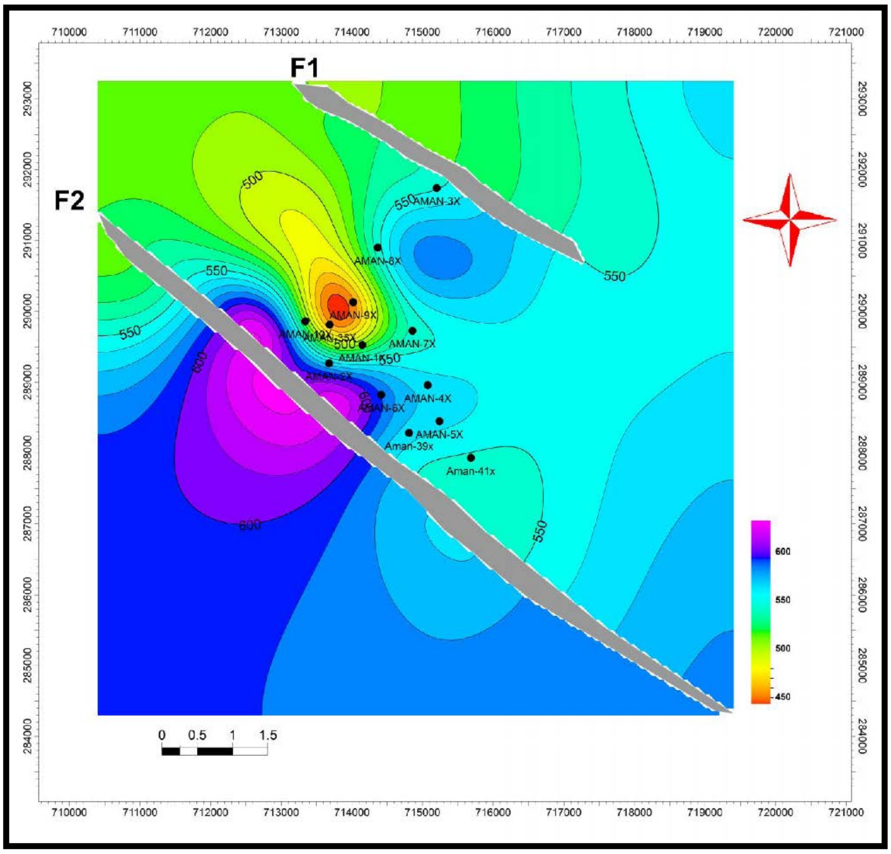

Figure (3): Isopach for Bahariya Formation.

This sub-basin is the eastern end of the coastal basin. It was rapidly subsided during Jurassic time was more than 9000 feet of shallow marine- deltaic sediments were deposited. It is overlained to the north and northeast by the Nile delta and to the south by the kattaniya horst. in the aman field is lie northwest-southeast trending horest block with three culminations separated by a fault.the structure is separated from the meleiha northeast field by a northeast-southweast down-to-the-northwest fault and by the north-south trending syncline that bounds the structure to the east. Figure (4).

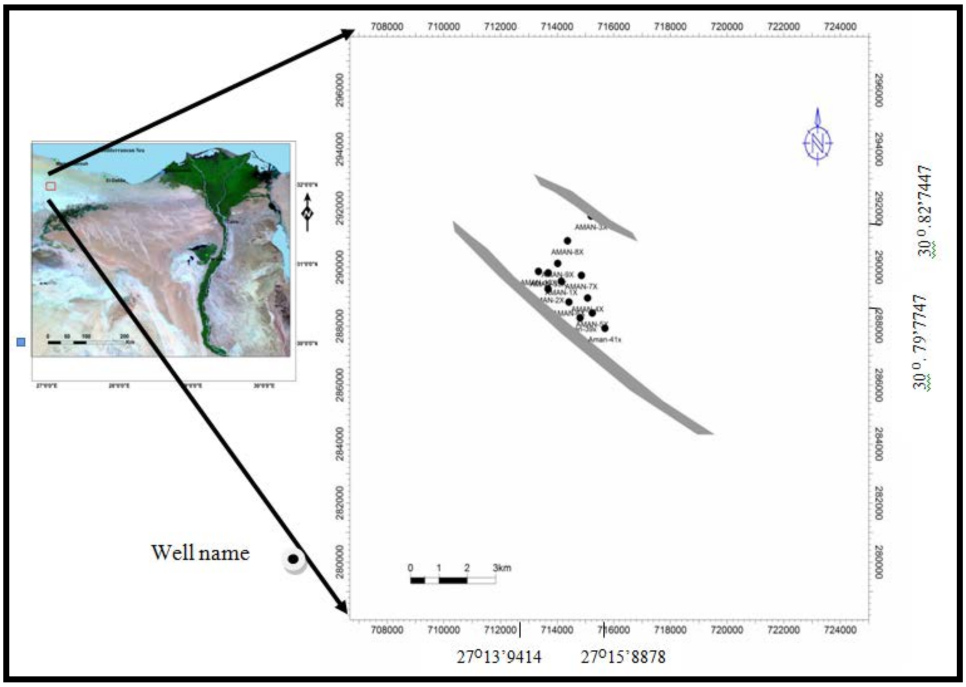

Figure (4): Fault Pattern Map for the Study Area

1.3: Seismic Interpretation:

The only way to match seismic recording with borehole logs, that contain various information about subsurface lithology, is to tray to correlate the seismic section with well data. Seismic data are recorded in time while well data are logged in depth; correlation requires that the seismic data be displayed in depth or the well data in time.

1.3.1:Interpreted horizons

An interpretation was carried out for the available 2D seismic lines and incorporating this data with the available drilling or well data it was found that data the top of the Apollonia, Khoman, A/R"A", A/R"B", A/R"C", A/R"D", A/R"E", A/R"F", A/R"G" Bahariya,and Alamein Formation could be picked out to follow up Bahariya concession structure Configurations. Five 2D time structure maps were constructed on for the Apollonia, Khoman, AR"A", AR"G", Alamein seismic horizons Figure (5).

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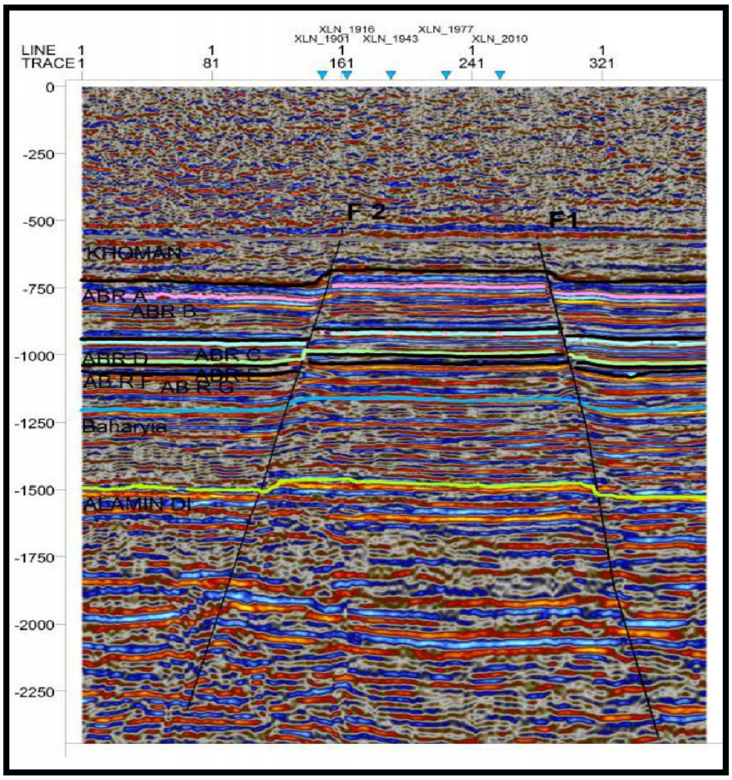

Figure 5: NW-SE interpreted 2D Seismic line showing eight horizons were picked

1.3.2: Time structure Map constructed on Top of Bahariya Formation

The time of Bahariya formation increases in the central and east part of the study area the hanging wall side of the faults (F1&F2), recording the maximum value 1140 sec .On the other hand, the time decreases on the south and north the foot wall for (F1 &F2) faults recording value 1220 ft Figure (6).

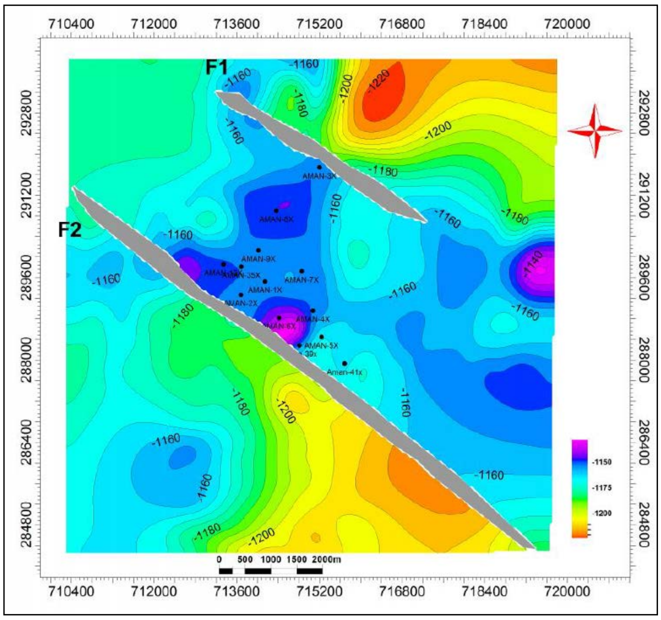

Figure (6): Time Map for the Top of of Bahariya Formation.

In Figure (8) showing N-S interpreted 2D Seismic line showing Bahariya Horizons, and show that the Horizon is affected by Two Fault that making Horest and in Figure (9) E-W interpreted 2D Seismic line showing Bahariya Horizons and affected by Normal Fault .

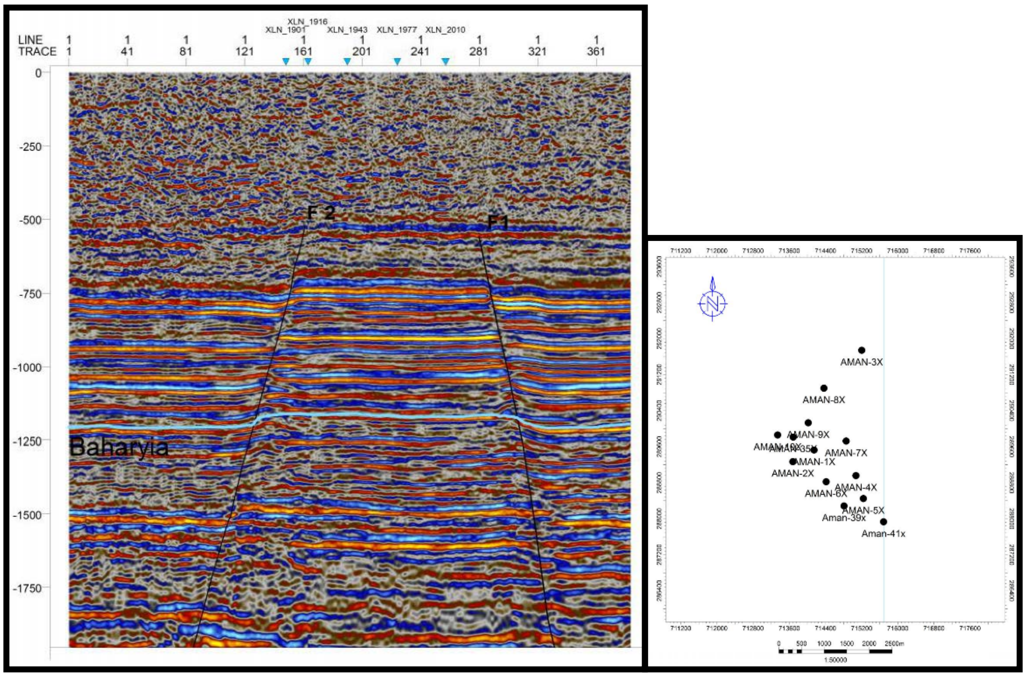

Figure (8): N-S interpreted 2D Seismic line showing Bahariya Horizons.

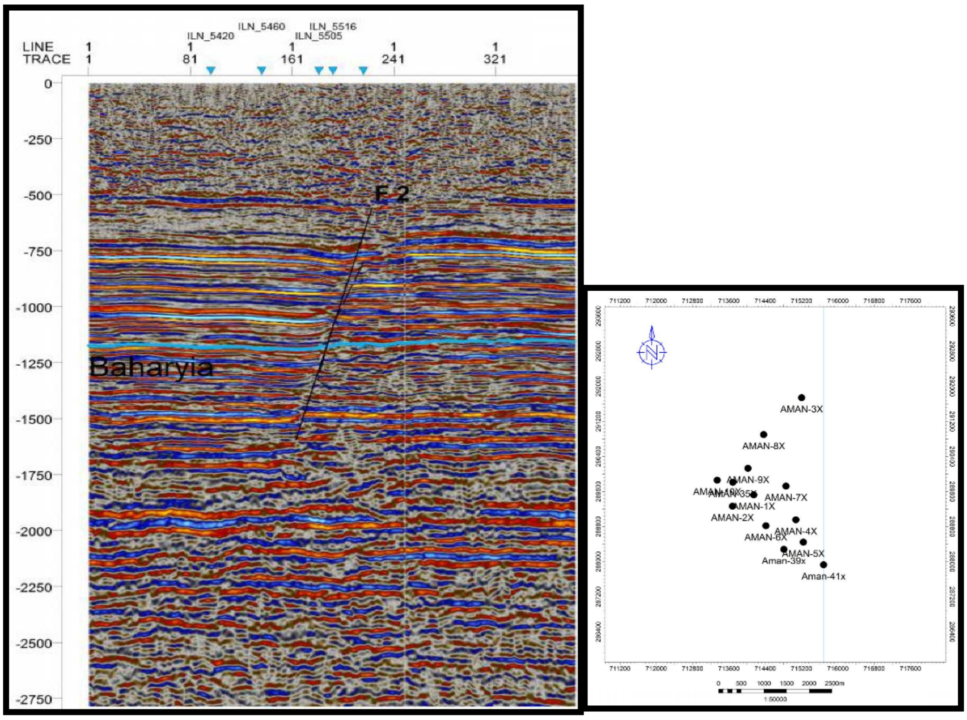

Figure (9): E-W interpreted 2D Seismic line showing Bahariya Horizons.

1.3.3: The depth structural contour maps

Eleven depth maps were constructed on top of the Apollonia, Khoman, A/R"A", A/R"B", A/R"C", A/R"D", A/R"E", A/R"F", A/R"G" Bahariya,and Alamein Formation using velocity data to depth conversion.

1.3.4: The depth structure map constructed on top of Bahariya Formation

The depth of Bahariya formation increase in the central part of study area records the maximum value on the hanging wall side of the fault (F2) to 5040 ft and to the east of the study area. On the other hand, the depth decreases on the south and north recording value -5280 ft Figure (10). Generally, these are controlled by WNW-ESE trending normal faults which define medium-sized horsts and grabens. Most of the sub-basins which have significant hydrocarbons are controlled by ENE-WSW trending normal fault (e.g. Alamein and Shushan Sub-basins) (Sultan and Halim 1988).

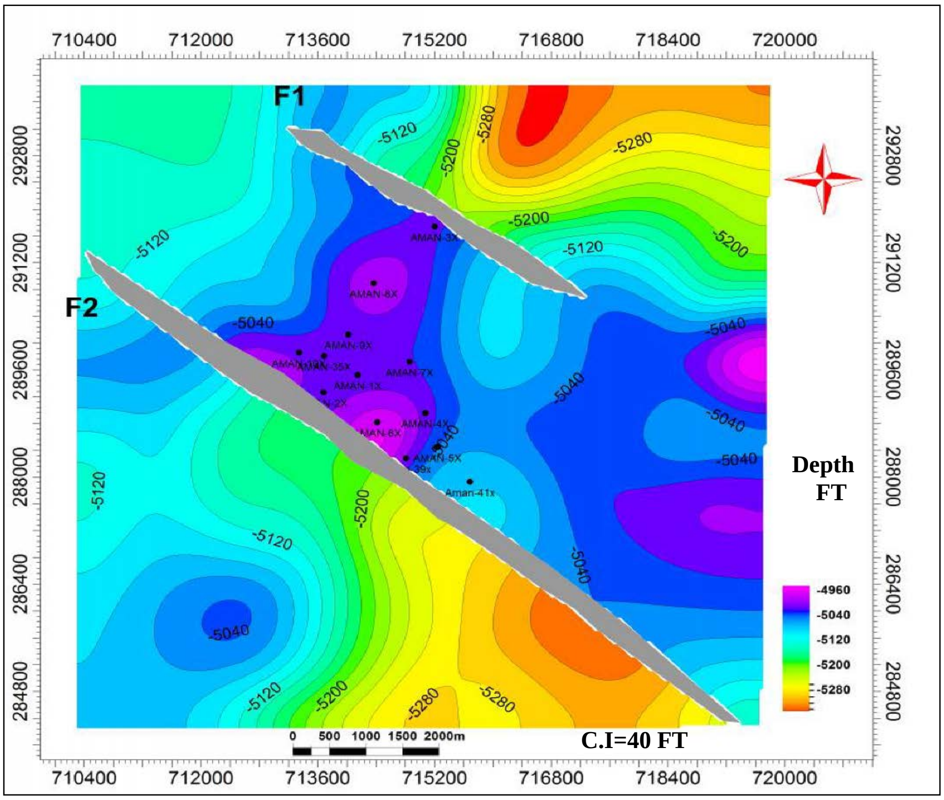

Figure (10): Depth structure map on the top of of Bahariya in the area of the aman field. The map based on 2D seismic data shows main trend NW-SE.

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ISSN 2348 – 7968

1.4: Structural Cross Section

Four structural cross sections, Figure (11, 12, and 13), have been constructed using the interpreted seismic lines. These structural cross sections reflect that the study area is affected by two normal faults F1 and F2, forming a horst block.

Figure (11) shows the NE-SW structural cross section-1. It is located at the southern part of the study area. Figure (12) shows the NE-SW structural cross section-2. It is located in the nearly central part of the study area. Figure (13) shows NE-SW structural cross section-3. It is located in the central part of the study area. These structural cross sections show that the area is affected by two normal faults forming a horst block. F1 is directed towards the NW-SE trend and its downthrown side are directed towards the NE trend. F2 is also directed towards the NW-SE trend and its downthrown side are directed towards the SW trend.

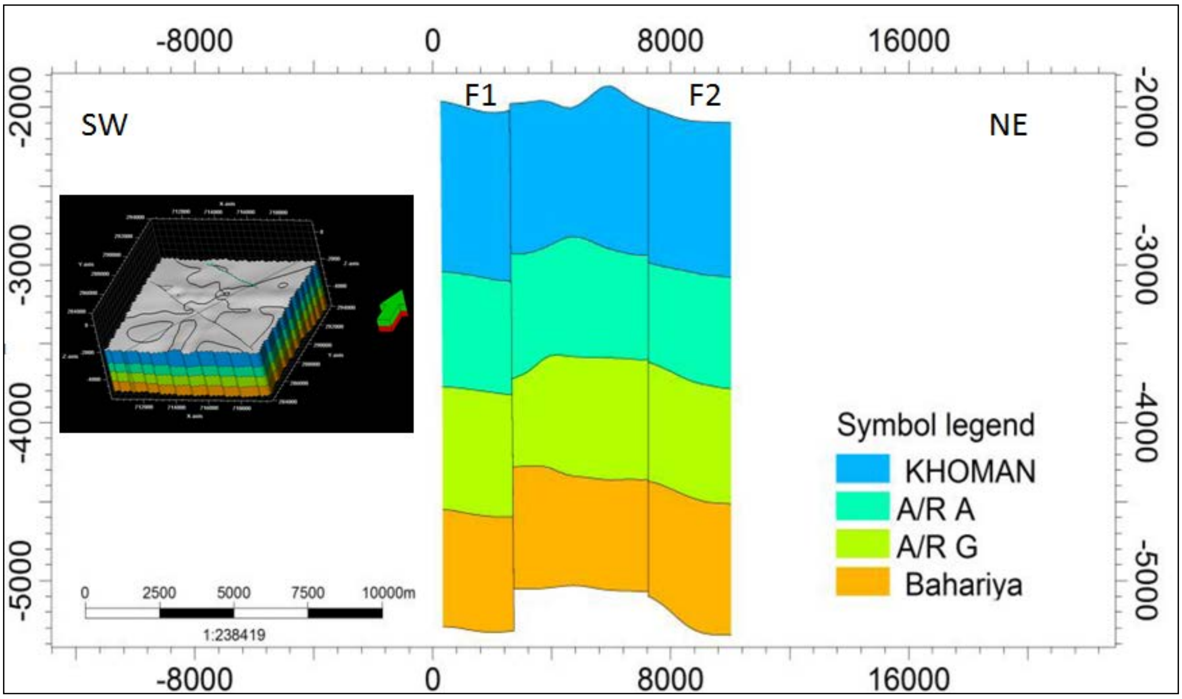

Figure (11): NE-SW structural cross section-1.It is located at the southern part of the study area and shows that the area is affected by two normal faults forming a horst block.F1 is directed towards the NW-SE trend and its downthrown side are directed towards the SW trend. F2 is also directed towards the NW-SE trend and its downthrown side are directed towards the NE trend.

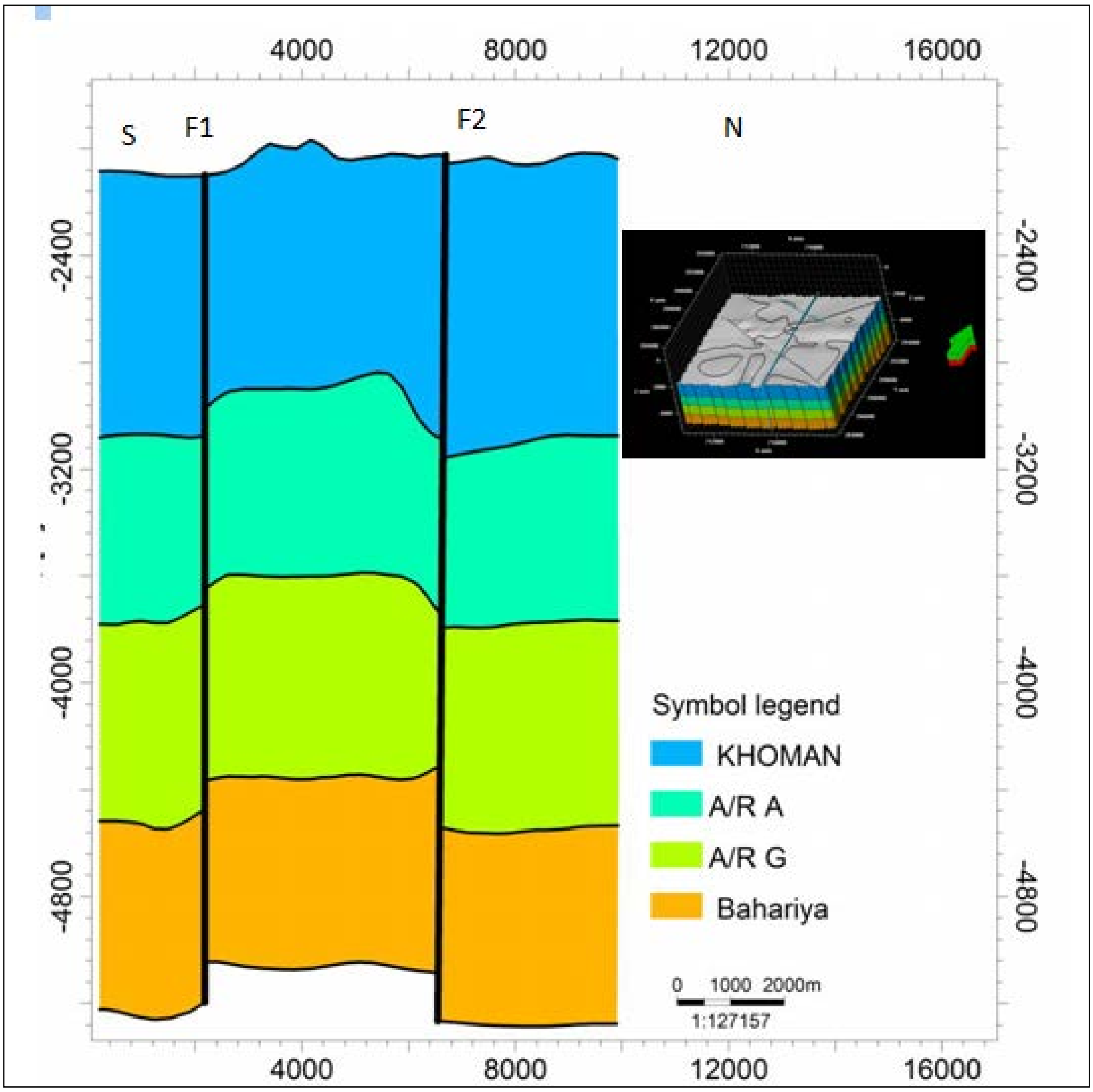

Figure (12): N-S structural cross section-2. It is located in the nearly central part of the study area and shows that the area is affected by two normal faults forming a horst block. F1 is directed towards the NW-SE trend and its downthrown side are directed towards the SW trend. F2 is also directed towards the NW-SE trend and its downthrown side are directed towards the NE trend.

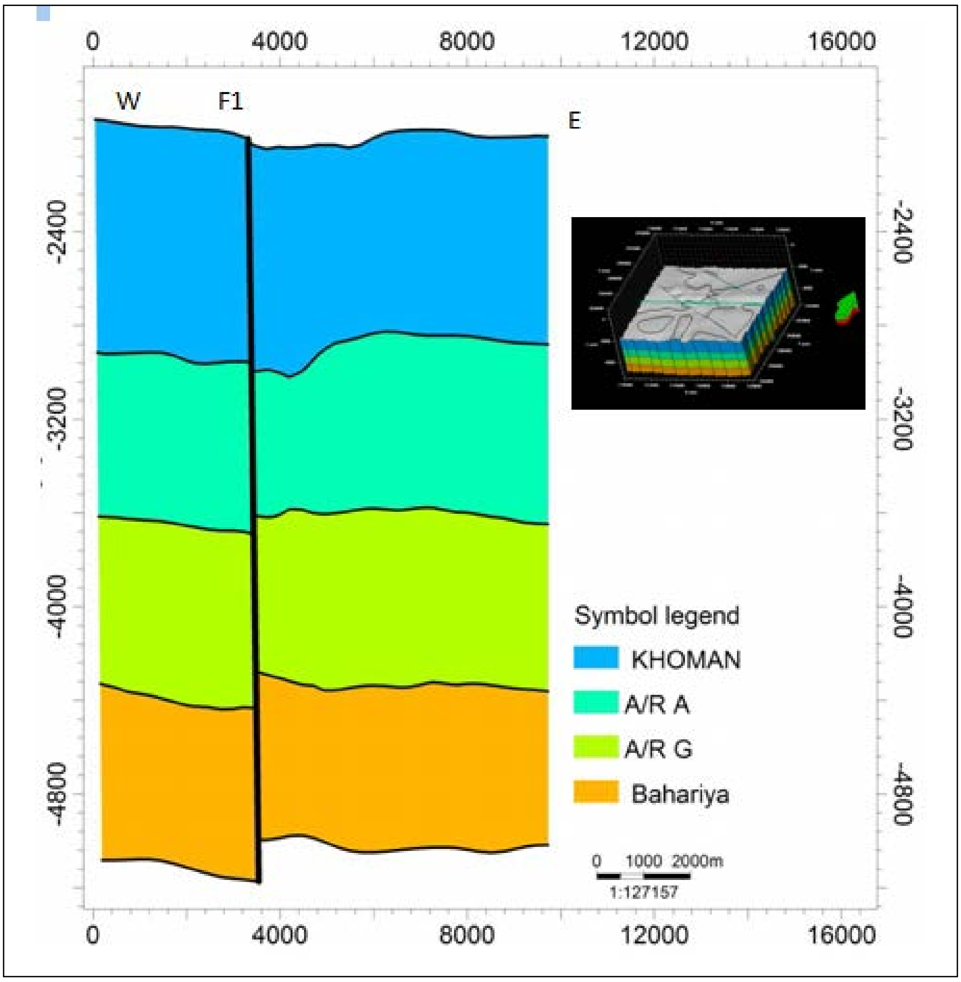

Figure (13): E-W structural cross section-3.It is located in the central part of the study area which illustrates that the area is affected by normal faults affecting on all formations. The downthrown side of F1 is directed towards the SW trends respectively.

1.5:Reservoir Characterization

1.5.1: Determination of Lithologic Components:

The classification of the lithologic components of the rock units into shale, dolomite, limestone, sandstone and porosity is essential in emphasizing the reservoirs capability of producing considerable amounts of hydrocarbon (Kenneth, 1978). Tri-porosity cross plots

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ISSN 2348 – 7968

are constructed utilizing the three porosity tools (Δt, ρb and $Ø_N$) through certain analytical steps and graphical techniques. These plots are utilized to determine the lithology in the form of the essential and accessory minerals in the analyzed rocks, these plots are mineral identification (M-N plots), matrix identification (MID plots) and the simultaneous equations.

1.5.2: Upper Bahariya Formation

Bahariya formation is composed mainly of sandstone intercalated with shale, siltstone and limestone. (Hantar, 1990).In the study area as in figure (14) represents neutron-density cross plots of upper Bahariya formation. It shows that the major lithology is sandstone and the average grain density (p_{mat}) is 2.66 gm/cc and neutron porosity is 17.5%, and shale.

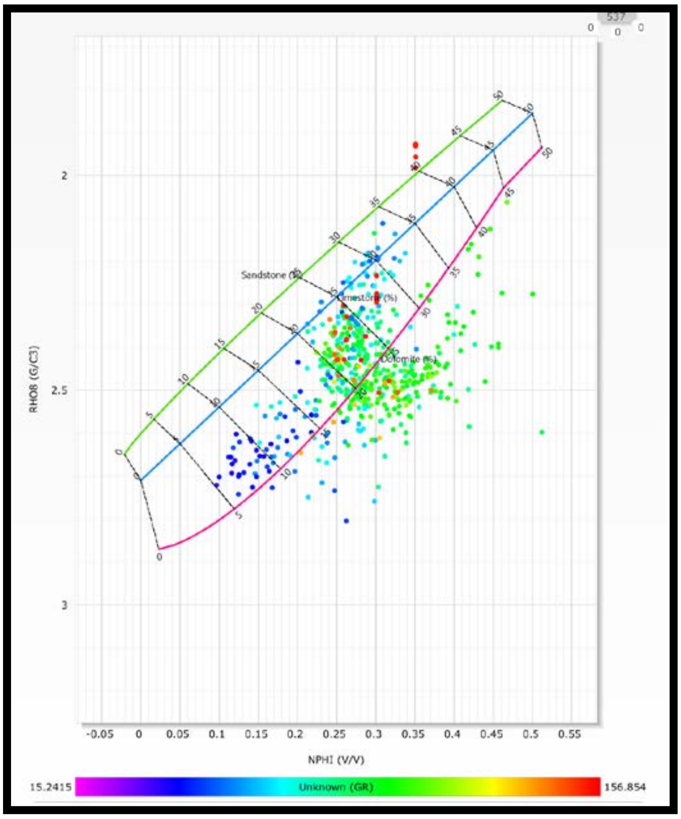

Figure (14): Upper Bahariya Formation Neutron-Density cross-plot

1.5.3: Hydrocarbon bearing formations

Table 1 the reservoir summaries resulting from the petrophysical analysis for U. Baharyia :

Reservoir	Net pay thickness (ft)	Porosity %	Shale volume %	Water Saturation %
U. Baharyia	3-20	16-28	12-30	22-49

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www.ijiset.com
ISSN 2348 – 7968

1.5.4: Results of CPI evaluation of Upper Bahariya member:

Figure (15) a CPI plot studied Upper Bahariya interval in the study area that extends from (5737 to 6130) ft. The neutron-density cross over shows the sand section of the Upper Bahariya member. The high Gamma ray against that sand and may be due to the high shale content or the presence of the radioactive the minerals in the Upper Bahariya sand in Figure (14) the resistivity curves indicates the presence of hydrocarbon accumulation where there is a good separation between deep curve and shallow curves.

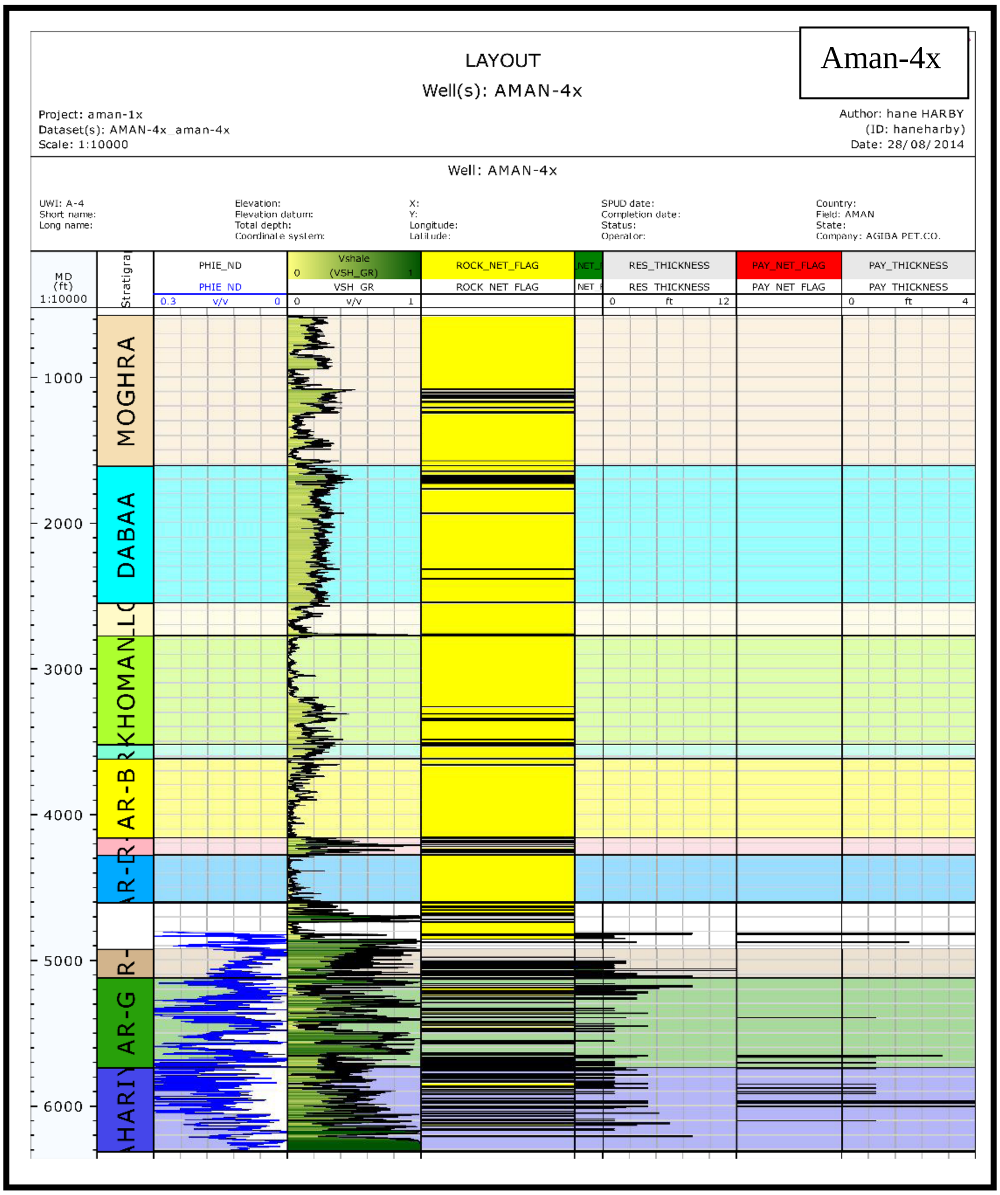

Figure (15): Computer processed interpretation (CPI) plot for Upper Bahariya intervals.

ISSN 2348 – 7968

1.5.5: Upper Bahariya Formation petrophysics distribution Map:

After making the analysis for all formation for all Wells from the avalable data we rencognize that Upper Bahariya Formation is pay zone.

1.5.6: Average Porosity Map:

The frequent Porosity occurrences are observed within the range of (16-28) %. The highest value distribution is found in the Central part, West and North East of the mapped area and decreases South and North West Figure (16).

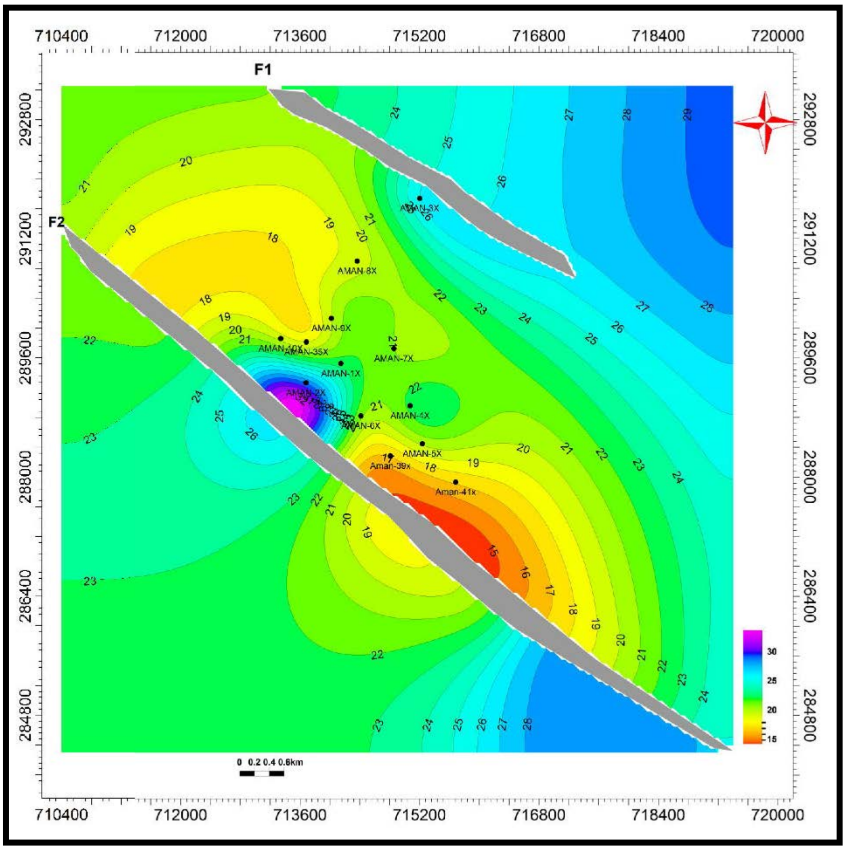

Figure (16): Average Porosity Map Upper Bahariya Formation.

1.5.7: Net Pay thickness distribution

Net Pay thickness calculated in the Upper Bahariya member is observed with the range of (3-22) ft in the wells. The highest calculated Net Pay is restricted to the Central part of the Field, the Net Pay increases to the East and decreases to North West of study area Figure (17).

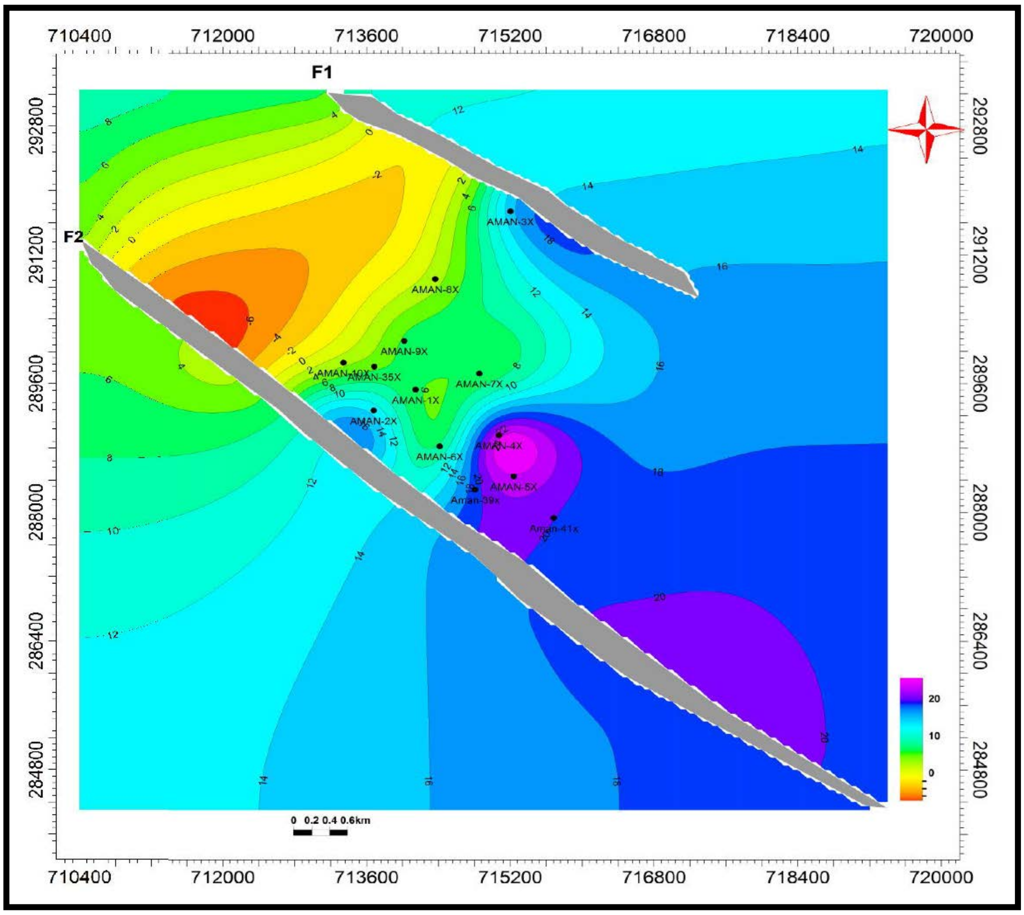

Figure (17): Net Pay thickness distribution Map Upper Bahariya Formation.

1.5.8: Hydrocarbon distribution of Upper Bahariya member

Hydrocarbon potential of Upper Bahariya member is promising in the central part of study area part of the study area in the hanging wall side of the faults (F1&F2) and East between (80-60) and decrease in the North West of study area Figure (18).

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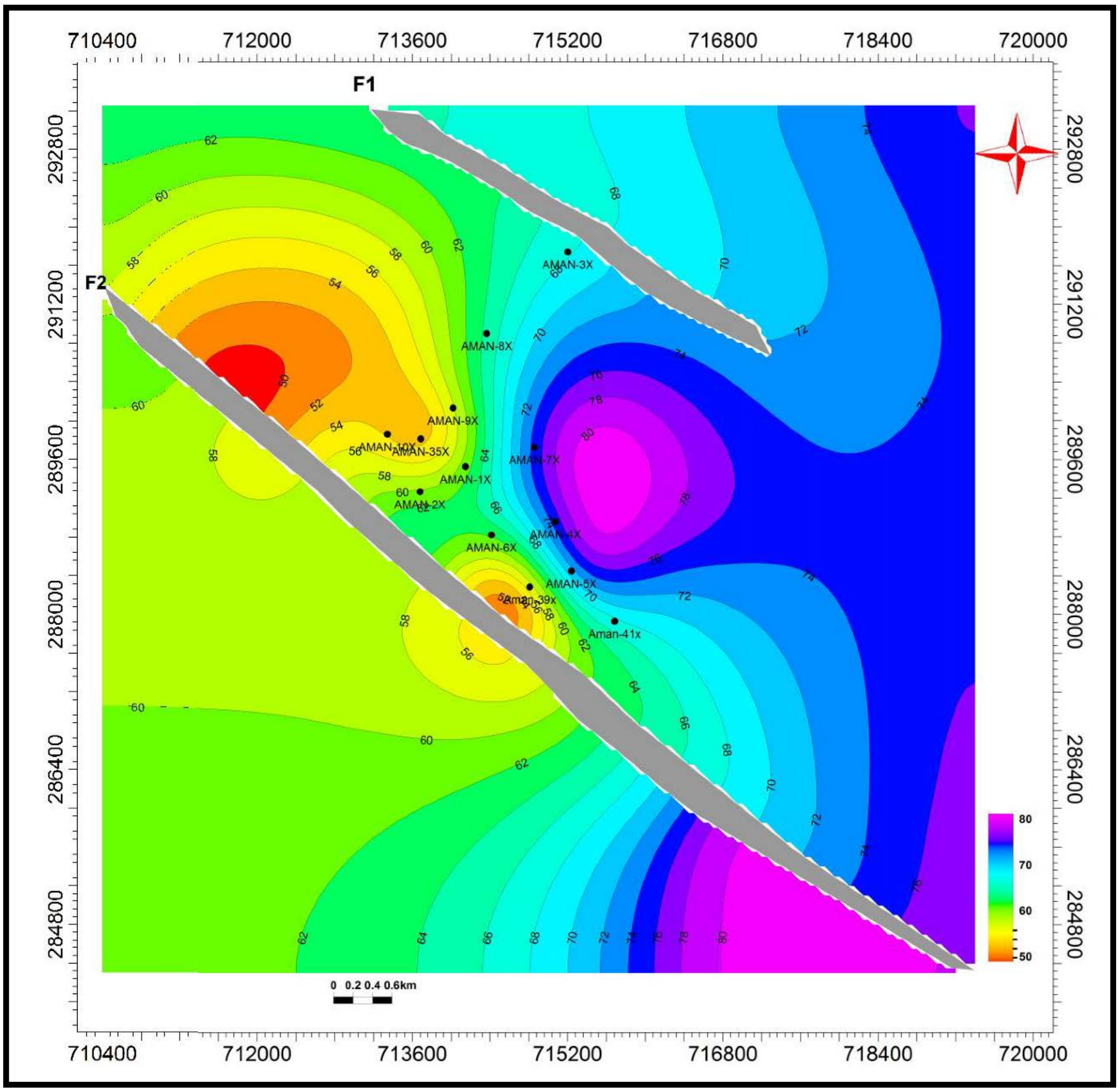

Figure (18): Hydrocarbon distribution Map Upper Bahariya Formation.

1.5.9: Distribution of the volume of Clay

The volume of Clay contained in the Upper Bahariya Shale volume increase in North and North East of Fault (F2) and in the middle part of study area decrease to middle part of study area the range of Shale volume (12-31) Figure (19).

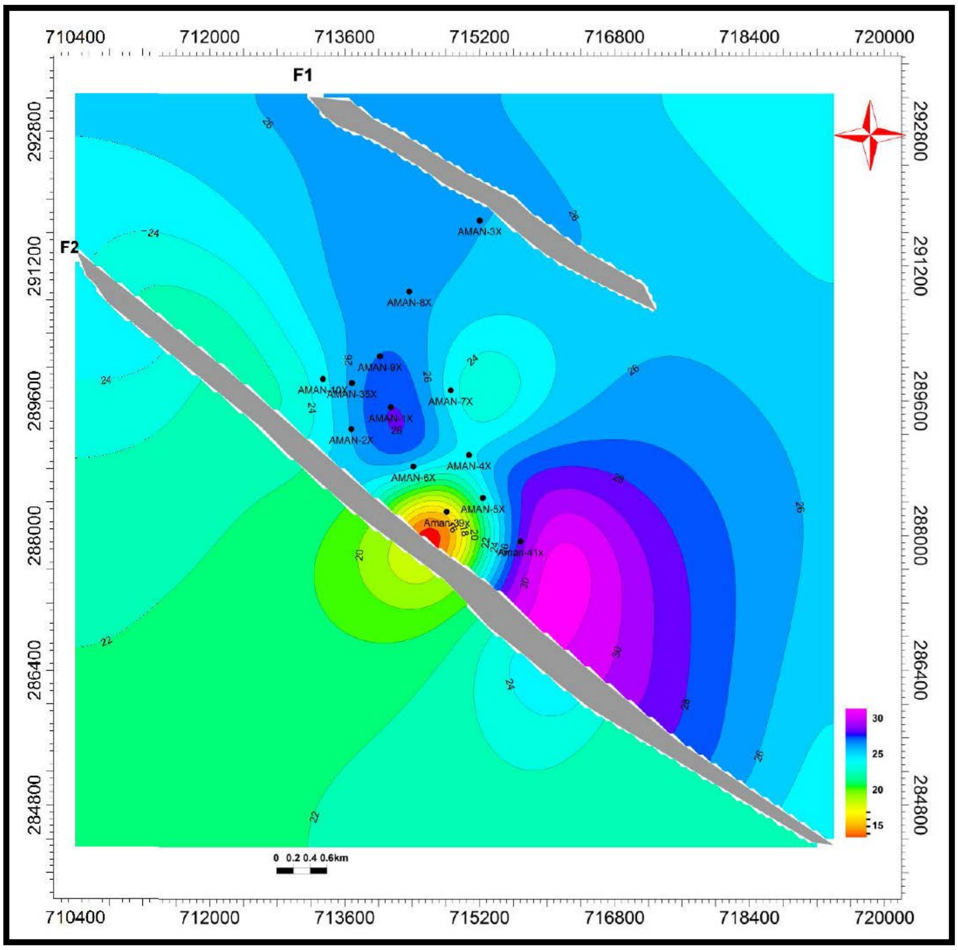

Figure (19): Map showing the distribution of the volume of Clay Upper Bahariya Formation.

SUMMARY AND CONCLUSIONS

Aman field is lie northwest-southeast trending horest block with three culminations separated by a fault.the structure is separated from Meleiha northeast field by a northeast-southweast down-to-the-northwest fault and by the north-south trending syncline that bounds the structure to the east,aman field is located in shushan basin in the northern half of the western desert of egypt, between latitudes 30° 81 to 30° 47N and longitudes 27° 095 to 27° 195 E .

In this study, petrophysical analysis was performed for the avalible wells and 10 seismic lines distributed in the shown study area and in location map (Figure 1). These wells have a complete suite of well logs (GR, RXOZ, MSFL, RLA3, LLS, LLD, RLA5, RHOB, NPHI) required for petrophysical analyses.

The study area is affected by shoushan basin lies to the south of matruh basin and shows the effect of ENE-WSW and WNW-ESE oriented faults on the basin architecture.

The location map for the wells in the study area and the correlation charts direction through the wells explain the formation thickness. The correlation done is using the available data from Gamma ray log, three types of resistivity logs (flashed zone, invaded zone, and non-invaded zone .The correlation and the Isopach map for the study area showing BAHARIYA formation range in thickness from 550ft to 400ft, increase to South and South-East as in the Isopach map.

The Aman field is lie northwest-southeast trending horest block with three culminations separated by a fault. The structure is separated from Meleiha Northeast Field by a Northeast-Southweast down-to-the-northwest fault and by the north-south trending syncline that bounds the structure to the East.

In the present study, the seismic interpretation conducted on 2D seismic sections extracted from Bahariya seismic survey. The seismic of the study Area interpretation which covers only the Area of Aman Field**.**

The seismic data was examined independently from the wells. Seismic interpretation is a process of transforming the physical responses displayed by the seismic lines into geologic information of interest, such as the structure. The initial step in the seismic interpretation process is to tie of geological Horizons to seismic reflectors, the next step is to pick the seismic Horizons by continuity and or by character of interest and interpret the structural elements. As for the most important step in this process is to tie a loop that allows us to check our interpretation. The lines at an intersection are at the same place, so they must agree there. Interpreting key seismic reflectors and Fault patterns and contouring of Time Depth values of those key Horizons in a significant way is the final step, represent relation between MD and TWT in AMAN-4X**.**

An interpretation was carried out for the available 2D seismic lines and incorporating this data with the available drilling or well data it was found that data the Top of the Apollonia, Khoman, A/R"A", A/R"B", A/R"C", A/R"D", A/R"E", A/R"F", A/R"G" Bahariya,and Alamein Formation could be picked out to follow up Bahariya concession structure configurations. 2D Time structure Maps were constructed on for the, A/R"A", A/R"B", A/R"C", A/R"D", A/R"E", A/R"F", A/R"G" Bahariya,and Alamein Formation ,seismic Horizons . Velocity Maps were constructed at Top of A/R"A", A/R"B", A/R"C", A/R"D", A/R"E", A/R"F", A/R"G" and Bahariya using Time data to Velocity conversion using (velocity=distance/Time) and we can observe on this Figure that increases to the Central part of the study Area in the hanging wall side of the Faults (F1&F2) for Bahariya formation 5.08 ft/sec and decrease to other direction same value in range from (5.01 ft/sec to 4.94 ft/sec). Nine Depth Maps were constructed at Top of A/R"A", A/R"B", A/R"C", A/R"D", A/R"E", A/R"F", A/R"G" ,Bahariya,and Alamein Formation using velocity data to Depth conversion. The Depth of Bahariya Formation increase in Central part of study Area record the maximum value in the hanging wall side of the Fault (F2) to 5640 ft and to East of study Area. On the other hand, the Depth decreases on the South and North recording value 6120 ft**.**

This distribution pattern indicates that the Hydrocarbon potential of Upper Bahariya member is promising in the central part of the study area we can recognize also increase in average Porosity in same direction for increasing Net pay, The range of average porosity from (16-28) .This studied wells show good Petrophysical parameters across the field. Net Pay thickness calculated in the Upper Bahariya member is observed with the range of (3-22) ft in the wells. the Hydrocarbon distribution of Upper Bahariya member is promising in the central part of study area part of the study area in the hanging wall side of the faults (F1&F2) and East between (80-60) and decrease in the North West of study area. The Upper Bahariya Formation shows that the major Lithology is SandStone and the average grain Density *(*p_{mat}*)* is 2.66 gm/cc.

The Upper Bahriya reservoir in the study area is characterized by clean sand, laminated shale and some disspresd shale all this result from (Gamma ray porosity Cross-Plot of Upper Bahariya reservoir in the study area , Density Gama Ray Cross-Plot of Upper Bahariya reservoir Aman figures and Density porosity Cross-Plot of Upper Bahariya reservoir) .

Recommendations:

After interpreted the depth structure contour maps for the Bahariya detect some of trapped structures which could be charged by Hydrocarbon, It is recommended to drill an Exploratory wells to evaluate the oil potentialities of the leads in the west of the study area.

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