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3D STRUCTURE MODELING OF RESERVOIRS UTILIZING SEISMIC DATA INTERPRETATION AT AMANA FIELD, EAST BAHARIYA CONCESSION, NORTH WESTERN DESERT, EGYPT

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النموذج التركيبى ثلاثى الأبعاد للخزانات باستخدام تفسيرات البيانات السيزمية فى حقل أمانة بمنطقة شرق البحرية -شمال الصحراء الغربية - مصر

الخلاصة: تهدف هذه الدراسة الي عمل تقييم لمنطقة شرق البحرية و خاصة حقل أمانة لبناء نموذج تركيبى ثلاثي الأبعاد عن طريق دراسة التراكيب الجيولوجية التحت سطحية و مصايد البترول اعتمادا على تحديد مجموعة من الأسطح علي القطاعات السيزمية متضمنه أسطح الخزانات Bahariya و Abu Roash "G" والتي تعتبر الخزانات الرئيسية في حقل الدراسة. وفي النهاية عمل نموذج تركيبي ثلاثي الأبعاد باستخدام البيانات السيزمية ثلاثية الأبعاد ليعطي نظرة تفصيلية عن حقل أمانة.

للوصول الى الهدف من الدراسة بدأ العمل بدراسة الوضع الجيولوجى للمنطقة من حيث التراكيب الجيولوجية و التتابع الطبقى ثمعمل تفسير كامل لبيانات المكعب السيزمى ثلاثي الأبعاد باستخدام برنامج Petrel بداية من تحديد مجموعات الصدوع المختلفة عن طريق القطاعات السيزمية الرأسية والأفقية والسمات السيزمية ثم أتبعه تحديد أسطح الطبقات الهامة مثل Khoman و"Abu Roash "A و"Abu Roash "G و Bahariya ومنها تم عمل خرائط جيولوجية تركيبية علي جميع هذه الأسطح .ومن ثم بناء نموذج تركيبى ثلاثي الأبعاد فى المنطقة باستخدام البيانات السيزمية ثلاثية الأبعاد المتضمنة علي أسطح طبقات الخزانات "Abu Roash "G و Bahariya وأيضا علي مجموعات الصدوع المختلفة لكل سطح.

أكدت النتائج من تفسير البيانات السيزمية ومن الخرائط التركيبية ومن نموذج تركيبى ثلاثي الأبعاد أن منطقة الدراسة قد تأثرت بحركات تكتونية و أن التركيب الجيولوجي للمنطقة عبارة عن مجموعه من الصدوع العادية جميعها ممتد في اتجاه شمال غرب الي جنوب شرق.

ABSTRACT: *The main purpose of this study is evaluating East Bahariya Concession to build 3D structure model, especially for Amana Field by studying subsurface geologic structural features and hydrocarbon trapping of the area based on 3D seismic cube through picking and identifying the major structural elements and horizon packages on seismic sections including interested reservoir markers (Bahariya Formation and Abu Roash "G" Member) which are considered the main potential reservoirs in the study field. To achieve this objective, the study started by explaining the geologic setting of the area, including the stratigraphic sequence and dominating structures through a review for the pervious geological studies. Then, detailed 3D seismic data interpretation was carried out and integrated with data of 4 wells to determine the structural geometry of interested reservoirs and develop a structure model of the reservoir rocks in the study area using Petrel® Schulmberger Software to provide accurate information about the subsurface structural geometry and fault pattern of the study area.*

3D seismic data interpretation has started by fault pattern interpretation in order to detect the subsurface structural features using conventional and unconventional seismic interpretation (coherence attributes) methods to delineate the optimum interpretation of seismic, highight the main faulting pattern and to enhance seismic reflector continuity. Then horizon interpretation process has been achieved including identification of the interested reservoirs markers. Seismic data interpretation has been used for constructing two-way time and depth structure maps on the tops of Khoman, Abu Roash "A", Abu Roash "G" and Bahariya seismic horizons to show some closures, major trends and subsurface structures in the area. Finally, 3D structure model has been built and confirms the interpreted structure from seismic data interpretation.

The present geophysical and geological study discloses that the structural geology of the area was affected by tectonic deformation system caused a regional uplift. The principle structure of the area is represented by three-way dip closure of NW-SE normal faults that was very obvious on seismic sections, structure maps and the 3D model.

INTRODUCTION

The study area; Amana Field is located in the western part of East Bahariya Concession. It is bounded by latitudes 29º 30' 15"N and 29º 33' 51" N and by longitudes 29º 23' 40" E and 29º 29' 15" E (Figure 1). East Bahariya Concession lies in the north eastern portion of the Western Desert of Egypt in south of the northeast Abu Gharadig Basin.

Western Desert is considered as one of most important oil and gas province in Egypt. Western Desert extends 1000 km from Mediterranean Sea to the Sudan border in the south and 600 to 800 km west of Nile Valley to the borders of Libya. It covers an area of approximately 700, 000 km^2, which represents two thirds of the total area of Egypt. **(EGPC, 1992).** Abu Gharadig Basin comprises many of the most productive oil and gas fields in the northern part of the Western Desert**.** Abu Gharadig Basin is located in the central of the northern part of the Western Desert and considered as one of the most important basins that developed during the Late Cretaceous-Tertiary time **(El-Toukhy and Bakry, 1988).**

East Bahariya Concession is valuable due to the availability of petroleum system elements. Where, the primary source rock is interpreted to be Jurassic Khatatba Shales, with possible contribution from Late Cretaceous Abu Roash "F" Carbonates. The main reservoirs are Bahariya and Abo Roash "G" Sandstones. The shale and carbonate sections of Abo Roash "G" Member and Bahariya Formation, would provide a top and lateral seals for reservoirs.

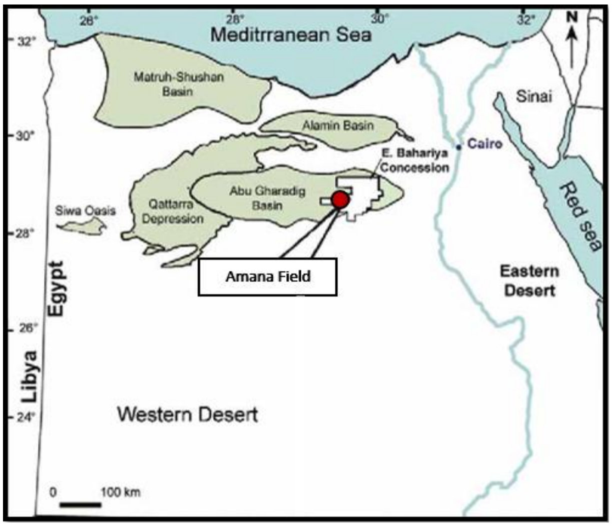

Figure (1): Location map of Amana Field at East Bahariya Concession.

Geological Setting

Abu Gharadig Basin, in which the study area is located, is a deep E-W asymmetric graben and one of the most important prolific basins in the northern part of the Egyptian Western Desert. It extends for about 300 km long and 60 km wide and represents about 3.6% of the Western Desert area, with age ranges from Late Jurassic to Early Cretaceous. The basin is bounded by Shareb-Shibe High to the north, Sitra Platform to the south, Gindi High to the east and Faghur-Siwa Basin to the west **(EGPC, 1992 and AbdelMalek and Zeidan, 1994)**.

Subsurface Stratigraphy

The stratigraphic column of northern Western Desert comprises rock units ranging from Cambrian to Recent with the oldest sediments resting on the basement rocks **(El-Ayouty, 1990).**Western Desert succession (Figure 2) is characterized by an alternation of carbonatic and clastic sediments that is coming from the repetition of transgressive and regressive cycles. This is one of the keys of the Mesozoic-Cenozoic petroleum system, as alternation of different sediments allows presence of potential source, reservoirs and seals. An important event in the formation of petroleum system in this zone is the subsidence phase developed from Upper Jurassic to Upper Cretaceous that created the main sedimentary basins and Upper Cretaceous-Paleocene movements that allowed traps formation **(Sestini, 1995)**.

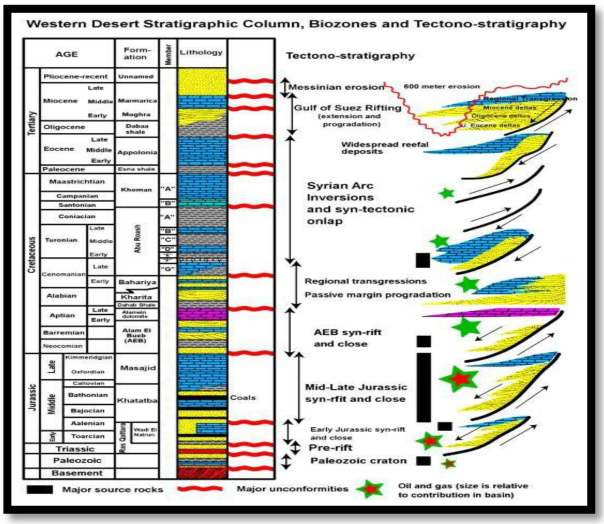

Figure (2):Stratigraphy and tectonic episodes, Western Desert, Egypt, (EEPC, 2011).

The lithologic characteristics of the interested reservoirs in the study area (Bahariya Formation and Abu Roash "G" Member) are given in details as follows:

Bahariya Formation: is the main gas and / or condensate pay in Abu Gharadig Basin. It is of early Cenomanian age **(Hantar, 1990)**. It is composed of sandstone with minor intercalations of shale and marly facies. Pyrite and glauconite are common and also thin limestone beds irregularly occur**.** Lithological evidences suggest that most of the formation was deposited in shallow marine environment **(EGPC, 1992)**.It rests unconformably over Kharita Formation and extends in the subsurface over most of the northern Western Desert. It conformably overlies Burg el Arab Formation and subdivided into six units of which the unit I is the upper pay and the unit IV is the lower pay **(Kandil, 2003).**

Abu Roash "G" Member: represents the main reservoir in the study area. It is a Late Cenomanianinage **(Abd El Aal, 1990)**.Abu Roash "G" Member is composed of shale and limestone with interbeds of sandstone and sometimes includes a locally developed dolomite that most probably to have been deposited in a near shore environment. Abu Roash "G" Member is further subdivided into upper and lower units representing two distinct depositional cycles. The bottom part of the Abu Roash "G" Member is well defined by a limestone marker bed. Abu Roash "G" shale acts as a very good top and lateral seal, while Abu Roash "F" carbonate acts as a lateral seal.

Structural Setting

Western Desert can be divided into a number of large scale structural provinces which developed along lines of weakness in the African basement in response to lateral movements between Europe and Africa **(Hegazy, 1992).** Western Desert is characterized by a southwestward thickening Paleozoic section and northward thickening Mesozoic and Tertiary strata which is interrupted by the major E-W trending Sharib-Sheiba High. This regional uplift separates Abu Gharadig Basin from the coastal basins (Matruh, Shushan, Dahab and Natrun Basins). These basins are superimposed, at least in the west, over the Paleozoic basin extending eastward from Libya (Kufra Basin) and termed Siwa Basin **(EGPC, 1992)** (Figure 3). The dominant structural style of Western Desert comprises two systems: a deeper series of low relief horst and graben belts separated by master faults of large throw and broad Late Tertiary folds at shallower depth **(Sestini 1984).**

Abu Gharadig Basin Structure Setting

Abu Gharadig Basin; in which the study area is located is a rift basin bounded to the north and south by two right lateral shears and from the east and west by northwest trending normal faults **(Meshref, 1990)**. It was formed during the Albian and reached maximum subsidence in the Late Cretaceous (Maastrichtian). It was subsequently inverted during the Paleocene-Eocene **(Lüning et al., 2004)**. It seems to be a continuous basin with a major uplift along its center that divides it into north Abu Gharadig Basin and south Abu Gharadig Basin **(Meshref, 1990)**. The structural pattern of Abu Gharadig Basin is dominated by NE-SW oriented faults coupled with a strong pattern of NW-SE conjugate faults. These fault patterns suggest regional wrench movement. This in turn, subdivided it into several structural units of varying importance named from E to W Mubarak High, Abu Gharadig Anticline and Mid Basin Arch **(Meshref, 1990)** (Figure 3).

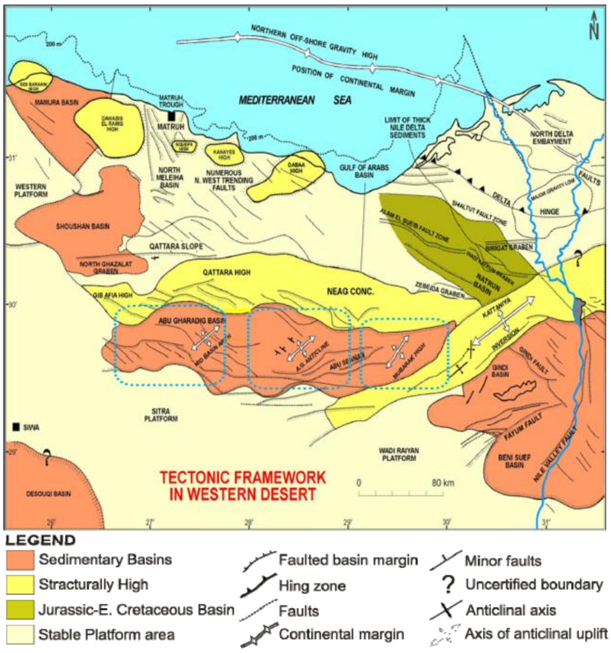

Figure (3): The tectonic elements in Western Desert, Egypt (modified by Abu-Hashish and Said, 2016 after Bayoumi, 1996).

Materials and Methods

The present study is based on the data supplied by Apache Egypt upon the approval of the Egyptian General Petroleum Corporation (EGPC). The study area of AmanaFieldencompasses3D seismic cube that covers approximately 58 km^2 surface area. It includes 261 in-lines from 5245 to 5600 and 356 cross-lines from 1340 to 1600 and includes 4 wells; (Amana_East-1), (Amana_1X), (Farasha_1X) and (Yamama_1X). This 3D seismic cubewas supported by the composite, velocity and vertical seismic profile (VSP) logs of the four selected wells to tie seismic data with borehole data and identify seismic horizons by formation tops. This study focuses on the interpretation of the structural setting of Amana Field utilizing 3D seismic data (Figure 4).

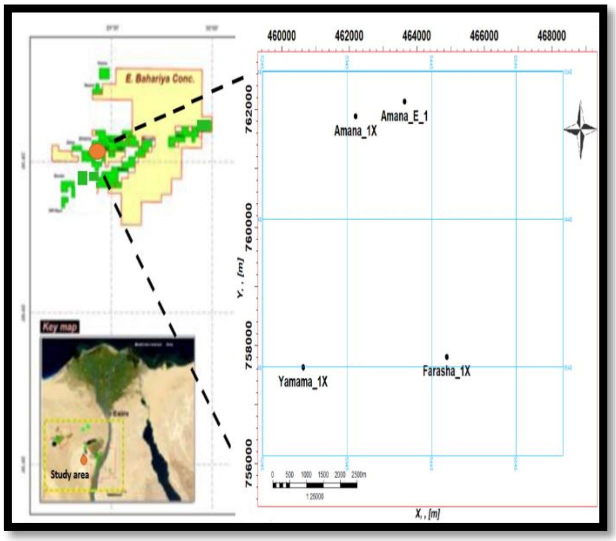

Figure (4): The base map location of the study area.

3D seismic cube was interpreted to construct depth structure maps on the top of Khoman, Abu Roash “A”, Abu Roash “G” and Bahariya horizons. This is to figure out the general geological setting and illustrate the structural framework affecting the study area. Also, 3D structural model has been built to imagine the discontinuities and follow faults dissecting the studied formation tops.

The objective of the study is to clarify the structural elements for Amana Field by studying the subsurface geologic structural features and horizon packages identification including reservoir markers; Bahariya Formation and Abu Roash “G” Member which are considered the main potential reservoirs in the study area. Then 3D structure model has been constructed using 3D seismic data to resolve the structural setting and hydrocarbon trapping in the study area. Seismic data interpretation and 3D structural model have carried out using Petrel® 3D Seismic Interpretation Software.

Seismic Data Interpretation

Seismic data interpretation is a process of transforming the physical responses displayed by seismic lines into geologic information of interest such as structural style or stratigraphic regime. The initial step in seismic data interpretation process is to tie geological horizons to seismic reflectors. The next step is to pick these is michorizons by continuity through characters of interest then detect the structural elements. The most important step in this process is to follow aloop that allows us to check the reflectors interpretation. The two lines at aninter section at the same place must agree.

Interpreting key seismic reflectors, fault pattern sand contouring depth values of key horizonsin a significant way represent the final step **(Sheriff and Geldart, 1995).**

Detailed seismic data interpretation started using 3D seismic cube, inline and crossline seismic sections depending on the properties of seismic reflectors. Five seismic horizons including Khoman, Abu Roash "A", Abu Roash "G", Bahariya and Alamein horizons were picked over a controlled seismic grid of in-lines and cross-lines. They were checked by arbitrary lines in all directions, keeping in mind the overall geologic concept. Then, structure interpretation was achieved for each interpreted horizon to create fault polygons depending on the intersection between the horizon and the fault sticks.

Some full interpreted seismic sections were selected in order to illuminate the picking of the horizons and the structural features in study area. Four seismic sections were selected; one section in cross-line direction, one in in-line direction and two lines in arbitrary directions which pass across certain structures.

The interpreted seismic section (cross-line 5463) (Figure 5) is located at the middle toward east of the study area. It is oriented in the N-S direction and integrates data from well Farasha_1X. This line shows five picked seismic reflectors. The Late Cretaceous reflectors seem to be parallel or semi parallel. This line reveals a system of normal dip slip faults forming fault-bounded blocks. It illustrates two major normal faults (F2 in red and F18 in orange) in pattern of step-like faults and oriented in NW-SE direction, downthrown towards the south. They bound Amana Field from north and south dividing the field into three fault blocks and affect Lower and Upper Cretaceous sequences. In addition to, asset of normal faults affects the sequence especially the Late Cretaceous sequence (Bahariya and Abu Roash Formations) and older units forming horst and graben structural patterns. These faults also die out at the top of Khoman and Apollonia Formations which less deformed than the older Bahariya and Abu Roash Formations. However, there are some additional deep-seated faults present in Alamein Formation.

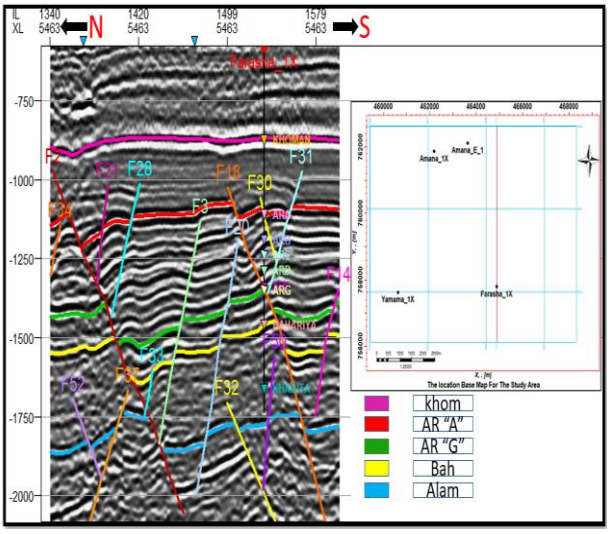

Figure (5): Interpreted seismic section; cross-line 5463.

The interpreted seismic section (in-line 1370) (Figure 6) is located at the northern part of the study area. It incorporates data from Amana_1X well and near to Amana_E_1 well. It is oriented in the E-W direction. This line shows one major normal fault (F2 in red)) that affects the northern part of the study area. This section exhibits several minor normal faults with small heaves and throws.

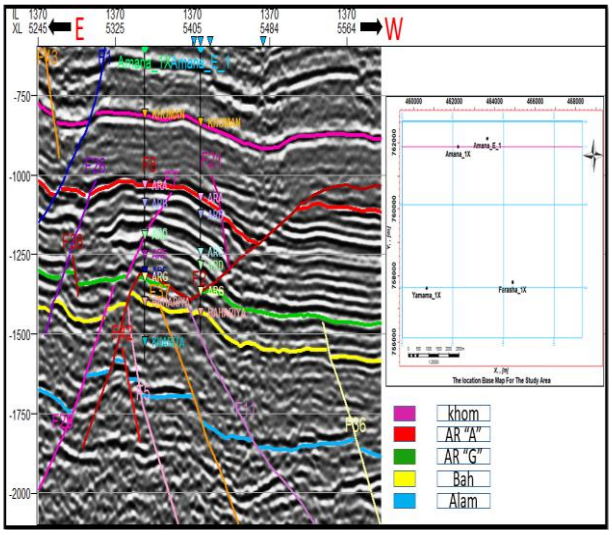

Figure (6): Interpreted seismic section; In-line 1370.

The arbitrary seismic section (Figure 7) is located in the middle part of the study area. It is oriented in the NW-SE direction. This line passes through wells Amana_1X and Farasha_1X and shows some of major normal faults that created this field. It illustrates two major normal faults (F2 in red and F18 in orange) in pattern of step-like faults. They bounded the study area from north and south. In additional to, several minor normal faults with small heaves and throws located between and surround the two major faults.

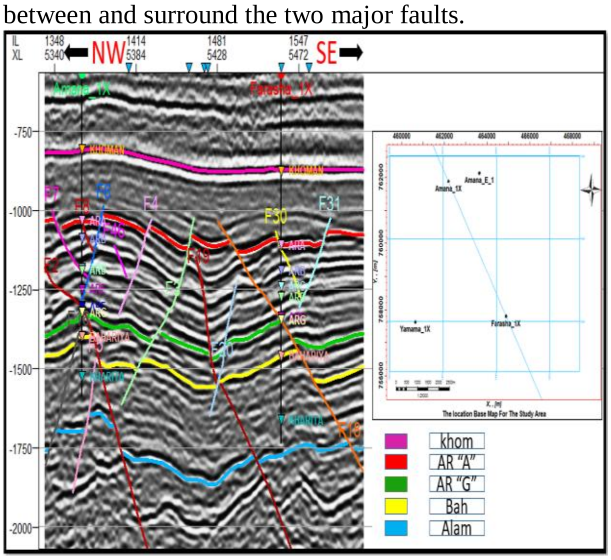

Figure (7): Interpreted arbitrary line in NW-SE direction.

The arbitrary seismic section (Figure 8) is located in the western part of the study area. It is oriented in the NE-SW direction. This line passes through wells Amana_E_1 and Yamama_1X. It illustrates two major normal faults (F1 in blue and F2 in red) in pattern of step-like faults and bounded the study area from north and south. It shows other several minor normal faults with small heaves and throws.

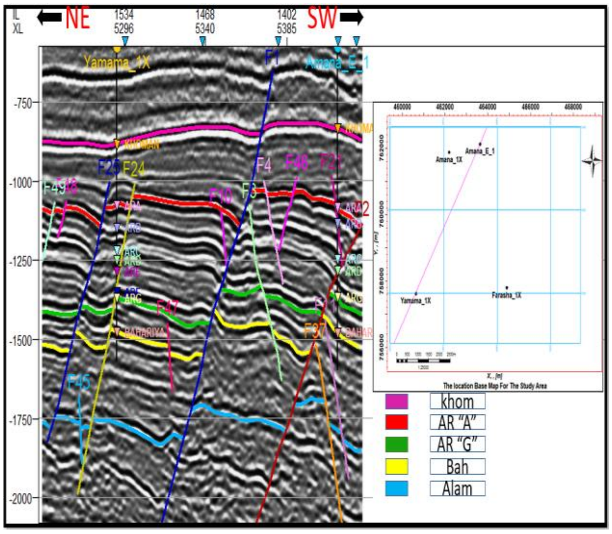

Figure (8): Interpreted arbitrary line in NE-SW direction.

After presenting full interpreted seismic sections, the structural features in study area are interpreted as three major normal dip slip faults (F1 in blue, F2 in red and F18 in orange) dividing the field into three fault blocks in pattern of step-like faults. In addition to, a set of minor normal faults with small heaves and throws located around the major faults. Some of faults that dissected the Upper Cretaceous section (Abu Roash "A", Abu Roash "G" and Bahariya) do not extend into the Lower Cretaceous and Jurassic sections and died out at the top of Lower Cretaceous Formations. However, there are some additional deep-seated faults appeared in Alamein Formation. Furthermore, Khoman Formation may deposit after the structural uplift occurred in the area. The major fault traces in Khoman Formation may be due to the rejuvenation followed to the major faults because of the overweight after Khoman Formation deposition.

After full interpretation of 3D seismic cube, maps are prepared on a base map which shows the locations of seismic lines, studied well locations and the concession boundaries of Amana Field. The fault polygons were interpreted for each horizon according to the intersection of fault sticks and horizon. To represent the geological features that produced from interpretation of 3D seismic volume, it is required to make mapping for interested horizons to clarify the anomalies and the structural trends existing in the study area. Three types of seismic maps; two-way time structure contour maps, average velocity maps and depth structure contour maps are constructed on the tops of the interested horizons.

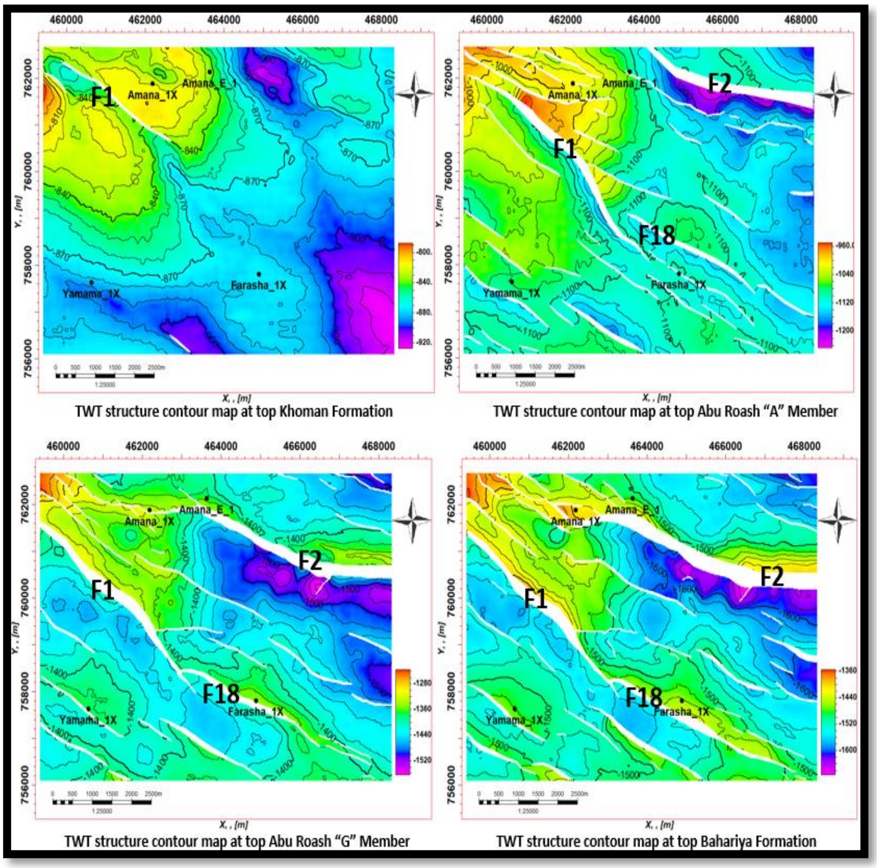

Figure (9): Two-way time structure maps on the tops of interested rocks.

Two-Way Time Structure Maps

Two-way time structure maps are constructed on a base map. Values of horizons reflection time (in milliseconds) below the datum plane are represented on these maps. For each interpreted horizon grid, the fault polygons were interpreted depending on the intersection between seismic horizon and fault sticks. Then the time values are contoured and the fault pattern is mapped to construct two-way time structure maps on the tops of interested seismic horizons; Khoman, Abu Roash "A", Abu Roash "G" and Bahariya horizons. (Figure 9).

Two-way time structure maps assembled on the tops of Khoman, Abu Roash "A", Abu Roash "G" and Bahariya surfaces based on 3D seismic data interpretation reveal that the area is dissected by three major normal dip slip faults (F1, F2 and F18) which divided the field into three fault blocks. F18 is died out at F1. The faults trend of the study area is divided into two groups. The first main group trends to the NW-SE direction. The second minor group trends to the E-W direction at Amana structure (it is a higher structural area at the northwestern part of the study field and bounded by wells Amana_1X and Amana_E_1). The NW-SE trend is the dominant one. The NW-SE trend is dissected by the E-W trend. This means that the NW-SE trend is older than the E-W trend. This change in faults trend is likely due to structural compression near the end of Cretaceous. Multiple normal faults trending in the NW-SE direction formed horst and graben blocks and divided the area into high and low structures. Some of the faults intersecting the area are died out on the tops of Khoman and Alamein Formations. However, there are some addition aldeep-seated faults appeared at the top Alamein Formation.

The time values reach to maximum values in the southeastern part of the study area (structurally low), while minimum values (structurally high) arise in the northwestern part of the study area with closure contour lines. These low and high anomalies reflect the regional uplift occurred in the study area. That indicates the basin is located toward southeastern part of the study area and the highly structure and promising area found in the central and northwestern part of the study area.

Average Velocity Maps

The conversion of two-way time structure maps into depth structure maps dictates average velocity maps on the tops of the interested horizons. In the study area, the average velocity is calculated from time-depth relation, where the average velocity is the total vertical distance to a certain top divided by the total one-way time equivalent to this depth. The average velocity maps constructed on top Khoman, Abu Roash "A", Abu Roash "G" and Bahariya horizons (Figure 10) reveal high velocity values in the southeastern part of the study area towards well Farasha_1X, and low velocity values in the northeastern part of the study area towards well Amana_E_1 and in the southwestern part of the study area towards well Yamama_1X.

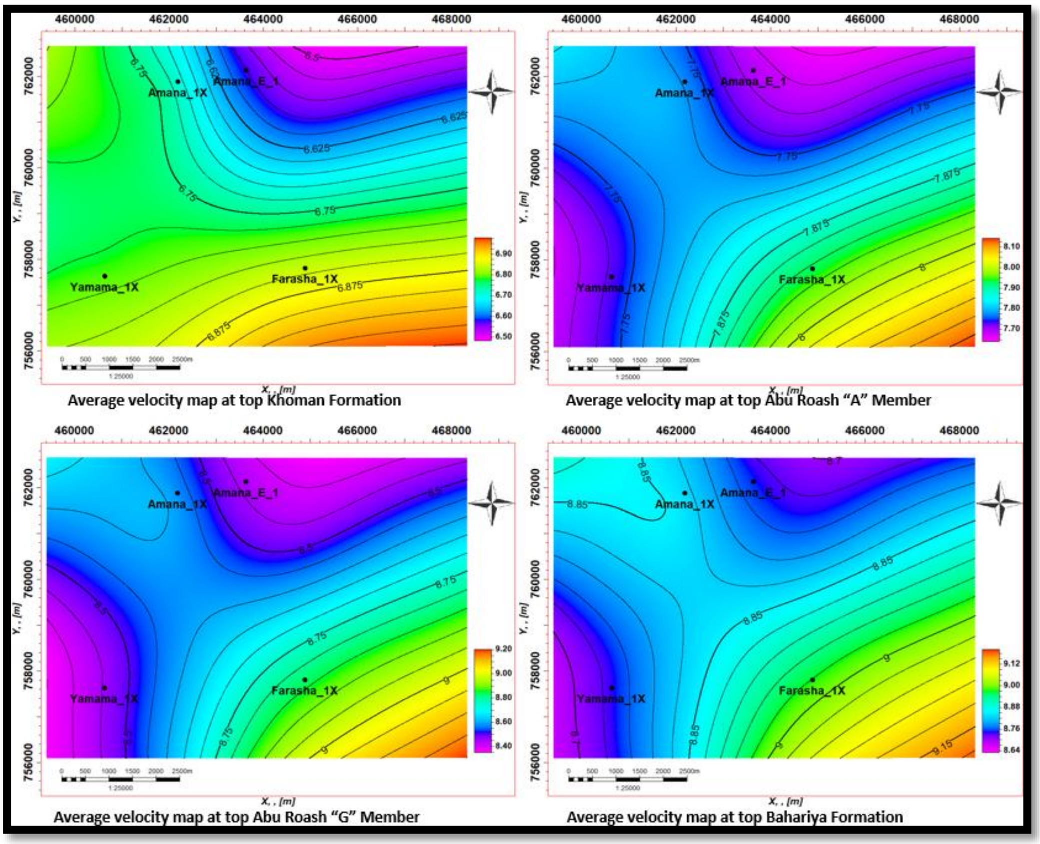

Figure (10): Average velocity maps on the tops of interested rocks.

Depth Structure Maps

Depth structure maps are the conversion of two-way time structure maps into depth structure maps using average velocity maps. The simplest way of converting the seismic time into depth is by multiplying time by velocity and divided by two (D=V*T/2). Depth structure maps have been constructed on the tops of the four interested seismic horizons; Khoman, Abu Roash "A", Abu Roash "G" and Bahariya based on the 3D seismic data interpretation (Figure 11).

The depth structure maps constructed on the tops of Khoman, Abu Roash "A", Abu Roash "G" and Bahariya horizons are similar to time structure maps of these horizons except in a slight variation due to lateral change in velocity. They reveal that the area is dissected by three major normal faults (F1, F2 and F18). F18 is died out at F1.These faults trend mainly to the NW-SE direction with minor trend to the E-W direction at Amana structure. This change in faults trend is likely due to structural compression near the end of Cretaceous. Set of normal faults trending in the NW-SE direction formed horst and graben faults and divided the area into high and low structures. Some of faults that dissected the Upper Cretaceous section (Abu Roash "A", Abu Roash "G" and Bahariya) do not extend into the Lower Cretaceous and Jurassic sections. Some of the above-mentioned faulting structural pattern did not affect Khoman Formation. Khoman Formation is affected by a smaller number of NW-SE normal faults. This in turn suggests that the structure has been formed post Abu Roash succession and pre-Khoman time deposition. The major fault traces in Khoman may be due to the rejuvenation followed to the major faults because of the overweight after Khoman Formation deposition.

Depth structure maps reveal that the area is high structure and show an irregular distribution pattern. The depth values reach to maximum in the southeastern part of the study area (structurally low), while minimum values (structurally high) arose in the northwestern part with closure contour lines. These low and high anomalies reflect the regional uplift occurred in the study area. They indicate that the basin is located toward southeastern part of the study area and the highly structure promising area found in the central and northwestern part of the study area. Depth structure maps confirm the structure traps of three-way dip closure of NW-SE normal faults.

Coherence Cube

Seismic coherence attribute is applied to check and confirm the fault pattern across the area. The coherence attribute is an edge detection attribute that measures the similarity of adjacent seismic traces which can be related to the continuity of geology. Therefore, discontinuities such as faults, fractures, channels, and other sharp-edged strati graphic features can be easily identified by similarity **(Bahorich and Farmer, 1995).** Coherency is

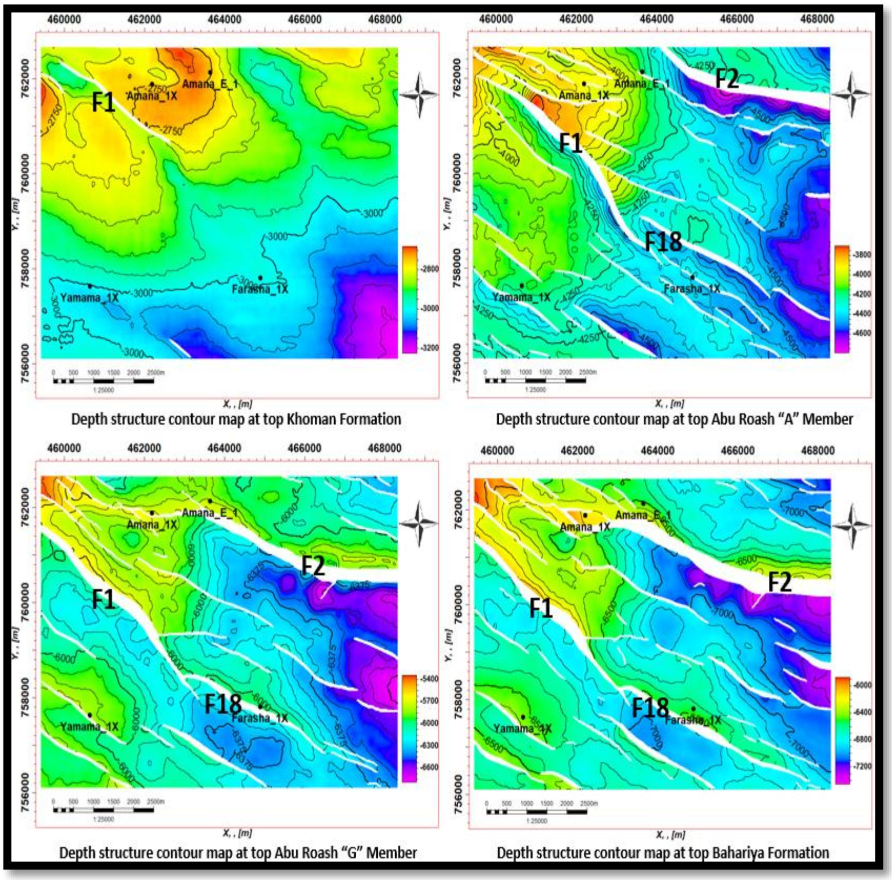

Figure (11): Depth structure maps on the tops of interested rocks.

a geometrical attribute used as an automated interpretation shows the similarity of adjacent seismic traces which can be related to the continuity of geology and imagines discontinuities and follows faults laterally to confirm the structural features that appeared through conventional interpretation and detect other new features as well.

The fault polygons derived from the conventional interpretation of seismic sections are projected on base map for the interested surfaces; Abu Roash “G” Member and Bahariya Formation. Then they were overlaid by the generated surface coherence attribute maps to find out the degree of matching of the fault pattern interpretation with that one deduced from variance attribute maps. This in turn, will increase the reliability of our interpretation. (Figures 12 and 13).

Variance attribute approves the results of structural analysis resulted by conventional seismic interpretation. A good example of this resemblance is shown in the intersection between an arbitrary seismic section in NE-SW direction and time slice extracted from variance volume attributeat1372msec. near top of Abu Roash “G” Member (chairdisplay) to tie faults between seismic sections and time slice extracted from variance volume attribute as shown in (Figure 14).

Structure Modeling

Structure modeling is the most important stage in the reservoir modeling process at which the structure model is built to capture all structural features in the study area.

In the study area, structure framework modeling is applied involving horizons and faults. Each are modeled as individual surfaces from their interpretations. Abu Roash “G” time surface, Bahariya time surface and set of the most effective faults in the study area have been loaded into Petrel® Schulmberger Software (2013) to build the structure model using the corner point gridding technique. These processes should undergo several iterations to enhance the final model. Structure model has been built through the three following steps:

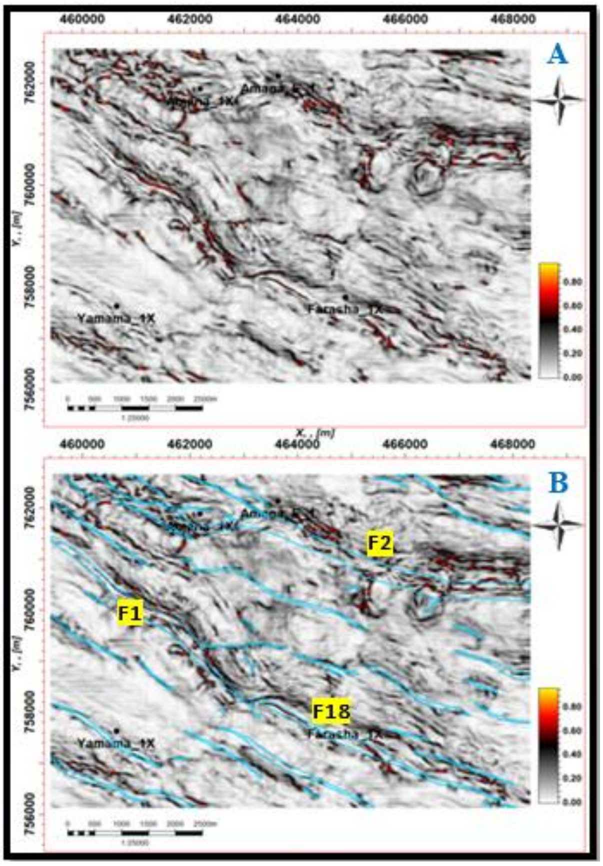

Figure (12) Variance map (A) on top Abu Roash “G” Member shows a great matching with the interpreted fault polygons from the seismic data (B) in illustrating the subsurface structural geometry specially the major NW-SE trending faults at that surface.

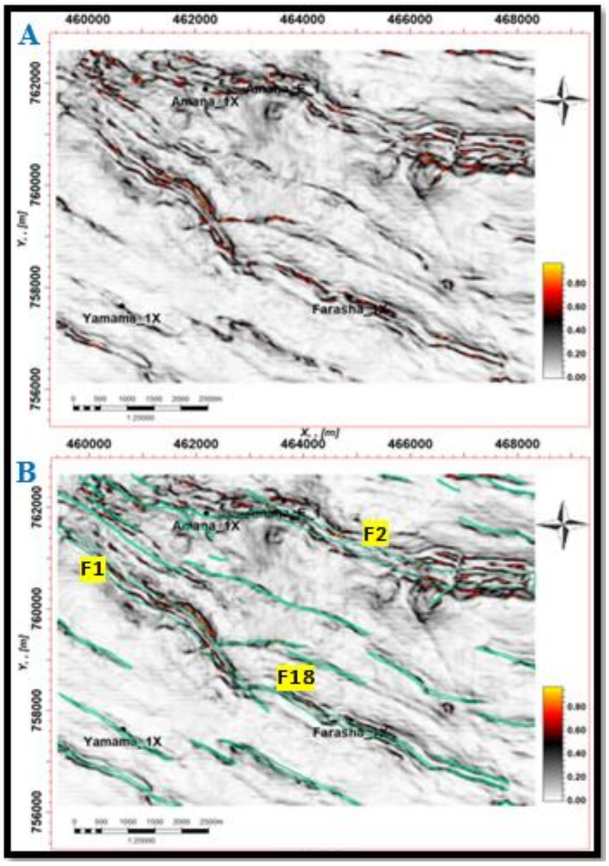

Figure (13) Variance map (A) on top Bahariya Formation shows a great matching with the interpreted fault polygons from the seismic data (B) in illustrating the subsurface structural geometry specially the major NW-SE trending faults at that surface.

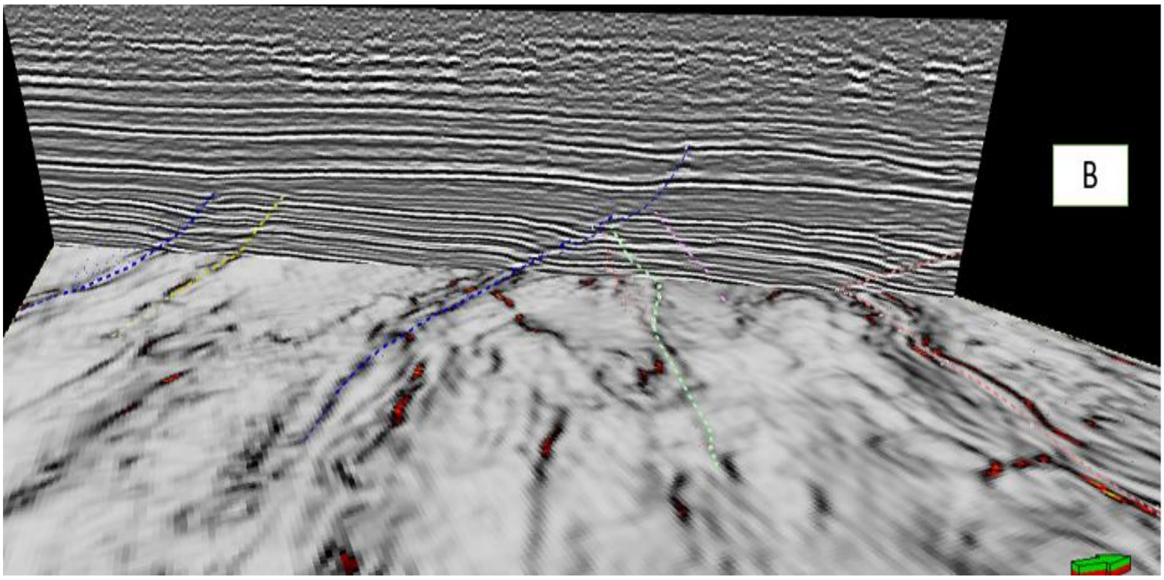

Figure (14): Shows the faults with different colors in seismic section and its extension on variance attribute time slice with corresponding colors.

Fault Modeling

Fault modeling process defines the faults in the structure model by converting the fault sticks exported from the interpreted surfaces into fault pillars, known as key pillars, which are lines describe the fault and outline the slope and shape of the fault. The key pillars are generated based on fault sticks. It is followed by adjusting the key pillars to the top and base of the model. The fault angles were honored and the resulting faults were placed in their proper positions. The fault model (key pillars) of the most effective faults of the study area in the 3D fault modelling process is represented by (Figure 15).

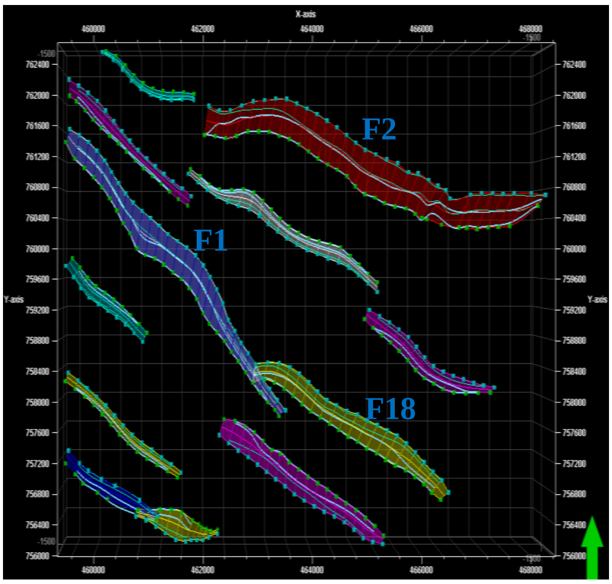

Figure (15): 3D view of fault model (key pillars).

1) Pillar Gridding

Pillar gridding is the process of creating the grid from the fault model. It produces a 3D skeleton framework comprised of three grids of cells to hold horizons. There are two directions; **I** and **J**, where the **J** direction is given to the vertical or nearly vertical faults, while the **I** direction is perpendicular to them.

In the study area, there are three skeletons as a result of the pillar gridding of Amana Field that will be used in building the horizons; top, middle and bottom skeletons. The grid increment is 100 m x 100 m (Figure 16). Selection of the **I** trend parallel to the main faults trend, and **J** trend perpendicular to the main faults trend is represented by (Figure 17).

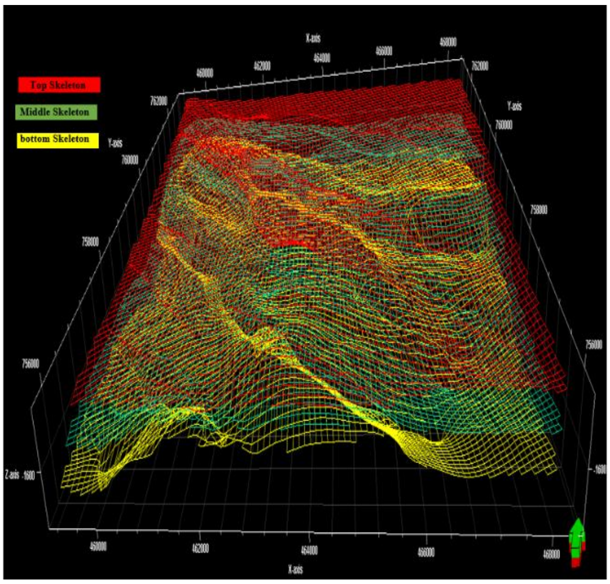

Figure (16): 3D gridding skeleton of 100 m*100 m.

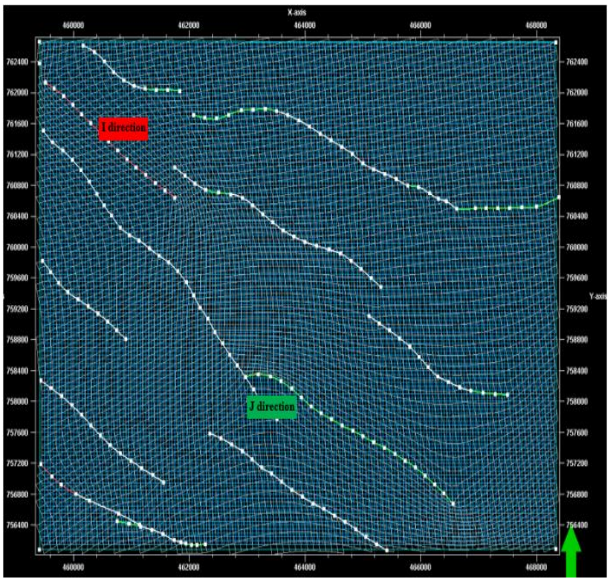

Figure (17): The I and J trends within Pillar gridding.

2) Make Horizons

The make horizons process includes generating stratigraphic horizons in the model, while honoring the faults defined in fault modeling **(Zhang et al., 2015)**. This is a true 3D approach in the generation of 3D seismically interpreted surfaces.

In Amana Field study area, there are two seismic time surfaces used as input data in making horizons process which are: Abu Roash “G” Member and Bahariya Formation. Also, the geological formation tops obtained from the well data have been used as control points at the location of the wells. The 3D time surfaces were integrated into the fault model and the three skeletons that resulted from the pillar gridding to build the final structure model as shown in Figure (18).

The obtained 3D structure model confirms the interpreted structure from the seismic data. The 3D structure model shows the regional uplift occurred in the study area and also, shows fault blocks in the area which is affected by the NW-SE mapped faults (Figure 19).

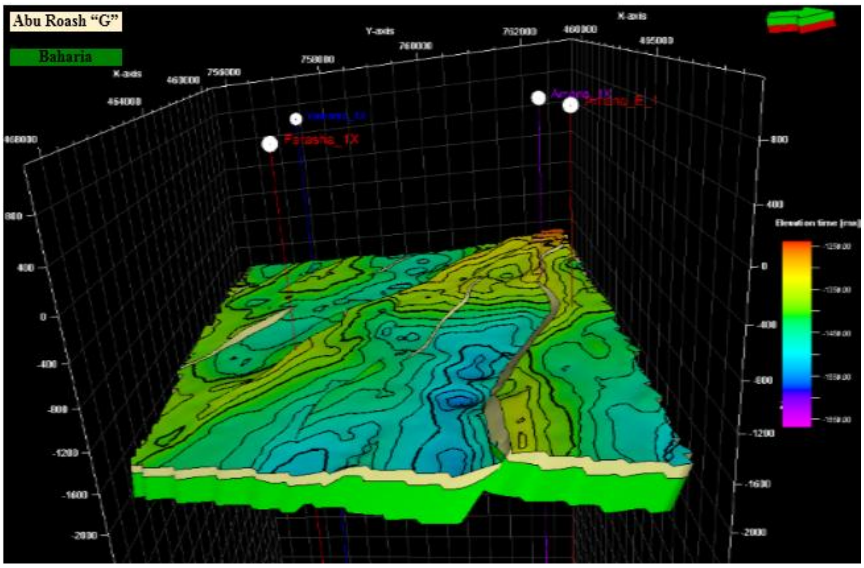

Figure (18): Final structure model in a 3D view.

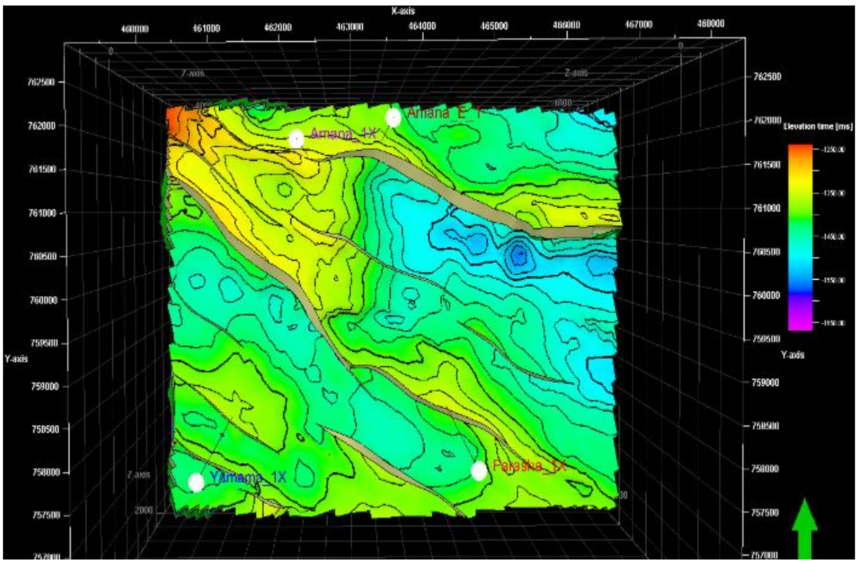

Figure (19): Fault Trends in the 3D structure model.

SUMMARY AND CONCLUSION

The study area (Amana Field) is located in the western part of East Bahariya Concession which is located in the most eastern part of Abu Gharadig Basin. The main purpose of this study is to delineate the subsurface geological structure analysis in the study area by reviewing the general stratigraphy and structural relationships, using subsurface geological and geophysical data. To achieve this objective, the current study started with the description of the geology of the area including a detailed discussion of stratigraphic rock units, structure of the north Western Desert where Amana Field is located.

Seismic data interpretation in terms of horizon and fault identification in the area indicated that Amana Field represents a positive prospect due to presence of structural petroleum trap (horst style). Seismic data interpretation clarified the structural elements in the study area by constructing depth structure maps on the tops of Khoman, Abu Roash “A”, Abu Roash “G” and Bahariya horizons. 3D structure model has been built by integrating all available data and interpretations of the geological interfaces to enhance the subsurface geological understanding and imagine the discontinuities and following faults dissecting the studied formation tops.

The final 3D structure model demonstrates the regional uplift (high structure) at the northwestern part of the study area confirming the results of the 3D seismic data interpretation. The principal structure responsible for the hydrocarbon entrapment in the study area is a high structure corresponding to the three-way dip closure of NW-SE normal faults.

REFERENCES

AbdelAal, A. (1990): Subsurface study of the Abu Gharadig Basin, Western Desert, Egypt, M.Sc. Thesis, A in Shams University.

Abdelmalek, K. and Zeidan, S. (1994): Cased-hole formation pressure tester-a practical application for better understanding of hydrocarbon migration and entrapment mechanism in greater Bed-3 area, WesternDesert.12thEGPCExploration and Production Conference, Cairo, pp. 263-276.

Abu-Hashish, M.F. and Said, A. (2016): Volumetric Assessment through 3D Geostatic Model for Abu Roash “G” Reservoir in Amana Field, East Abu Gharadig Basin, Western Desert, Egypt. Journal of Geology & Geophysics Vol. 5, No. 2.

Bahorich, M. S., and Farmer, S. L. (1995): 3D seismic discontinuity for faults and stratigraphic features:The Coherence Cube. The Leading Edge,Vol.14, pp. 1053-1058.

Bayoumi, T. (1996): The Influence of Interaction of Depositional Environment and Synsedimentary Tectonics on the Development of Some Late Cretaceous Source Rocks, Abu Gharadig Basin, Western Desert, Egypt. 13th EGPC Petroleum Exploration and Production Conference, Cairo, Vol. 2, pp. 475-496.

Egyptian General Petroleum Corporation “ EGPC” (1992): Western Desert,Oil and Gas Fields (A Comprehensive Overview), The Egyptian General Petroleum Corporation (EGPC), 11th EGPC Exploration and Production Conference, Cairo, pp. 1-431.

ElPaso Exploration and Production Company “EEPC”, Houston, Texas, (2011): Jurassic rift architecture in the northeastern Western Desert, Egypt.

El-Ayouty, M.K. (1990): Petroleum geology of Western Desert. In (Ed. R. Said), The Geology of Egypt, Rotterdam, NetherLands, Balkema, pp.567-594.

El-Toukhy, M. and Bakry, G. (1988): Bed-3:Agas/condensate and oilfield, badr ElDin Concession, Western Desert, Egypt. 9thEGPC Petroleum Exploration and Production Conference, Cairo, Vol. 2, pp.76-96.

Hantar, G. (1990): north Western Desert, in (Ed. R. Said). The Geology of Egypt, A.A. Balkema, Rotterdam, Brook filed, pp. 293-320.

Hegazy, A. (1992): Western Desert oil and gas fields (a comprehensive overview), the 11th EGPC petroleum exploration and production Conference, Cairo, 431p.

Kandil, M. (2003): Reservoir characterizations of Bahariya Formation in Khalda Oil Field,WesternDesert,Egypt.M.Sc.Thesis,ZagazigUniversity,Zagazig, 168p.

Lüning, S, Kolonic, S, Belhadj, M.E, Belhadj, Z, Cota, L, Baric, G, and Wagner, T. (2004): Integrated depositional model for the Cenomanian-Turonian organic-rich strata in North Africa. Earth Science Reviews, Vol. 64, Is. 1, pp. 51-117.

Meshref, W. M. (1990): Tectonic framework of Egypt. In (Ed.R.Said, 1990), The Geology of Egypt. Balkema, Rotterdam, pp. 113-156.

Sestini, G. (1984): Tectonic and sedimentary history of the NE Africa margin (Egypt -Libya) In Dixon, E.J., Robertson, F. H. A. (Ed.), The geological evolution of the Eastern Mediterranean, Blackwell Scientific Publications, Oxford, pp. 161-175.

Sestini, G. (1995): Regional petroleum geology of the world, part2. Africa, America, Australia and Antarctica, pp. 66-87.

Sheriff, R.E., and Geldart, L.P. (1995): Exploration Seismology, Cambridge University Press, 423 p.

Zhang, M., Yang, Y., Xia, Z., Cui, Z., Ren, B., and Zhang, W. (2015): A Best Practice in Static Modeling of a Coalbed-Methane Field: An Example from the Bowen Basin in Australia. Society of Petroleum Engineers, pp. 149-157.