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Geological Modeling for Yamama Formation in Abu Amood Oil Field

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Abstract

3D geological model of a simple petroleum reservoir for Yamama Formation has been built in Abu Amood Oil Field using Petrel software, which is a product of Schlumberger. This model contains the structure, stratigraphy and reservoir properties (porosity and water saturation) in three directions(X, Y and Z).Geologic modeling is an applied science of creating computerized representations of portions of the earth's crust, especially oil and gas fields.

Yamama Formation in Abu Amood Oil Field is divided into thirteen zones by using well logs and their petrophysical properties, six of which are reservoir zones. From the top of the formation these six zones are: (YB-1, YB-2, YB-3, YC-1, YC-2 and YC-3). These reservoir zones are separated from each other by barriers, which are of little or no porosity.

Keywords: Geological Model, Reservoir Properties, Yamama Formation.

موديل جيولوجي لتكوين اليمامة في حقل ابو عمود النفطي

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الخلاصة

تم بناء موديل جيولوجي بسيط لتكوين اليمامة في حقل ابو عامود النفطي بأستخدام برنامج البترل الذي قدمته شركة شلمبرجر النفطية. يشمل هذا الموديل الصفات التركيبية والبيئية والمكمنية المتمثلة بالمسامية والتشبع المائي في ثلاث ابعاد على المحاور الثلاث (Y,X وZ) حيث يعتبر هذا الموديل علم تطبيقي في عمل تمثيل حاسوبي لاجزاء من القشرة الارضية، ولا سيما في حقول النفط والغاز. قُسِم تكوين اليمامة في حقل ابو عامود النفطي الى ثلاثة عشر نطاقاً بأستخدام المجسات البئرية وصفاتها البتروفيزيائية، ستة من هذه الانطقة تعتبر وحدات مكمنية من اعلى التكوين هذه الوحدات هي (YB-1، YB-2، YB-3، YC-1، YC-2 و YC-3) وهذه الوحدات المكمنية معزولة عن بعضها البعض بطبقات عازلة مع مسامية قليلة او معدومة.

Introduction

The Yamama Formation, which is a heterogeneous carbonate reservoir, is one of the important oil production reservoirs in southern Iraq, which was deposited during the Lower Cretaceous period within the main retrogressive depositional cycle (Berriasian - Aptian) south of Iraq. This cycle is represented from shore to deep basin by the Zubair, Ratawi, Yamama, Shuiaba, and Sulaiy Formations [1].

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Yamama Formation is one of the promising carbonate reservoirs, because of its wide geographic distribution over most parts of Southern Iraq, and consists of one of the richest petroleum systems attributed with distinctive structural traps and the appearance of subtle stratigraphic traps [2].

Area of Study

Abu Amood oil field is located in Dhi Qar Governorate, about 250km southeast Baghdad. The field covers an area of approximate (120) km^2 and is distributed in the northwest-southeast direction. It is located between (Longitudes. 45.30-46.30 E., and Latitudes. 31.00-32.00 N.). Figure-1.

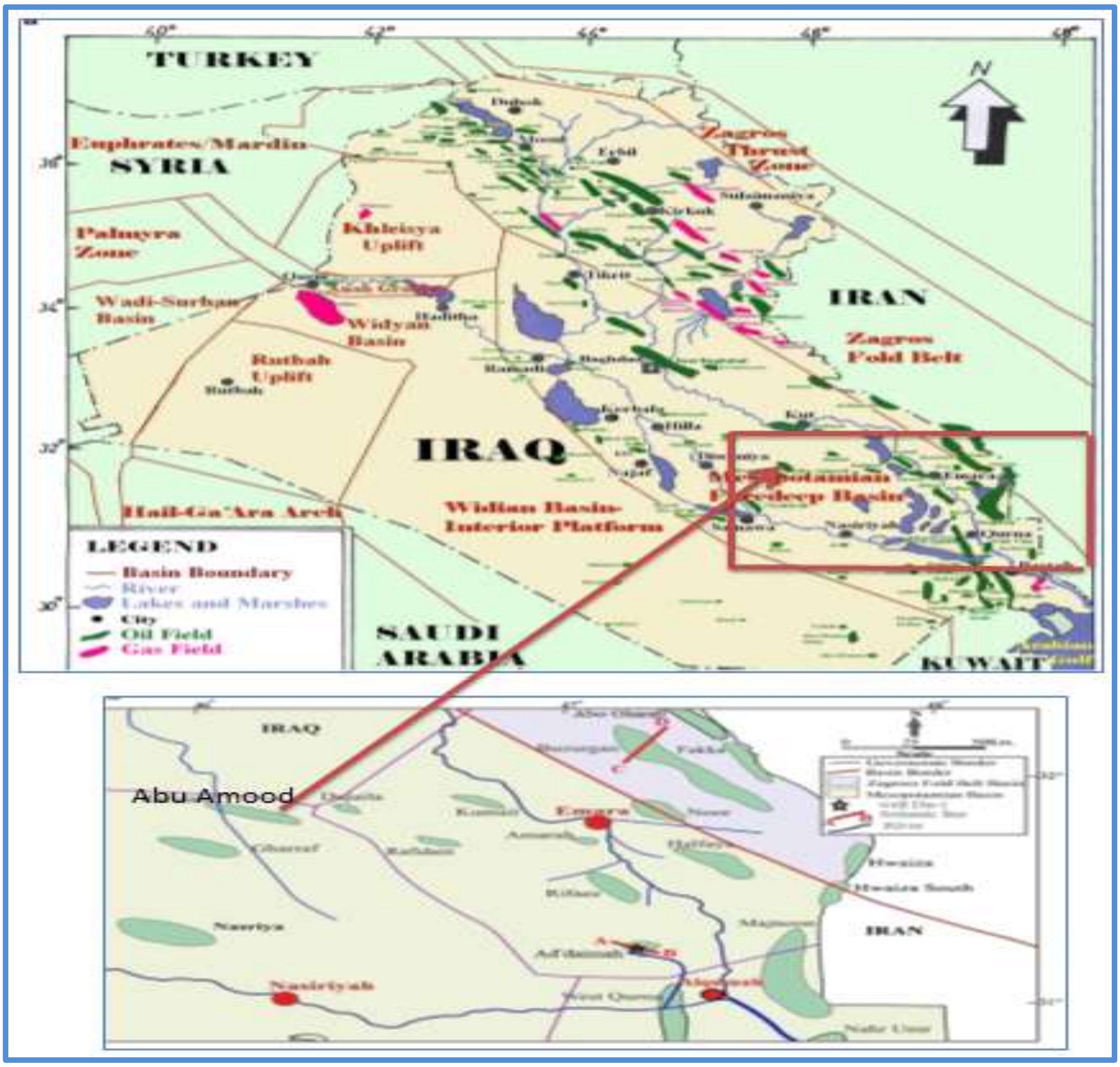

Figure 1- Location map of study area.

Aims of Study

The main purpose of the present study is to build 3D geological & Petrophysical modeling includes structural, facies and petrophysical models to illustrate the variation of these properties in Yamama Formation using Petrel software.

Methodology

To delineate the mentioned aims of the study, data from the available logs such as (Spontaneous Potential, Gamma Ray, Density, Sonic, Neutron and Resistivity logs) were used by interactive petrophysics software IP (3.5V). The result of these logs carried out to Petrel software to construct structural maps and 3D geological models and distributing the petrophysical properties (Facies, Porosity and Water saturation) in the model.

Well Correlation

After data were entered into Petrel Software, correlation sections of Abu Amood wells were carried out. Well correlation has been applied as a relatively easy method to give an idea and allow simple visualization of the changes in the thickness within Yamama units and the change of the petrophysical properties (porosity and water saturation) [3].

Three well sections have been made in Abu Amood Oil Field. Figure-2 shows the direction of correlation between wells, first one represents by Red line in NW-SE direction. The second represents by Blue line in E-W direction. The third represents by Black line in NE-SW direction. Figures-3 to 5 illustrates the variation in reservoirs thickness of the Yamama units as well as the variation in petrophysical properties (porosity and water saturation).

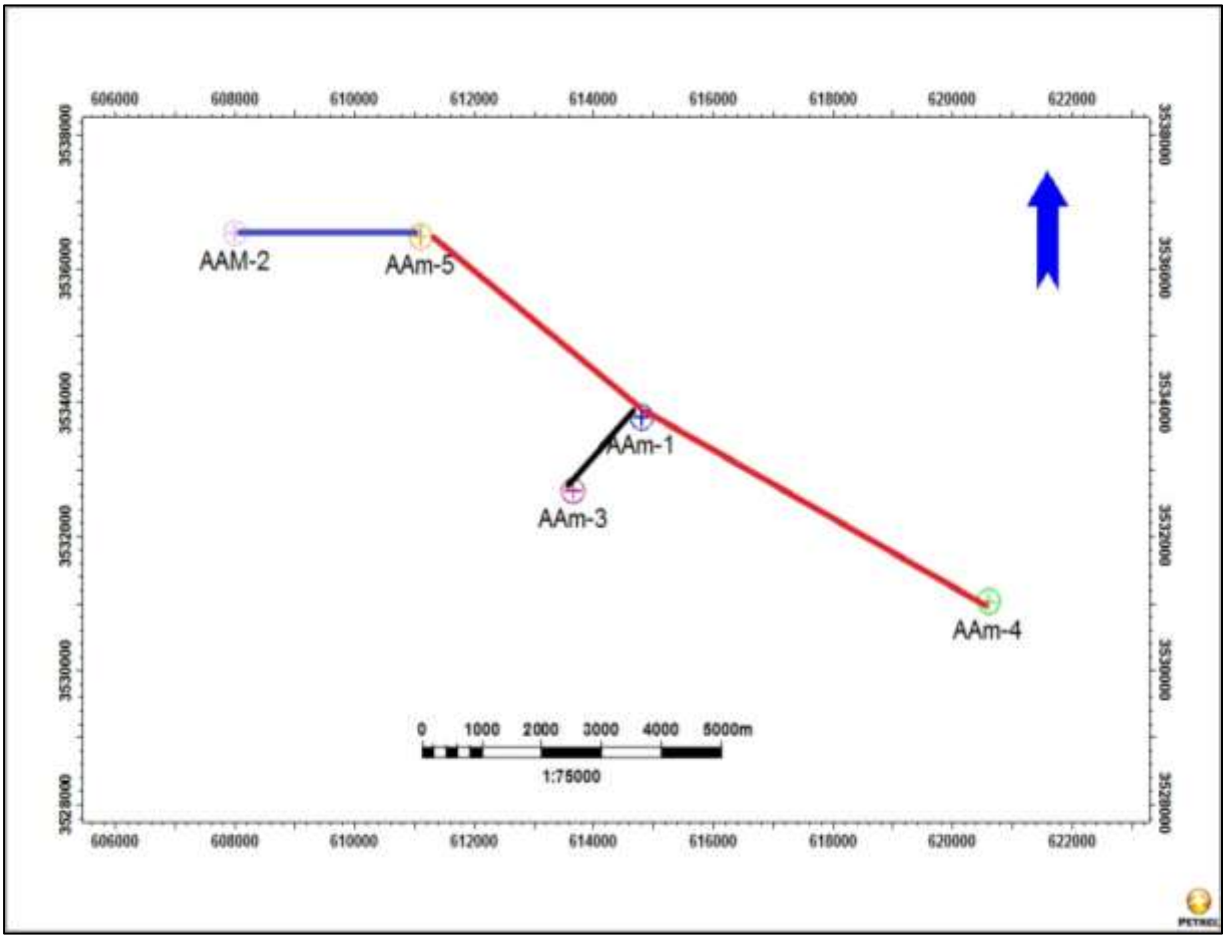

Figure 2- Map view shows the directions of correlation between the wells.

The correlation well sections show that the thickness increases from the NW at AAm-5 to SE direction at AAm-1 and AAm-4, also the petrophysical properties enhanced in the same directions in AAm-5, AAm-1 and AAm-4 respectively and decreased in AAm-2 and AAm-3.

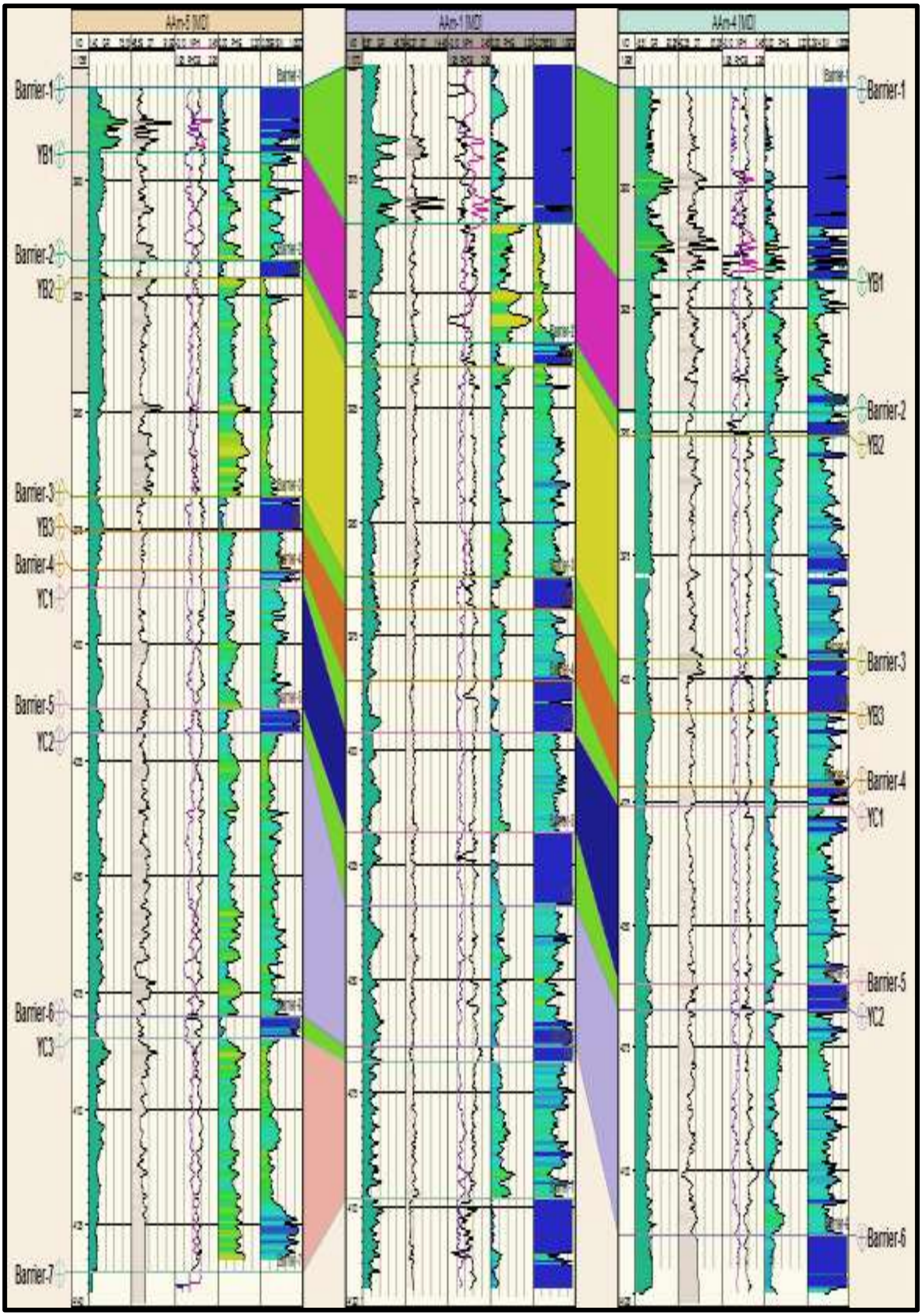

Figure 3- NW-SE Correlation section of Yamama Formation for wells (AAm-5, AAm-1 and AAm-4).

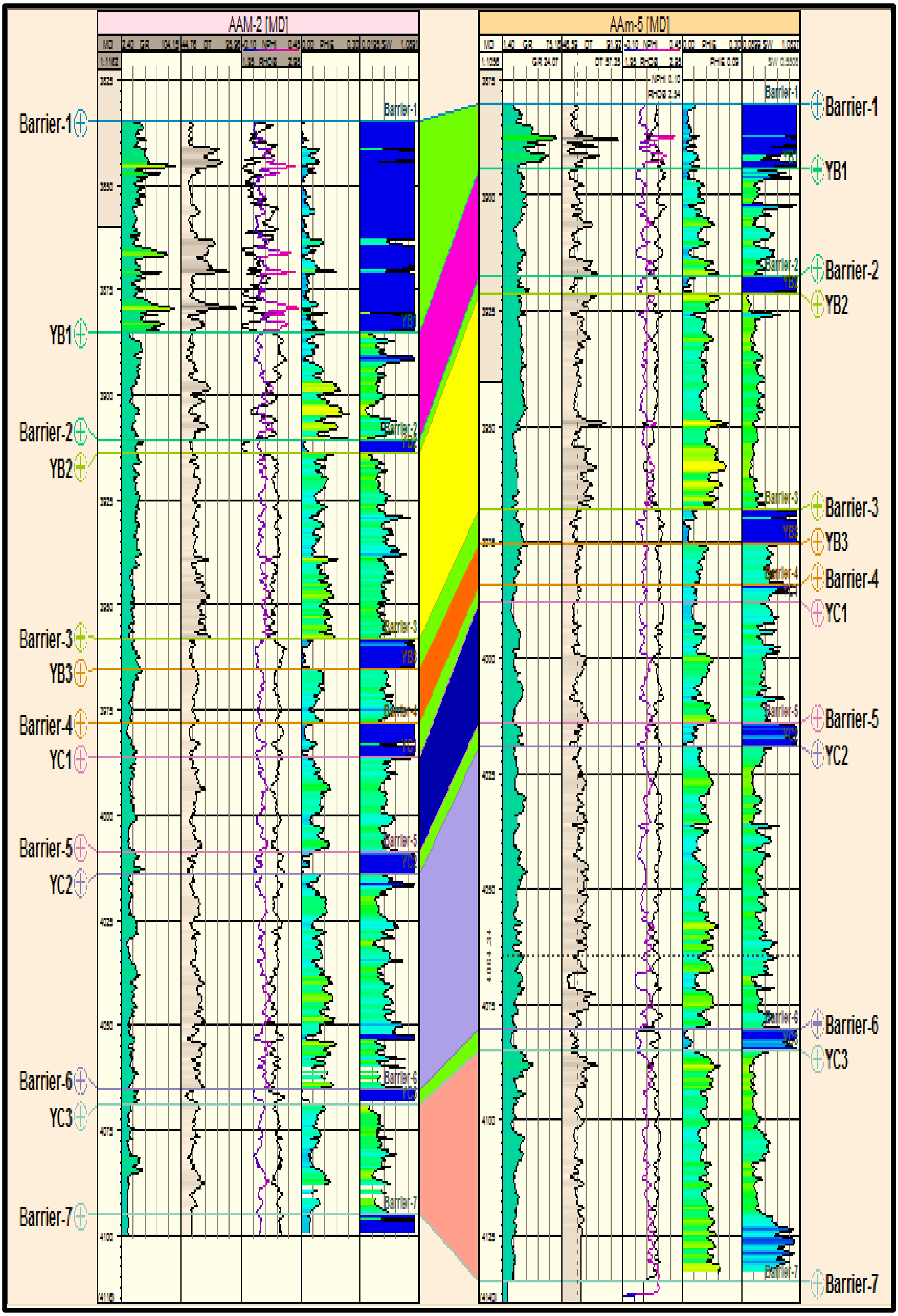

Figure 4- E-W Correlation section of Yamama Formation for wells (AAm-2 and AAm-5).

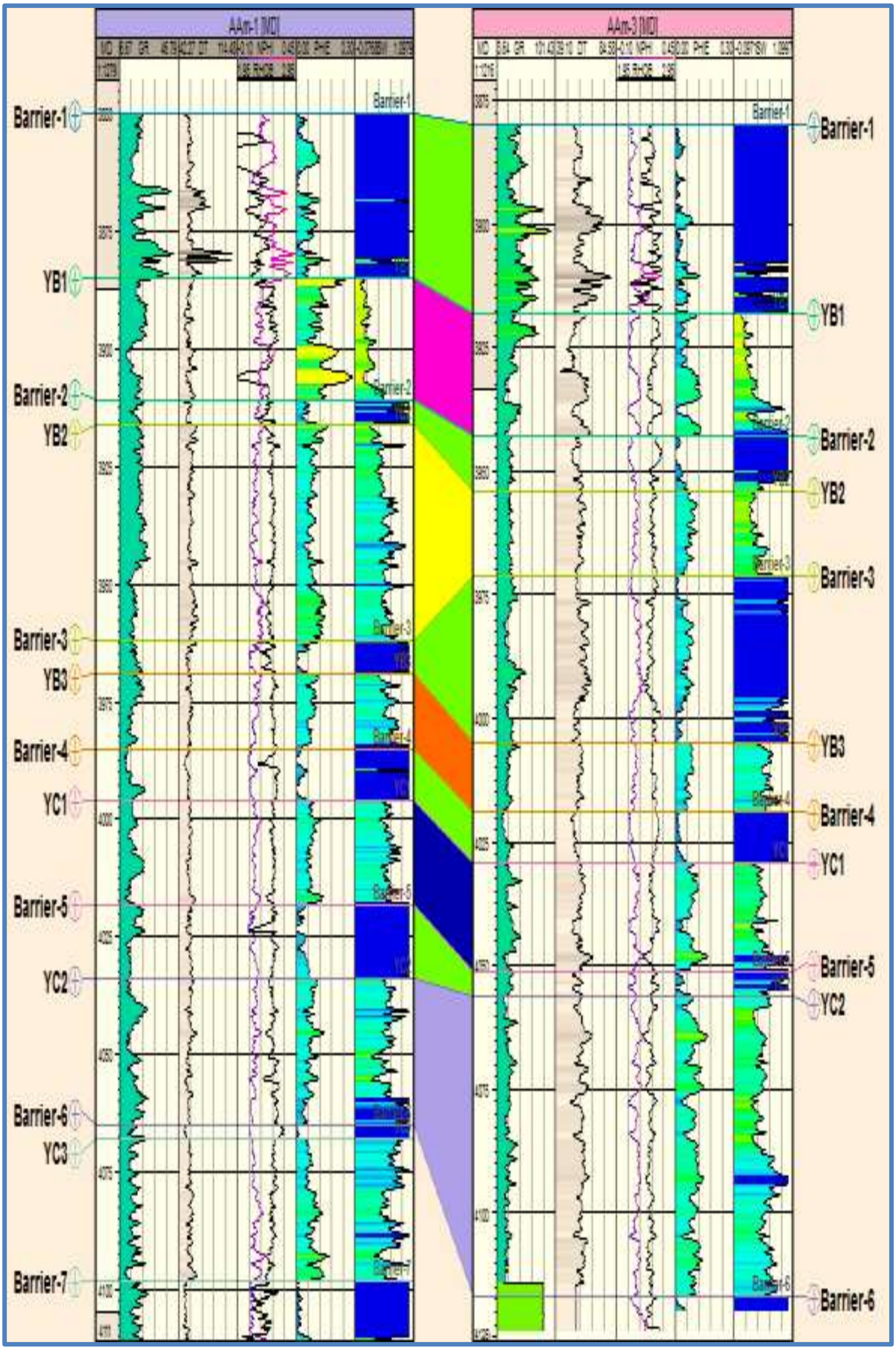

Figure 5- NE-SW Correlation section of Yamama Formation for wells (AAm-1 and AAm-3).

Structural Contour Maps

Contour maps can be constructed by computer from the surface and correlated borehole [4]. Structure contour maps of top Yamama Formation were built depending on well tops as well as the available structure map from (2D seismic). These structural contour maps show that the Yamama structure in Abu Amood Field is composed of two assymetrical anticlinal domes, and its axis extends toward Northwest–Southeast and the length is 26km and width of (5-5.5km) with structural closure of about 60m. Structural contour maps for top of Yamama have been introduced Figure-6.

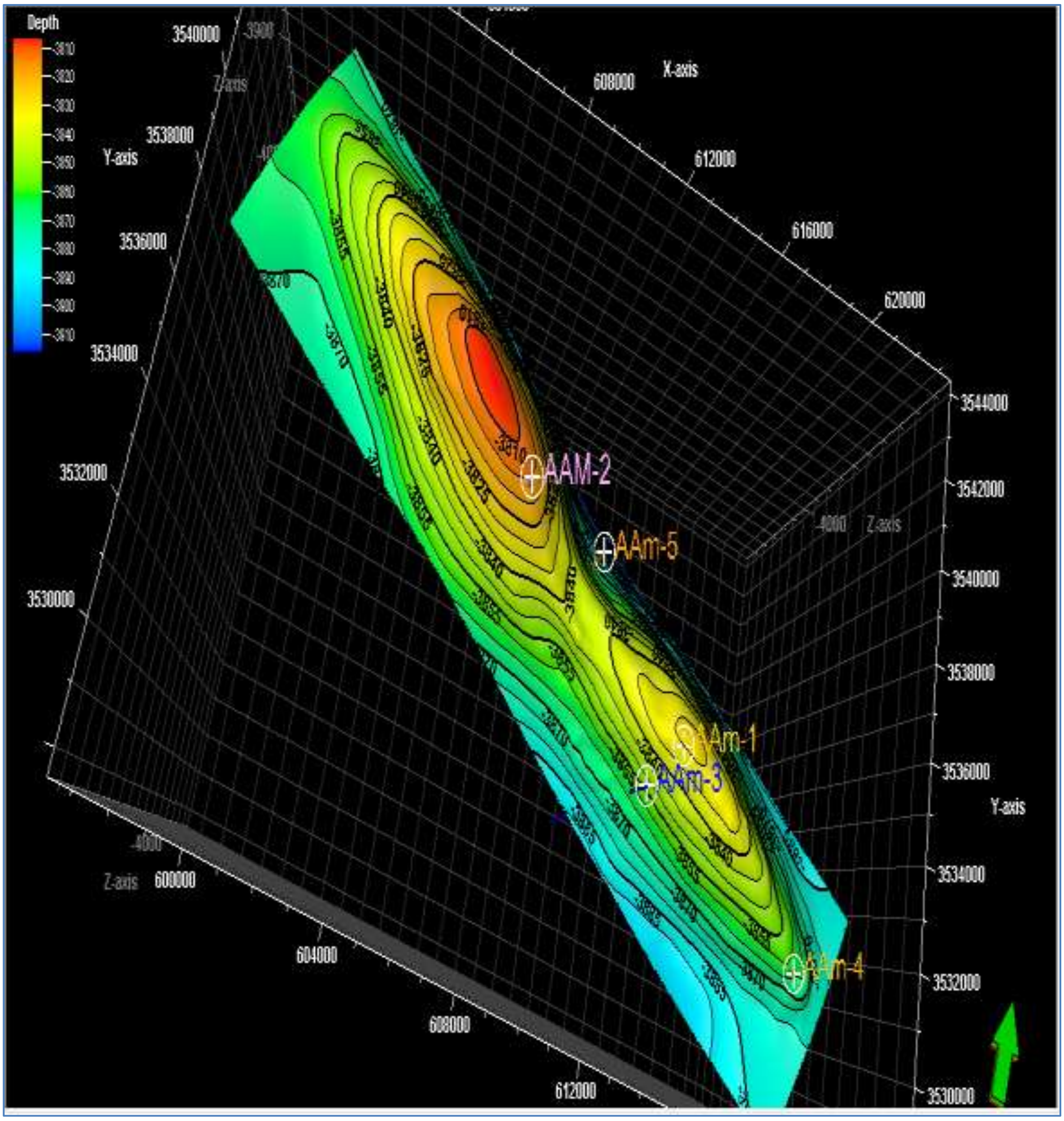

Figure 6- Structural contour map of the top of Yamama Formation in Abu Amood Oil field.

Property Modeling

Property modeling is the process of filling the cells of the grid with discrete (facies) or continuous (petrophysics) properties. Petrel assumes that the layer geometry given to the grid follows the geological layering in the model area. These processes are therefore dependent upon the geometry of the existing grid. When interpolating between data points, Petrel will propagate property values along grid layers [5].

The aim of a geological reservoir model is to provide a complete set of continuous reservoir parameters (i.e. Porosity, Permeability and water saturation) for each cell of the grid. Many different techniques can be used to generate these parameters [6].

Facies and Environmental Model

Facies modeling is distributing discrete facies throughout the model grid. Normally, the user will have scaled up well logs with discrete properties in the model grid, and possibly defined trends within the reservoir, by analyzing this data [7].

Environmental modeling of Yamama Formation in Abu Amood Oil Field was built depending on the results of the facies interpretation of sedimentary environments as obtained from logs interpretation and other geological data.

Yamama Formation is divided into four depositional environments are (Inner-ramp, Middle-ramp, Outer-ramp and Basin) were they generally interpreted for each well. Inner and middle-ramp environments represent the reservoir units whereas outer-ramp and basin environments represent barriers beds. Figure-7 shows the 3D facies and environmental model of Yamama Formation in Abu Amood Oil field for the reservoir and barriers units.

The general intersection for the environmental model shows that the Yamama Formation in Abu Amood Oil Field has many traps within its column Figure-8.

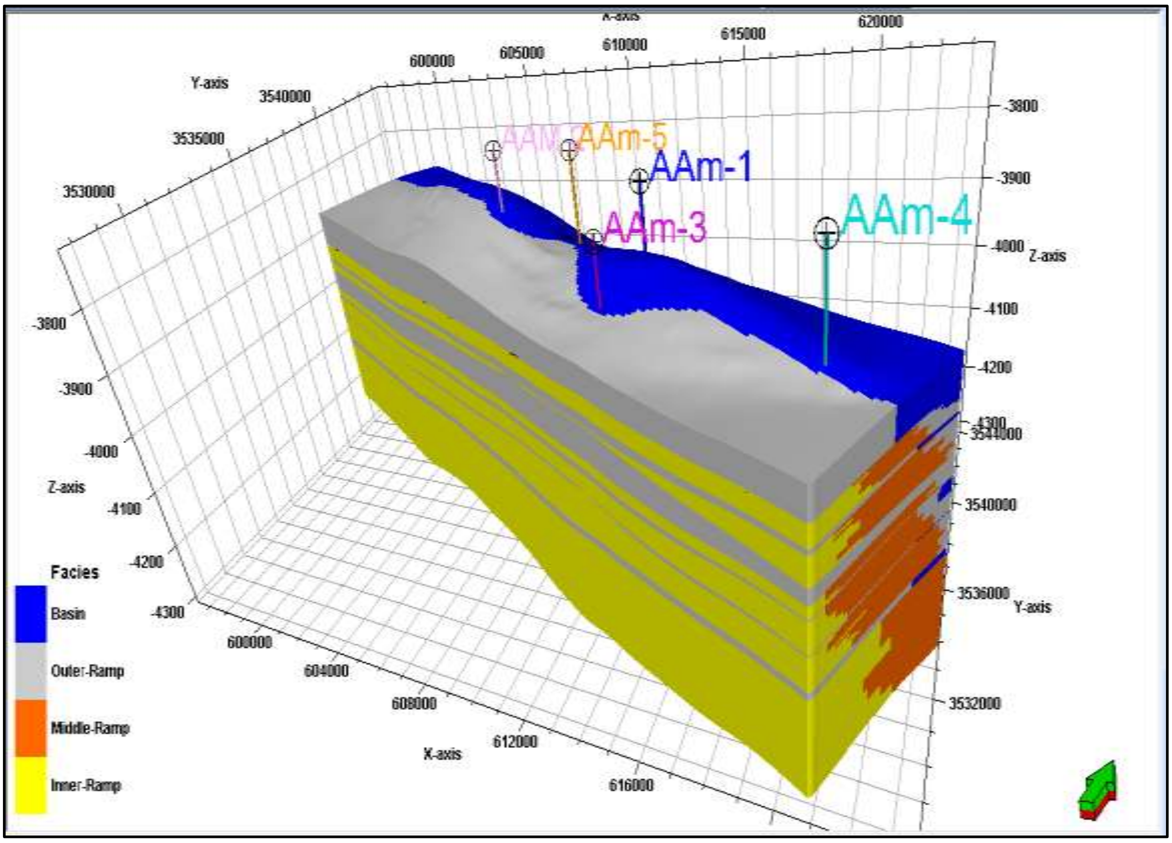

Figure7- Facies and environmental model of Yamama Formation in Abu Amood Oil Field.

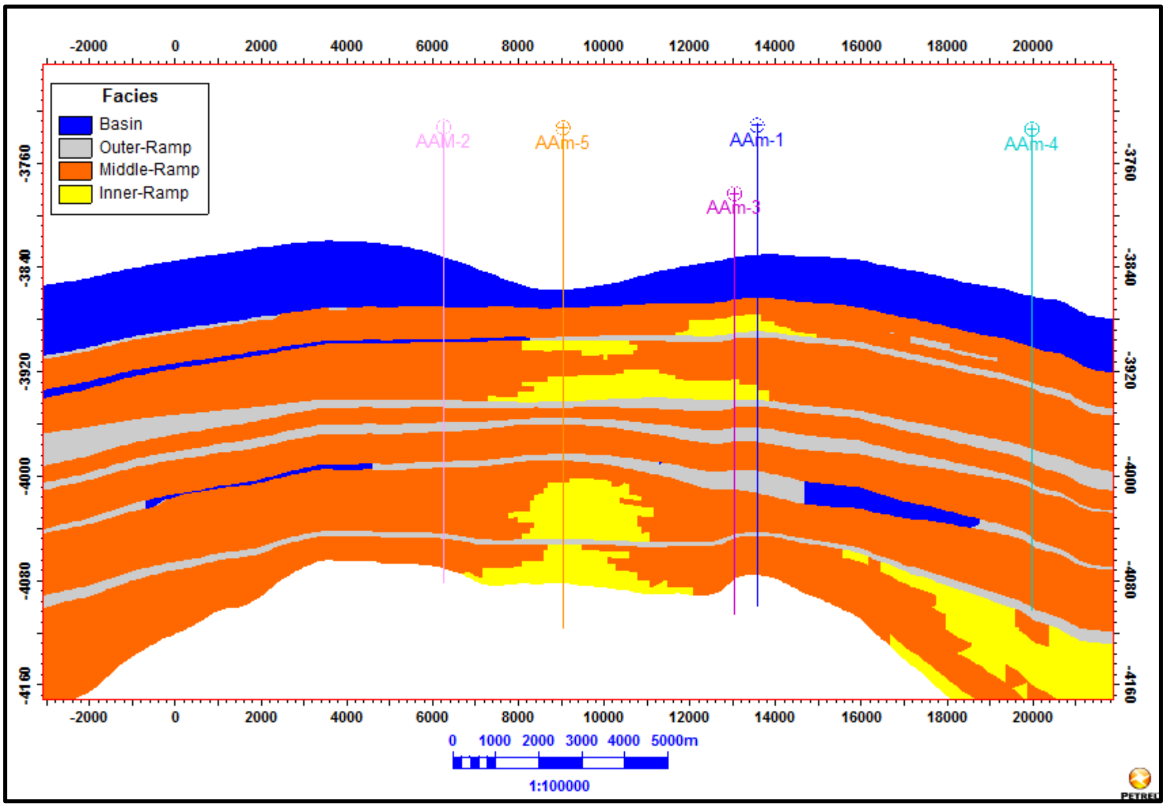

Figure 8- Facies and Environmental cross section of Yamama Formation in Abu Amood model.

Petrophysical Model

Petrophysical Model is the interpolation or simulation of continuous data (e.g. Porosity, Permeability and Saturation). Petrel offers several algorithms for modeling the distribution of petrophysical properties in a reservoir model [5].

Porosity Model

Porosity model was built depending on the results of porosity logs (density and neutron) which have been corrected and interpreted in the IP software. Statistical sequential Gaussian simulation algorithm was used as a statistical method, which fits with the amount of available data [7].

The essential step in the "porosity model" process is to scale up the porosity from the well grid cells to the entire model with the aim of distributing the porosity from the well log data to the grid cells in the 3D model as realistically as possible preserving the heterogeneity of the geological subsurface. Before the porosity could be modeled the original porosity distribution was transformed into a stationary and normally distributed data set. The reason for removing trends prior modeling is for the input data to be stationary [6].

The environmental model was depended as a base for distributing the porosity and building the porosity model. Figure-9 shows the general porosity model for the reservoir and barriers units of Yamama Formation. It was noted that the porosity within reservoir units increases where the Middle and Outer ramp facies exist, and decreases where the outer ramp and Basin facies present. Figure-10 shows the general intersection for the Porosity model of Yamama Formation in Abu Amood Oil Field.

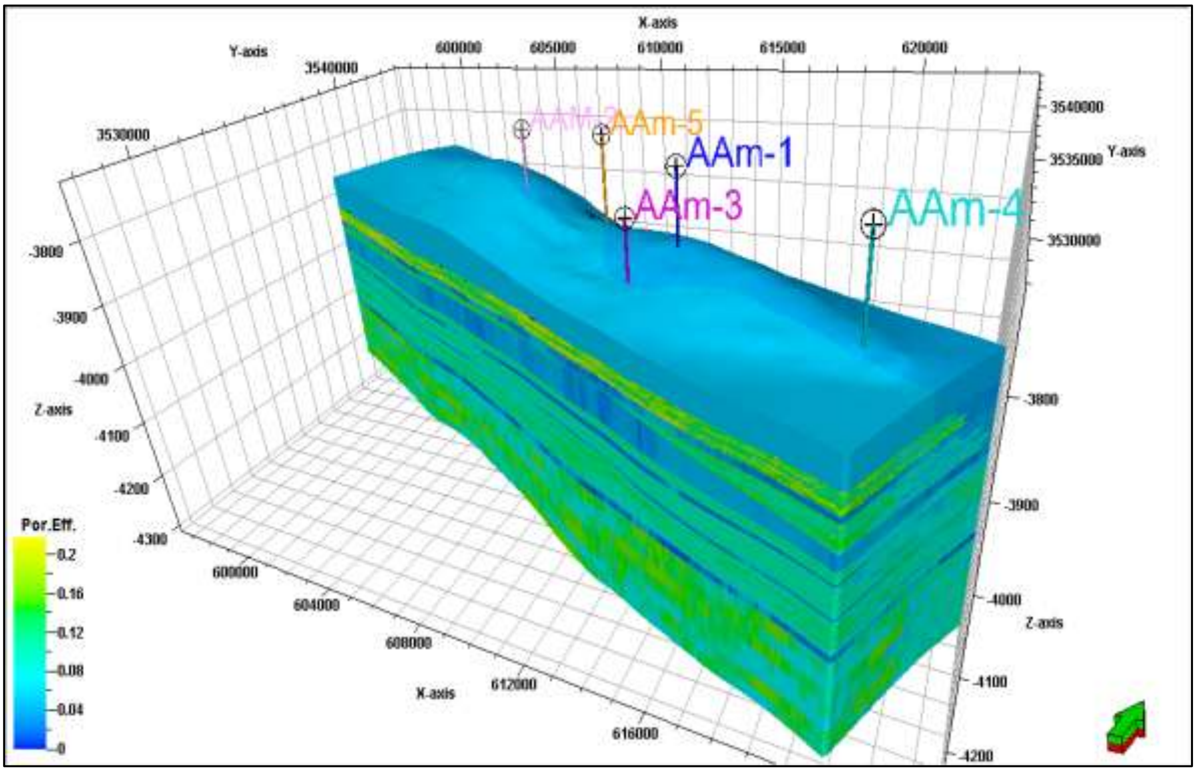

Figure 9- The porosity distribution model of Yamama Formation in Abu Amood Oil Field.

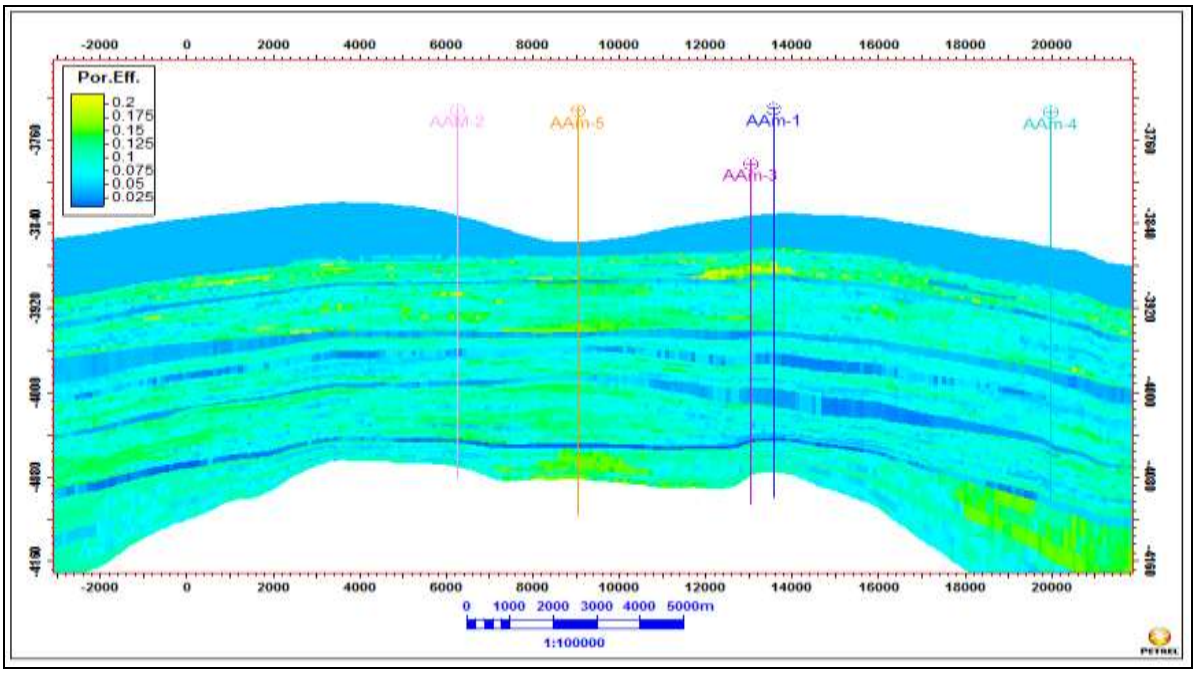

Figure 10- Porosity cross section of Yamama Formation in Abu Amood Porosity model.

Water Saturation Model

Water saturation model has been built using the same geostatistical method of porosity model after scale up. The environmental model was also used as a base for distributing the water saturation values in the model.

Figure-11 shows the general water saturation model for the reservoir and barrier units of Yamama Formation. It was noted that the water saturation characterized by almost low within reservoir units where the Middle and Outer ramp facies exist.

The barriers which are dominated by Outer ramp and basinal environments show high water saturation values. Figure-12 shows the general intersection for the water saturation model of Yamama Formation in Abu Amood Oil Field.

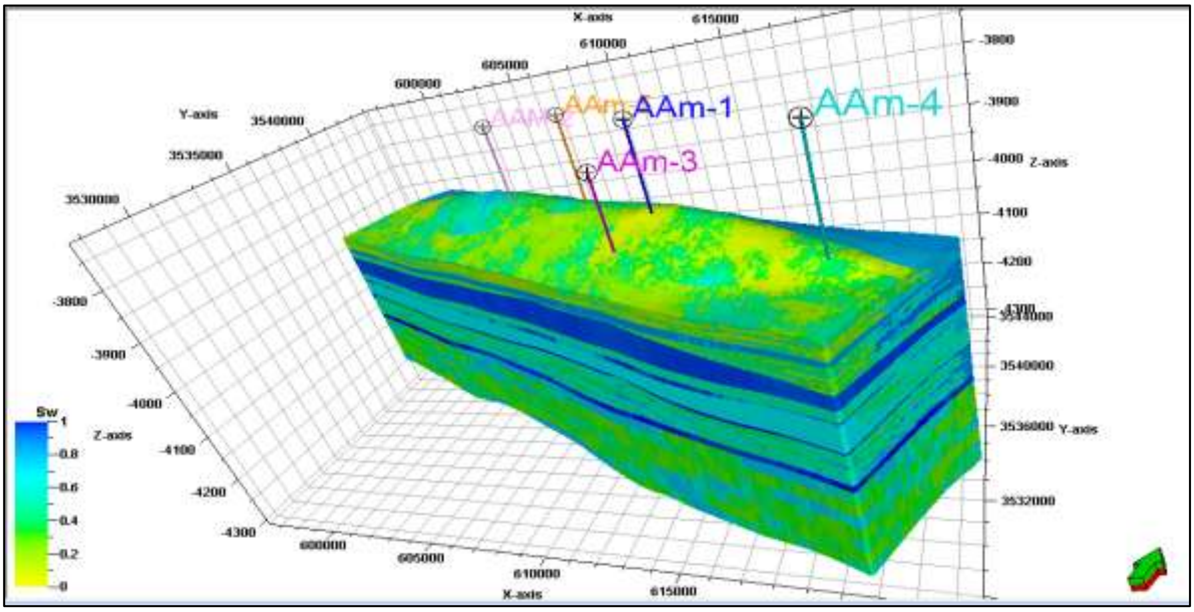

Figure 11- The water saturation distribution model of Yamama Formation in Abu Amood Oil Field.

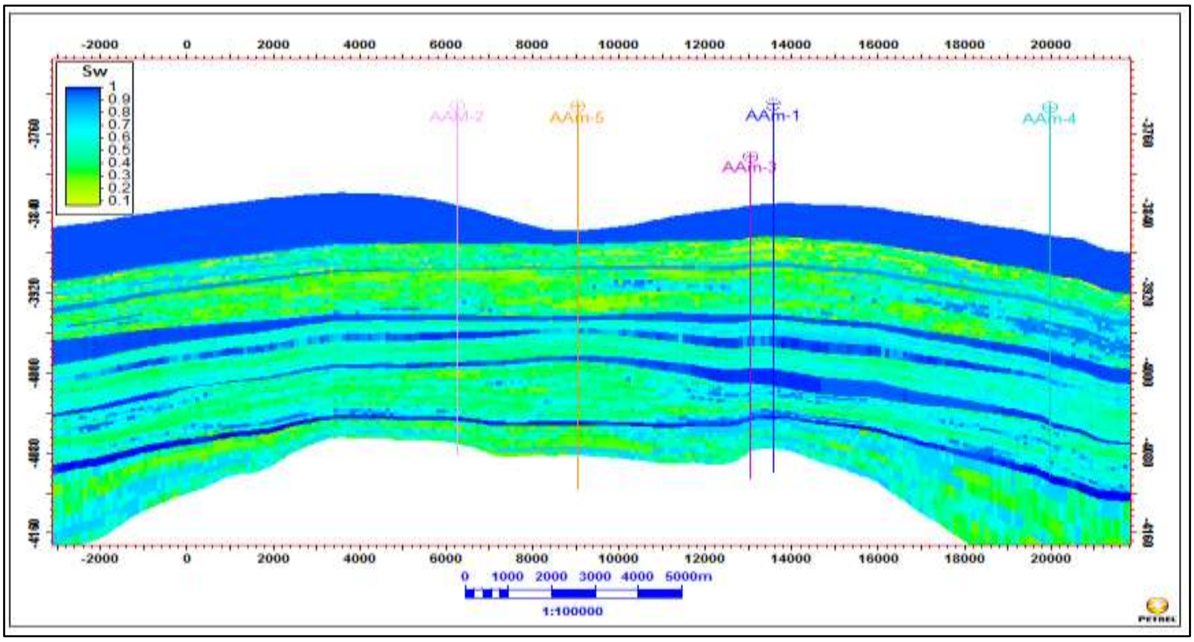

Figure 12- Water saturation cross section of Yamama Formation in Abu Amood model.

Evaluation of 3D Yamama Model

The 3D geological model (which includes facies & environmental, porosity & water saturation models) that was built for Yamama Formation in Abu Amood Oil Field represents an integral part to the results and interpretation of well logs and other geological data.

The model shows that the Yamama is a multiple oil column reservoir; entirely composed of carbonates. In Abu Amood Oil Field, Yamama Formation is divided into six units; (YB-1, YB-2, YB-3, YC-1, YC-2 and YC-3) the reservoirs are separated by dense non porous units (6 Barrier beds). The following is an evaluation of all the reservoir units of Yamama Formation:

- **YB-1 Reservoir Unit**

This Unit is the uppermost reservoir unit within Yamama Formation in Abu Amood Oil Field. The thickness of this unit ranges from (26-28) meters with average thickness of 27 meters all over the field. Figure-13 shows the inner and middle ramp environments were dominated. They have moderate to good petrophysical properties, overall porosity distribution in this unit between (0.02– 0.2), while water saturation ranges between (0.16-0.85) through all wells.

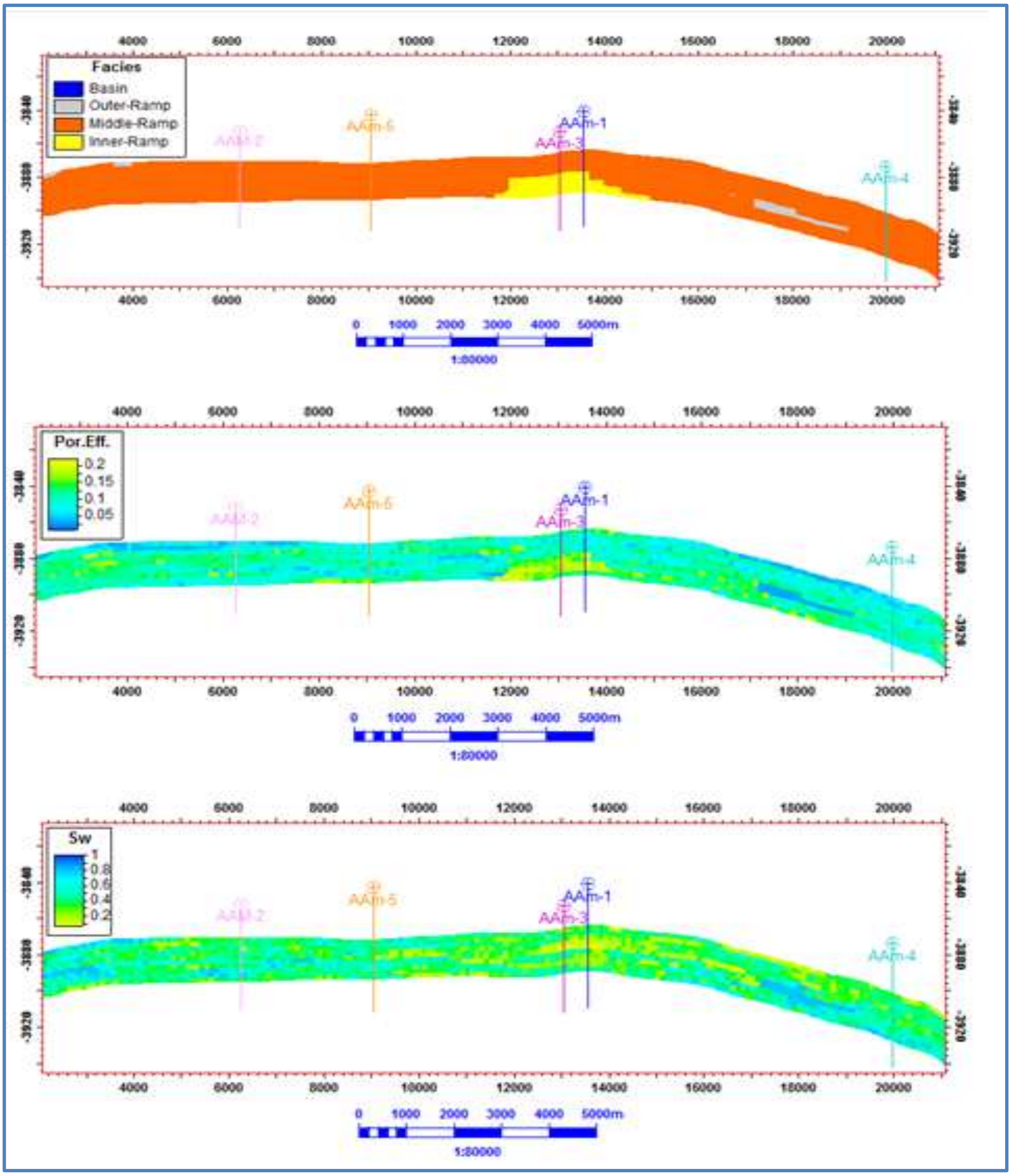

Figure 13- Intersection of YC-3 for Yamama Formation in Abu Amood Oil Field.

- **YB-2 Reservoir Unit**

This Unit is a reservoir unit within Yamama Formation in Abu Amood Oil Field. The thickness of this unit ranges from (19- 48) meters with average thickness of 32.5 meters all over the field. Figure-14 shows the inner and middle ramp environments were dominated. They characterized by good reservoir properties including porosity with values range between (0.07-0.15), and water saturation value ranges between (0.24-0.84), is interpreted as an oil-bearing zone.

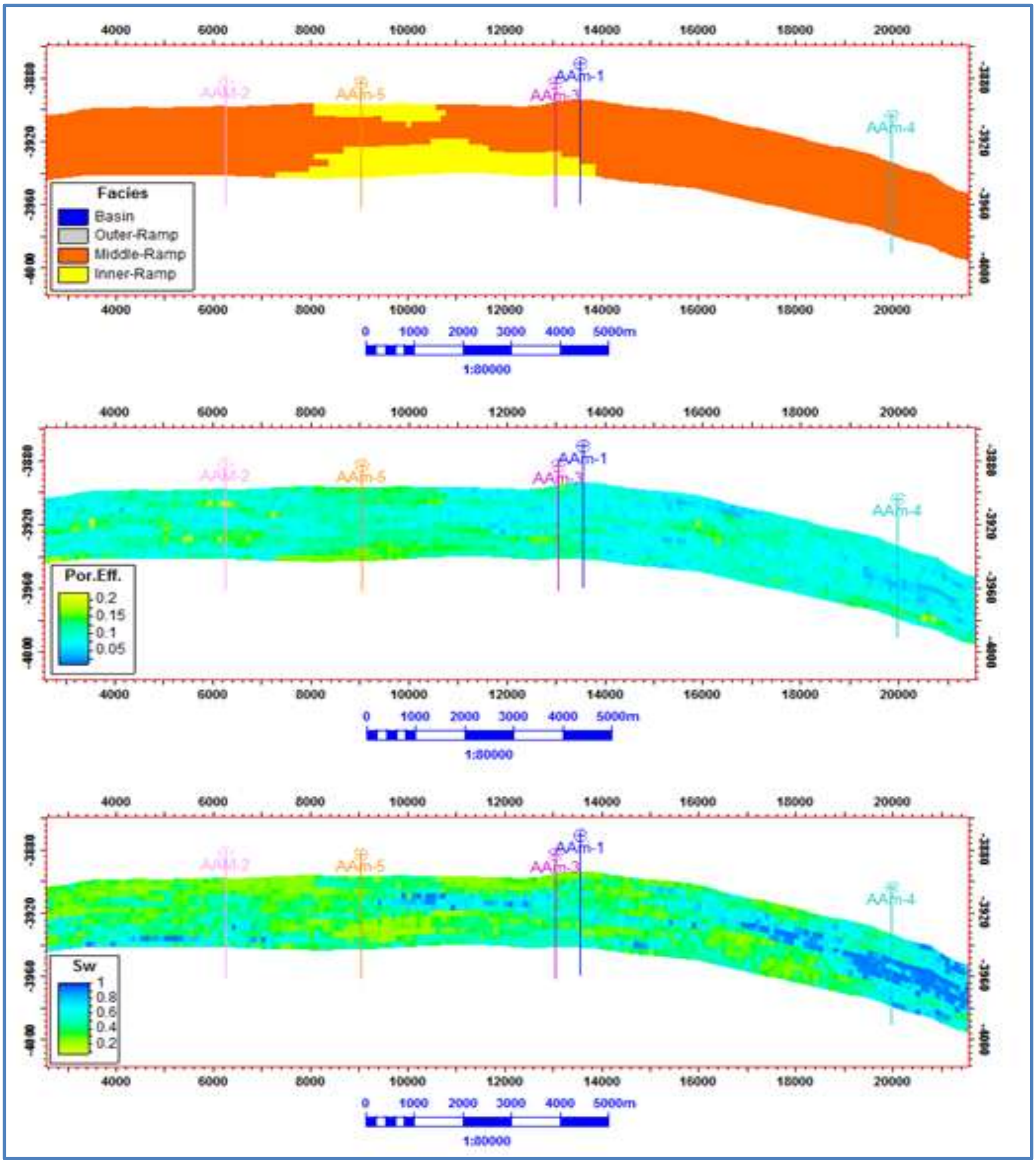

Figure 14- Intersection of YB-2 for Yamama Formation in Abu Amood Oil Field.

- **YB-3 Reservoir Unit**

The YB-3 unit is much smaller in thickness ranges from 9 meters at well AAm-5 to 18 meters at well AAm-1, with average thickness 13.5 meters along the field. Figure-15 shows the middle ramp environment was dominated and has low porosity value range between (0.06-0.11) while water saturation between (0.49-0.96), is interpreted as a water-bearing zone.

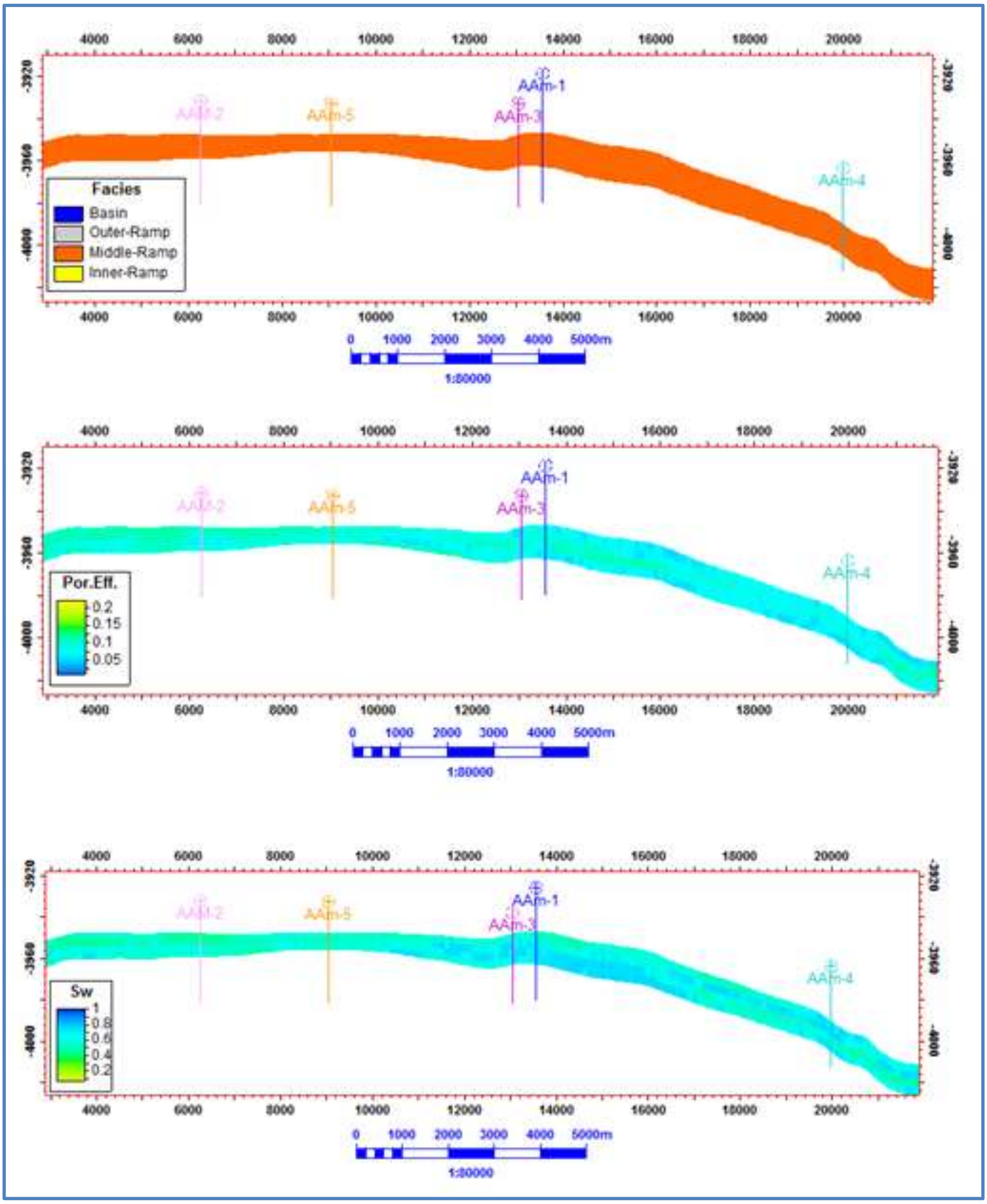

Figure 15- Intersection of YB-3 for Yamama Formation in Abu Amood Oil Field.

- **YC-1 Reservoir Unit**

The thickness of this Unit ranges from (21-36) meters, with average thickness of 25.4 meters all over the field. Figure-16 shows that Middle ramp environments were dominated. The porosity of this unit shows low value range between (0.05–0.08) and water saturation between (0.34-0.71). This unit is not an oil-bearing unit.

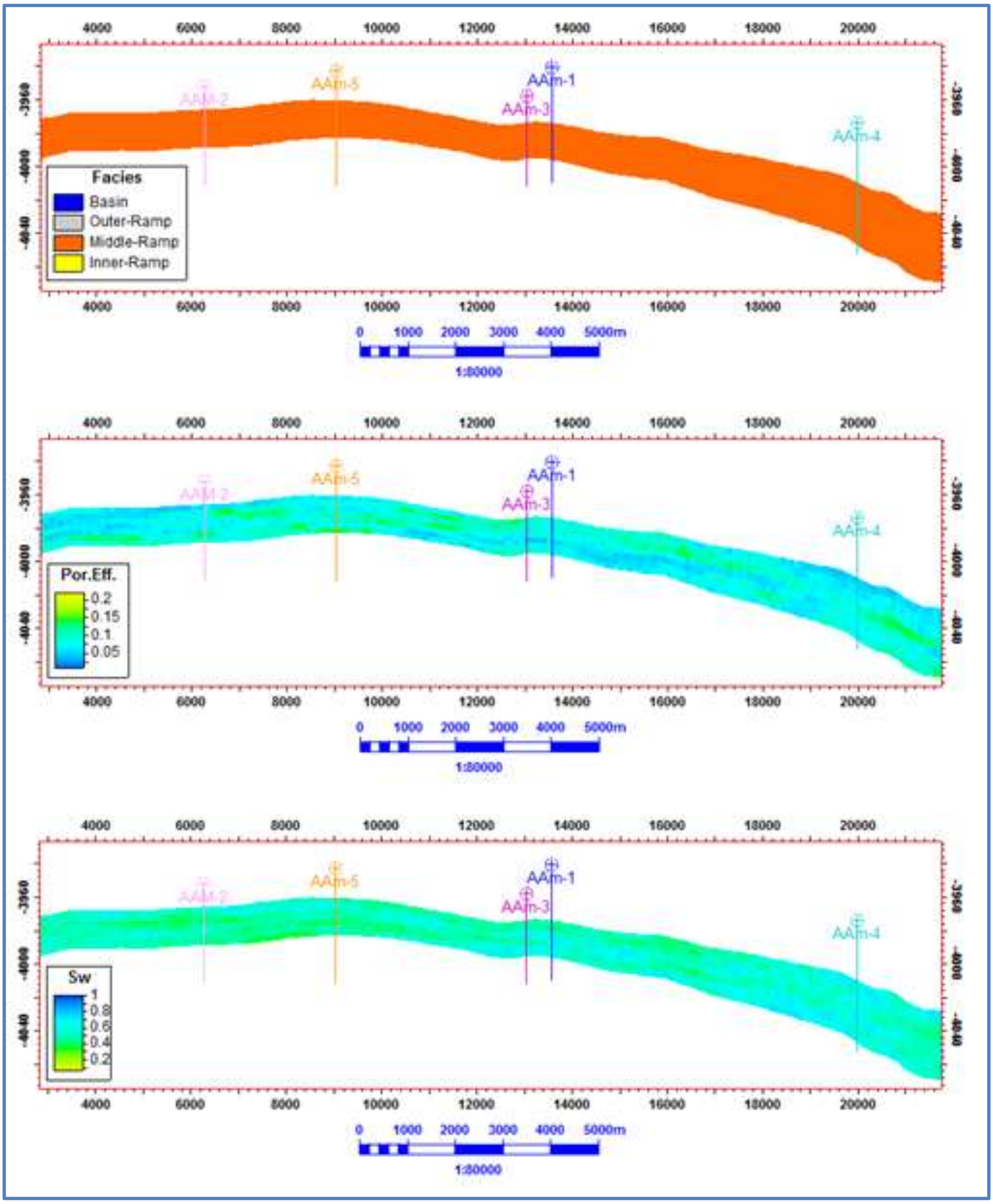

Figure 16- Intersection of YC-1 for Yamama Formation in Abu Amood Oil Field.

- **YC-2 Reservoir Unit**

This unit is characterized by a higher thickness within Yamama Formation in Abu Amood Oil Field. The thickness of this unit ranges from 31meters within the well AAm-1and increases to reach 61 meters at wells AAm-3 and AAm-5. Figure-17 shows the inner and middle ramp environments were dominated. This unit shows good reservoir properties. Porosity distribution between (0.02-23) and water saturation values range between (0.38-0.84). This unit was described as an oil-bearing zone.

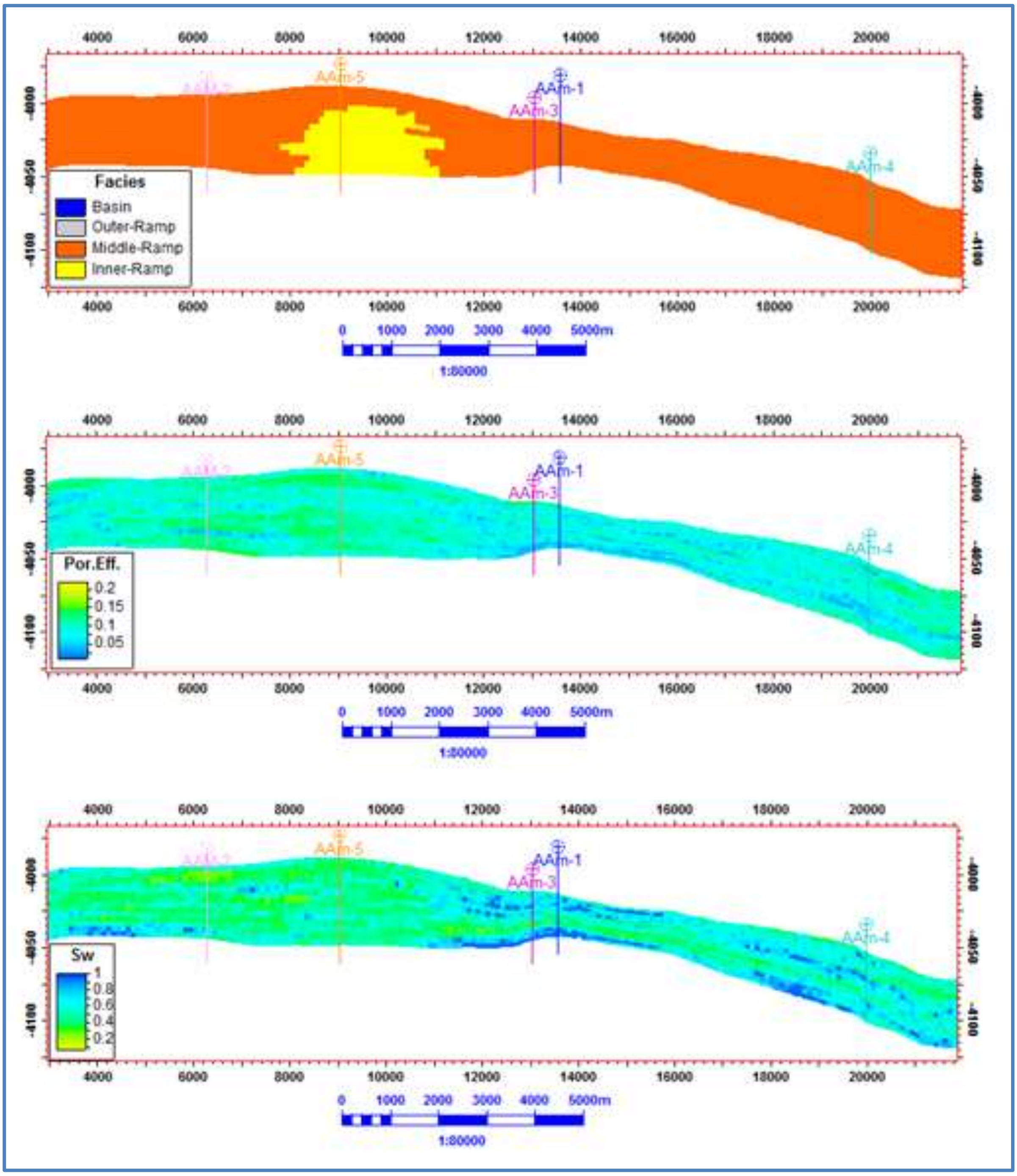

Figure 17- Intersection of YC-2 for Yamama Formation in Abu Amood Oil Field.

- **YC-3Reservoir Unit**

This unit represents the lowermost reservoir unit within Yamama Formation in wells (AAm-1, AAm-2 and AAm-5), and has good reservoir properties. The thickness of this unit ranges from (30–50 m) with an average thickness of 35 meters all over the field. Figure-18 shows the Inner and Middle ramp environments were dominated. Porosity distribution between (0.08-0.18), and water saturation ranges between (0.29-0.79), is interpreted as an oil-bearing.

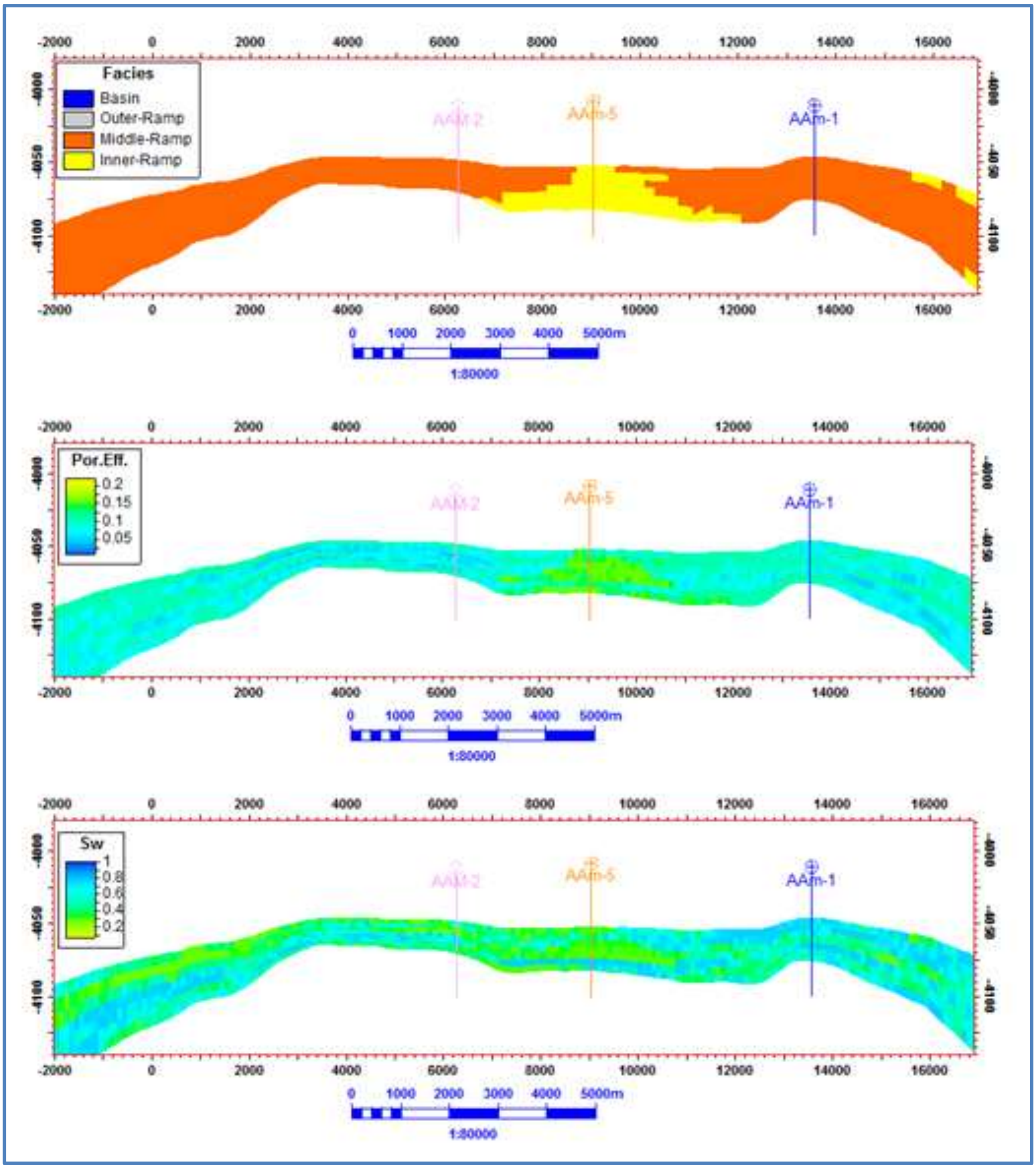

Figure 18- Intersection of YC-3 for Yamama Formation in Abu Amood Oil Field.

Conclusions

1. Abu Amood structure within Yamama Formation is composed of two assymetrical anticlinal domes, its axis extends toward Northwest–Southeast and the length is about 26km and the width of (5-5.5km) with structural closure of about 60m. Five wells penetrated Yamama reservoir (AAm-1, AAm-2, AAm-3, AAm-4 and AAm-5) were chosen in this research.
2. Yamama Formation at Abu Amood Field is divided into six reservoir units extend through wells (AAm-1, AAm-2 and AAm-5), and Five reservoir units extend through wells (AAm-3 and AAm-4) depending on well logs, separated by low porosity and high water saturation barrier beds. These units are (YB-1, YB-2, YB-3, YC-1, YC-2 and YC-3).
3. A 3D geological Model (Environmental, Porosity and Water Saturation Model) were made using Petrel software and shows that Yamama Formation environments were (Inner-ramp, Middle-ramp, Outer-ramp and Basin) which are generally interpreted for each well. As well as shows (YB-1,

YB-2, YC-2 and YC-3) are the most important reservoir units that have good reservoir properties and oil-bearing zones.

Recommendations

1. To increase the accuracy of the formation evaluation, new wells should be drilled along the field and penetrate Yamama Formation to cover the area of the field.
2. 2D and 3D seismic data are very important for building advanced geological models.

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