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Structural and Stratigraphic Study of the Nahr Umr Formation (Lower Cretaceous) Using 3D seismic Survey in Abu Amood Oil Filed, Southern Iraq

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Abstract

3D seismic reflection study was applied to Abu Amood oil field which is located at the southern part of Iraq within DhiQar province that carried out by oil Exploration Company to an area of 1534.88 Km^2 for studying Nahr Umr Formation. Synthetic seismogram was prepared by using available data of well (AAM-1) in order to define and picking the reflectors on the seismic section. These reflectors are (Top of Nahr Umr Formation and middle unit of Nahr Umr Formation which represents the layer of sand). The seismic section time slice maps confirmed that the Nahr Umr Formation was not affected by faults and the faults may probably present in the Ratawai and Yamama Formations, where the variance attribute applied on seismic sections showed that the area was affected by normal fault, this fault was very deep. The time, velocity, and depth maps are drawn for the top of Nahr Umr Formation to get the structural picture: these maps showed that Abu Amood oil field was a semi symmetrical structure that has an axis trending NW-SE, the slope of NE limb is greater than SW limb. Isochrone and Isopach maps are drawn for Nahr Umr Formation to display thickness of Nahr Umr Formation which gradually increases to the west as well as NW and SW parts of the study area and more gradually increases to the East and NE part of the study area. Seismic attributes were applied to the study area (instantaneous phase, instantaneous frequency and variance attribute) these attributes showed the presence of Direct Hydrocarbone Indicator at Nahr Umr Formation in Lower Cretaceous age as a Dim spot at In-lines 51500 and 49500 by applying instantaneous phase and bright spot at AAM-1 well by applying instantaneous frequency.

Keywords: Seismic Attribute, Abu Amood oil field, Nahr Umr Formation.

دراسة تركيبية طباقية لتكوين نهر عمر (الطباشيري الاسفل) بأستخدام مسح ثلاثي الابعاد في حقل "ابو عامود النفطي" في الجزء الجنوبي من العراق.

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الخلاصة

أجريت دراسة زلزالية انعكاسية ثلاثية الابعاد لتكوين نهر عمر في حقل ابو عامود النفطي الذي يقع في الجزء الجنوبي من العراق ضمن محافظة ذي قار وتم تنفيذ هذا المسح من قبل شركة الاستكشافات النفطية وبمساحة km^2 1534.88. وتم أعداد ألاثر المصنع من المعلومات للبئر(AAM-1) للتعرف على

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العواكس في المقاطع الزلزالية و هذه العواكس هي (أعلى تكوين نهر عمر و الوحدة الوسطية لهذا التكوين والمتمثلة بالطبقة الرملية). و من خلال الشريحة الزمنية وتطبيق (variance attribute) للمقطع الزلزالي لعاكس نهر عمر تبين ان هذا التكوين غير متأثرة بفوالق ومن المحتمل وجود فالق في تكويني الرطاوي و اليمامة . تم رسم خرائط زمنية وعمقية وسرعية لأعطاء صورة تركيبية لحقل ابو عمود النفطي حيث تبين ان الحقل عبارة عن تحدب قببي غير متناظر وله امتداد شمال غرب و جنوب شرق وان طرف الشمال الشرقي أكثر ميلاناً من طرف الجنوب الغربي. وتم رسم خرائط الزمن البيني و السمكي حيث تبين ان السمك يزداد باتجاه الشمال الغربي ويزداد أكثر بأتجاه الشرق والشمال الشرقي اي باتجاه طرف الشمال الشرقي. من خلال تطبيق تقنية Attribute وثلاثة انواع رئيسية من هذه التقنية وهي :-

(instantaneous phase, instantaneous frequency and variance attribute)

ومن خلال هذه التقنيات تم الكشف عن وجود DHI في تكوين نهر عمر في عمر الطباشيري الاسفل وذلك لوجود (Dim spot) في الخطوط الزلزالية (49500-51500) In-lines والتي تدل على وجود النفط والغاز،وايضا تبين وجود (Bright spot) في المقطع الزلزالي عند بئر AAM-1 والتي يدل على وجود هيدروكاربون.

Introduction

Abu Amood field is located in the province of Dhi Qar, about 16 km north of Qall'at Sukkar area, it is about 26 km north of the Refa'i area Figure- 1. The field is located 17 km southwest of the Dejaila field [1].

According to OEC plan in 2012 the second seismic crew has carried out 3D seismic survey of Abu Amood Oil field in 2012/6/26, the survey area was 1534.88 Km^2[2].

The seismic data were processed at the processing center of the oil Exploration Company. The primary objective is to enhance the quality of the recorded data with special regard to the 3D data. Basically, this improvement is essential to facilitate the structural and stratigraphic seismic interpretation. The noise attenuation process leads to improve reflection continuity and enhance the ability to compute seismic attributes. The processing of seismic data was carried out using Omega ve.2.7[3].

The composition of Nahr Umr Formation Figure- 2 is shale overlapping with limestone rocks and sand in the upper part of the formation, then a layer of sand which is considered as the most important part for the reservoir properties since the thickness of Formation ranges between (134-145 m) [4].

The oil is showed in the Middle unit (layer of sand) of Nahr Umr Formation in AAM-1 where the thickness of pay reached to (13m) with the continuity in the seismic section [5].

Methodology

Loading seismic cube on HRS-10 (Hampson-Russell version 10) and Petrel v14.2 programs is used to identify the reflectors using wells data. Figure-3 shows the flow chart of work. Making Synthetic seismogram from well AAM-1 data and comparing it with seismic sections as shown Figure -4. Using seismic attributes like amplitude and frequency which disposed within the new software interpretation system [6,7].

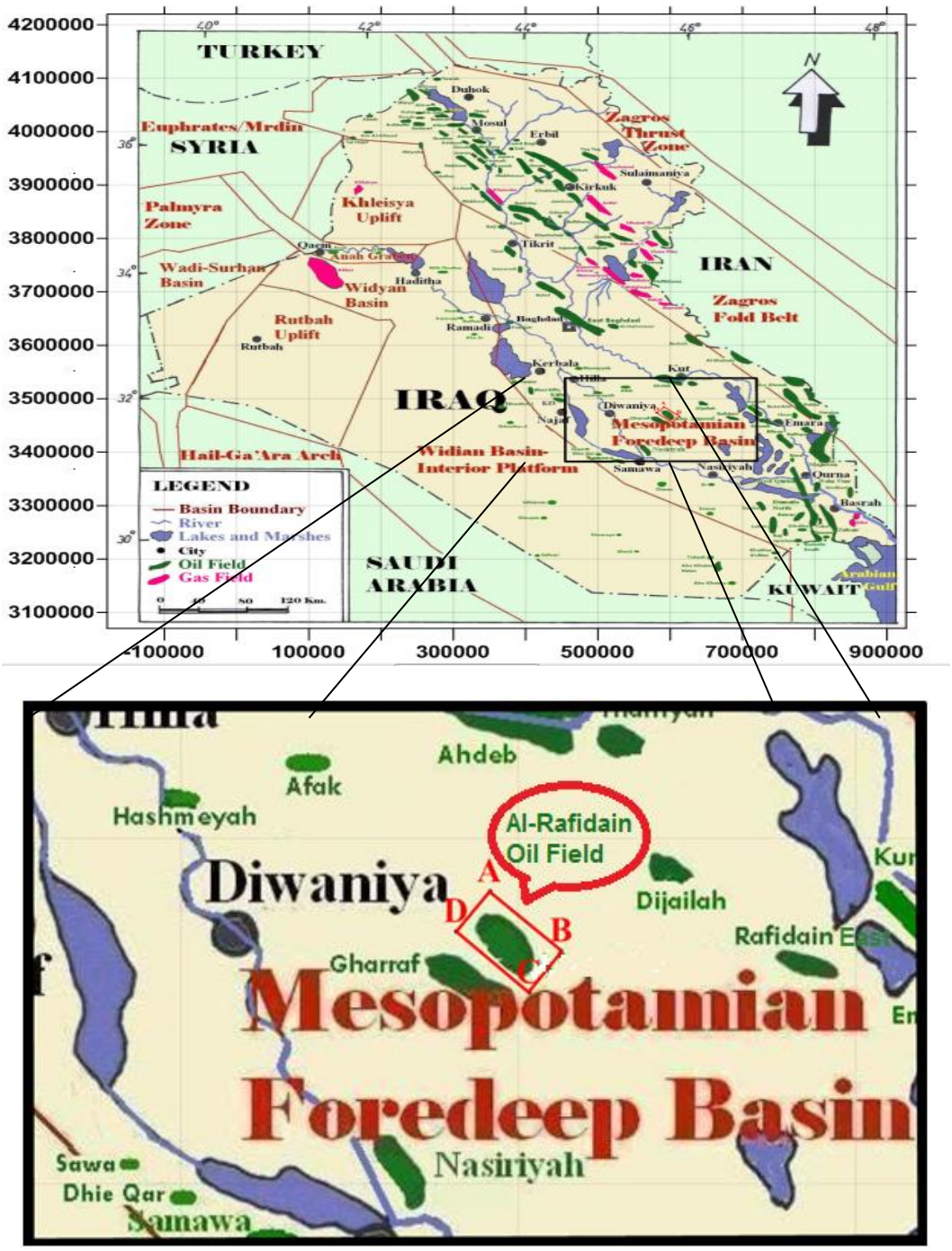


Figure 1-Location Map of the study area [8].

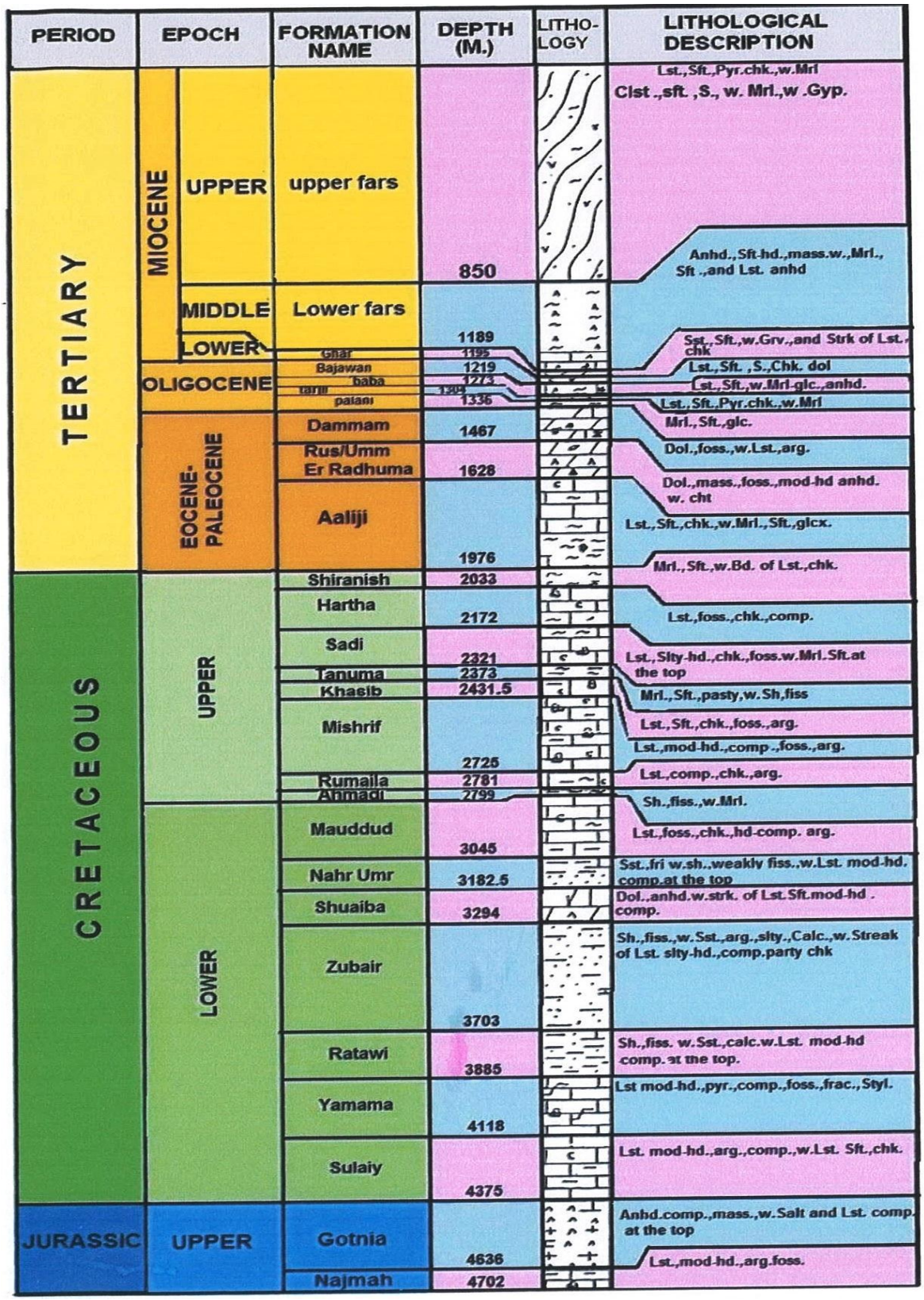


Figure 2- Shows the Formations in the study area in well AAm1 all depths are taken from R.T.K.B. [9]**.**

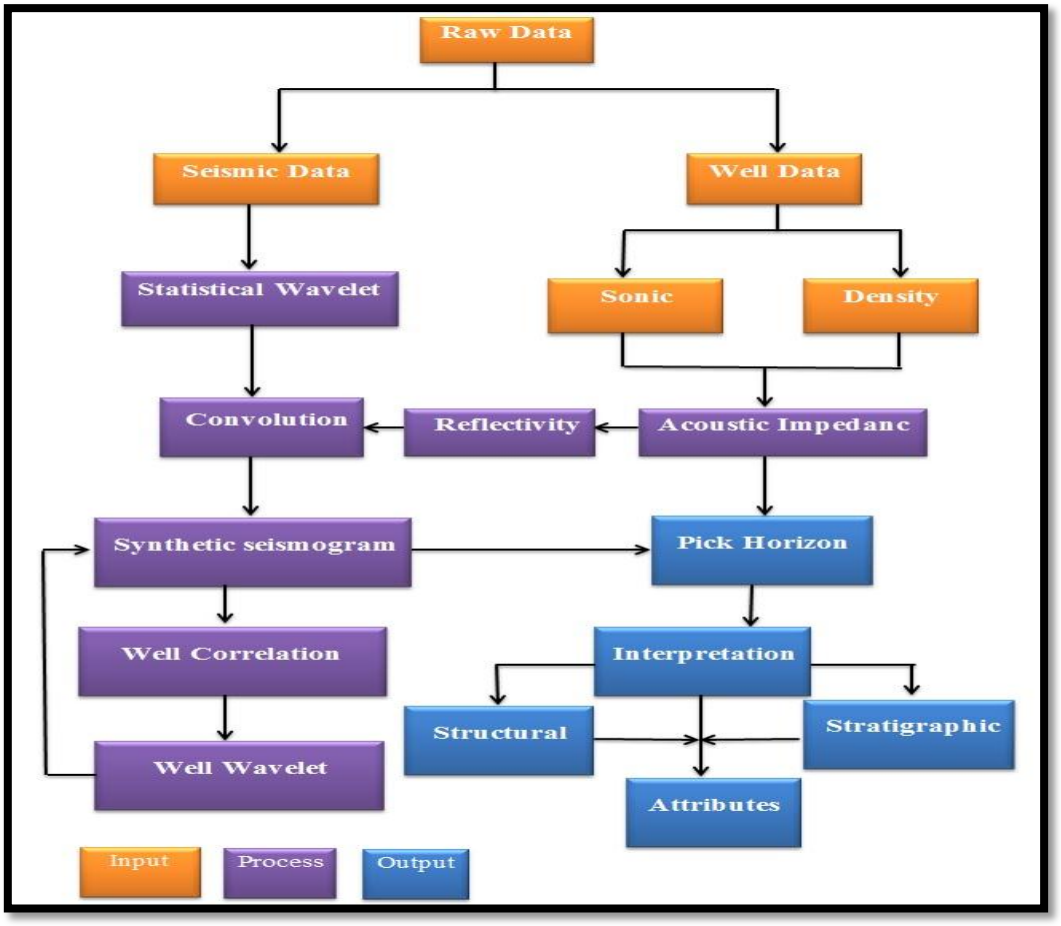


Figure 3- Flow chart shows the stages of the work [6].

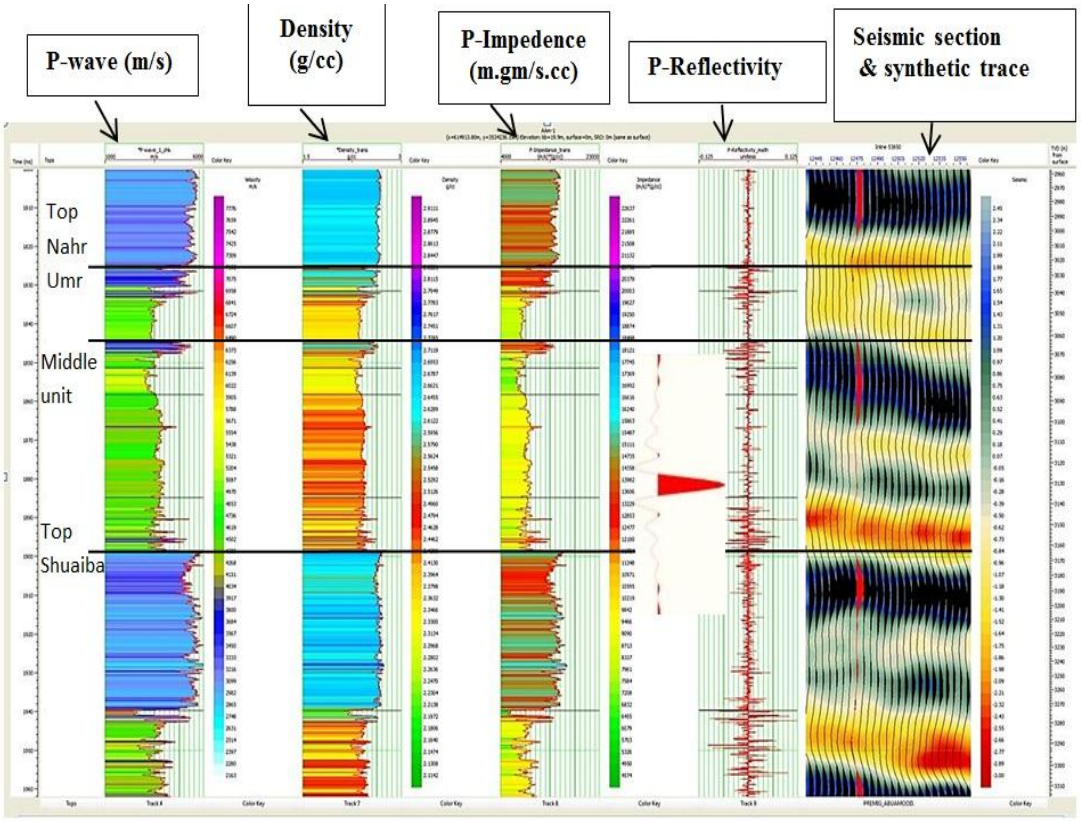


Figure 4- Acoustic impedance and Reflection Coefficient with synthetic seismic trace at AAM-1.

Synthetic Seismogram at Well AAM-1

Both $v(z)$ velocity model and $p(z)$ density model, which are a function of depth are needed to create a synthetic seismogram at well. The product of these two models offers an acoustic impedance model of the subsurface. Because a vertical or nearly vertical well is similar to a seismic trace, an impedance model may be estimated for nearby seismic traces. One can compare this with the amplitude data from the seismic survey for quality control, attribute correlation, and wavelet extraction. The impedance model may be obtained from the sonic logs and density (or neutron) logs [10,11].

Sonic logs record interval transit time, that is, estimates of the reflection time between layers which is shown as estimated thickness of layers (from logs) divided by velocity.

$$\Delta t = \frac{z_2 - z_1}{v}$$

Velocity of a layer also is obtained from this equation because sonic gives the transit time (At) and most logs give thickness of a layer $(z_2 - z_1)$. Using the density and velocity models, reflection coefficients were estimated at the rock boundaries. reflection coefficient (RC) of each interface is a function of travel time (from sonic logs).

A synthetic is created by convolving the RC series with a wavelet . A wavelet is a wave pulse approximation for a seismic source which contains many frequencies and is time- limited. If the wavelet is a good approximation for the wave produced by the actual source, comparing the reflectors between the synthetic and actual seismic data gives the geological horizons that cause seismic reflections at the well (or trace).

A series of related reflections on several vertical traces is referred to as a reflection event. By correlating reflection events across the wells, an estimated cross-section of the geologic structure can be interpreted [10,11] Figure-4 Shows the synthetic at well AAM1.

Structural picture of the picked horizons

After definition of the studied reflector by using synthetic seismogram in the time domain for well (AAM-1). This reflector was picked in all area and mapped the top of Nahr Umr and Middle unit in Nahr Umr Formation in time domain, which was later converted to structural maps in depth domain using velocity data of this reflector. Sea level was used as a reference datum to all maps. The structural features of these structural maps were described below:

1-Time Map of top of Nahr Umr

Time map of top of Nahr Umr Formation is showed in Figure- 5 which has been prepard with contour interval (10) millisecond and reference surface is represented by sea level.

The TWT map of top of Nahr Umr reflector shows of Abu Amood structure has asymmetrical anticline which has an axis trending NW-SE, the slope of NE limb is greater than SW limb which is very clear Figure -5.

Note that the TWT value at AAM-1well is lesser than north and north western part of the study area and increasing gradually at south and south eastern part of the study area .

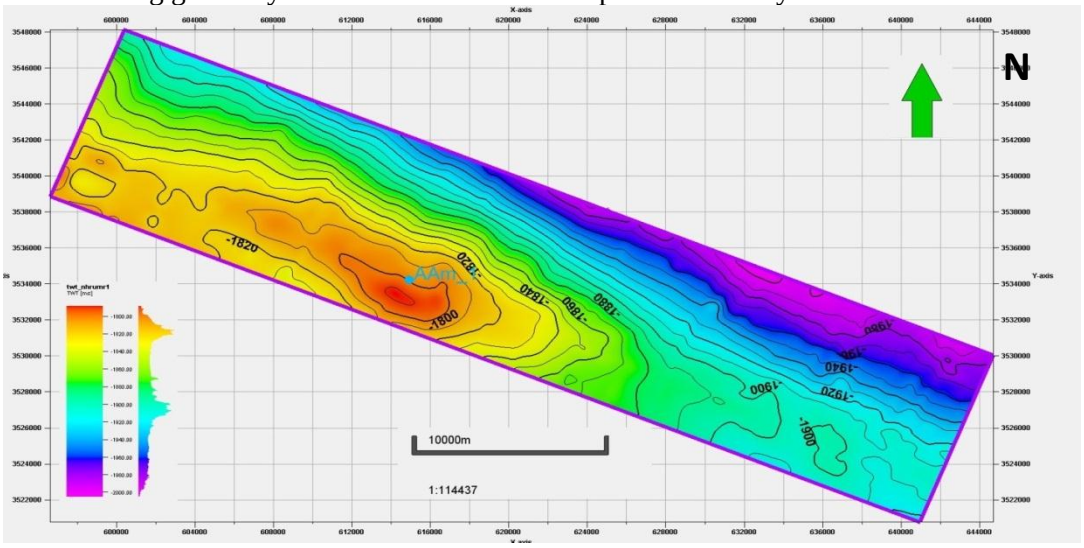


Figure 5- 2D TWT map of Top Nahr Umr Formationat Abu Amood oil field.

2- Velocity map of Nahr Umr Formation

The average velocity map of top of Nahr Umr was prepared by using contour interval (5 m/s). It shows the presence of homogeity between the values which mean the absence of anomalies in the velocity values.

The velocity of top of Nahr Umr Formation increases toward the north western part of the Abu Amood oil field and increases more toward South Eastern part of this field Figure -6.

3- Depth map of Top Nahr Umr Formation:

This depth map reflects the same subsurface picture as in time domain. Thus, the shape of depth map is looks like the two way time map, and shows the same picture of the studied formation. It is obtained by using the time map of given reflector with velocity map, as follows:

Depth at any point = (Velocity × One way time) at this point.

The structural picture can be described as appears in Figure-7 which represents the depth map for top of Nahr Umr, with a contour interval (10m), this map shows a major anticline with axis trend NW-SE and it consists a structural dome and it shows that the depth at AAM-1 well is low which gradually increases in the north and north western part of the study area and more gradually increases to the south, east and south eastern part of study area.

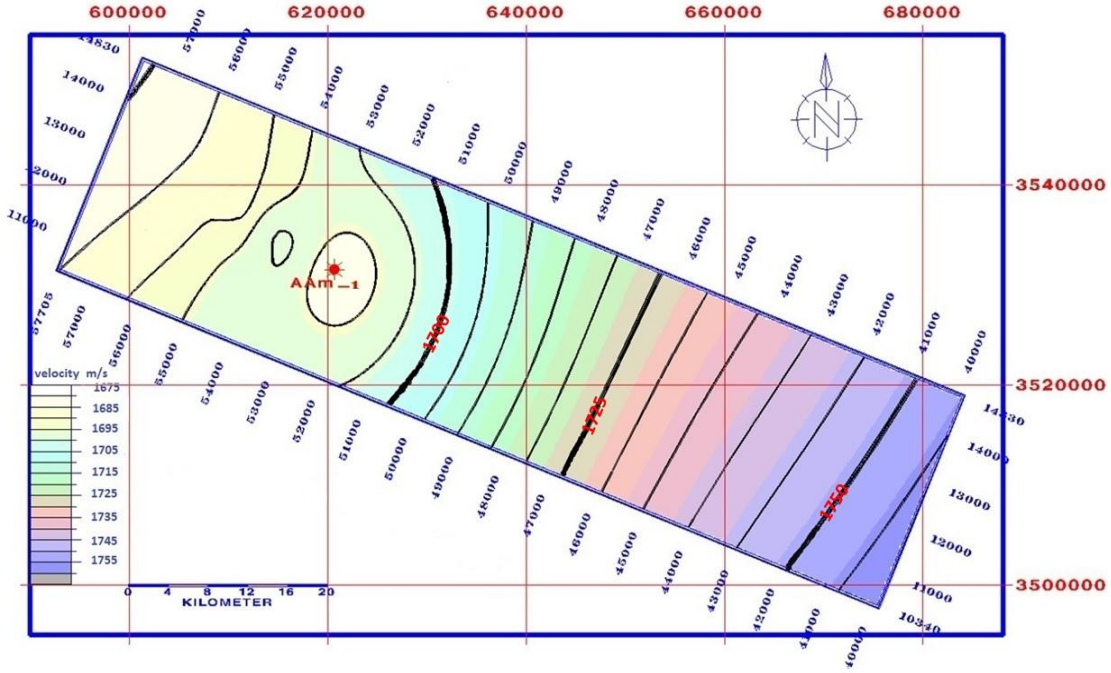


Figure 6- Shows the average velocity map of top of Nahr Umr Formation at Abu Amood oil field.

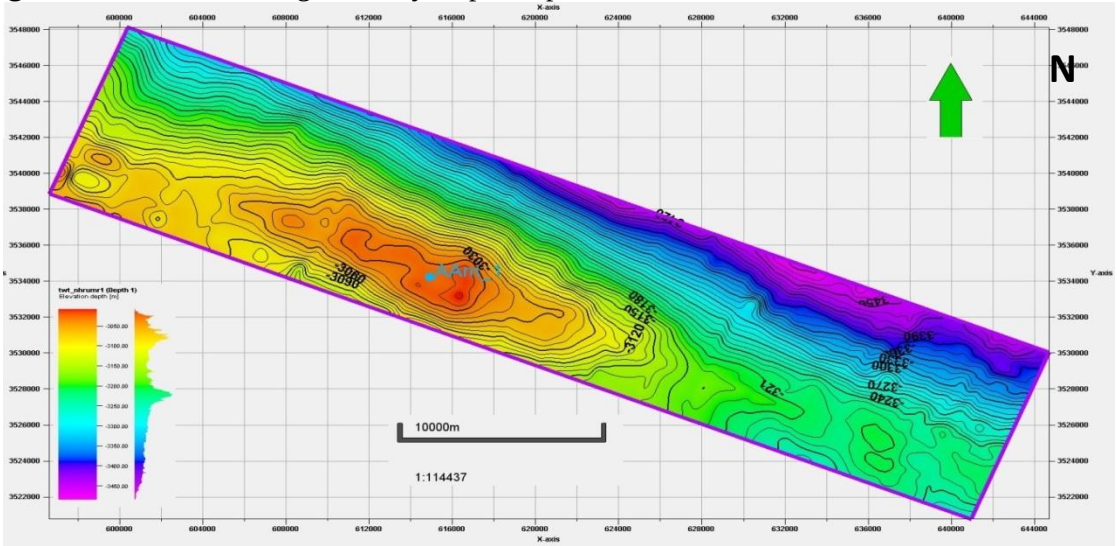


Figure 7- 2D depth map of top of Nahr Umr Formation at Abu Amood oil field.

4 Isochrone & Isopach Maps:

Thickness maps are a fundamental tool in structural geology. They represent thickness variations and thickness trends of a given unit. Isochorne and isopach maps are two different types of thickness map. To make it clear from the beginning the must be defined them [12]:

- An isochorne is a line that connects points of equal vertical time
- An isopach is a line that connects points of equal true thickness (i.e. measured perpendicular to bedding).

4-1 Isochrone map

Isochrone map of Nahr Umr sequence boundary was calculated and prepared with a contour interval (10 ms) by subtracting top of Shuaiba from top of Nahr Umr time maps Figure- 8. It helps to study the varying thickness of Nahr Umr Formation in time domain.

This map shows that the time of Nahr Umr Formation values ranges between (30-90 ms).
Note that low values at AAM-1well and gradually increase in the north and north western part of the study area and more gradually increase in the south , east and south eastern part of study area .

4-2 Isopach map

The isochrone map in time domain was converted to isopach map in depth domain by multiplaying it with an interval velocity of Nahr Umr Formation that is available in check-shots logs of the AAM-1 well. It helps to make the seismic stratigraphic interpretation of the studay area through the variation in the thickness of layers in the depth domain[12].The map was prepared with contour interval (10 m) and this map shows that the thickness of Nahr Umr Formation value ranges between (100 – 160 m) as shown in Figure -9.

Siesmic Attributes

Seismic attributes techniques were applied to Abu Amood on 3D seismic cube, it includes three main attributes instantaneous phase , instantaneous frequency and variance attribute. These types of attributes are important in structural and stratigraphic interpretation studies to detect reflector termination, such as faults and facies change pinch-out, on lap,top lap, dwon, etc [12-15]

1- Variance attribute

Through studying the seismic section for seismic cube by using varince attributes private of the section shows that there is not any type of faults in Nahr Umr Formation (Nahr Umr reflector) and seismic slice for all study area of target reflector (Nahr Umr). This type of attribute helps to distinguish the animation of faults and fractures affected, while the reflectors of lower Sulay and Gotnia Formations shows normal faults [15]. Figure -10 Shows Nahr Umr with variance attribute at 1800 ms, which describe the absence of faults in this formation atAbu Amood oil field.

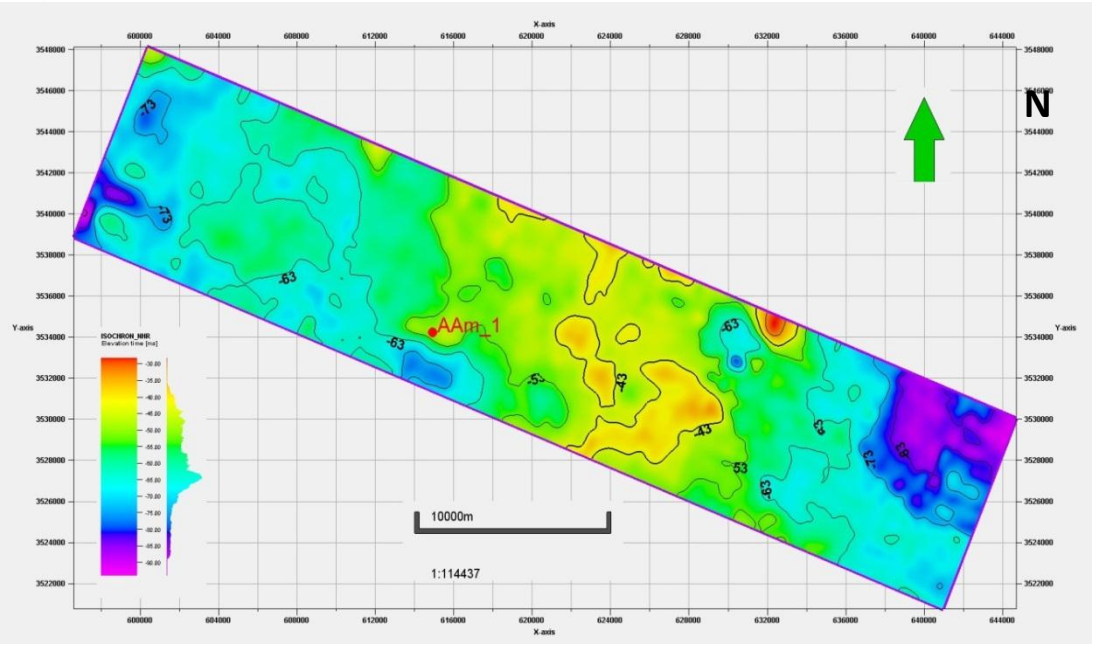


Figure 8- 2D Isochrone map of Nahr Umr Formation at Abu Amood oil field .

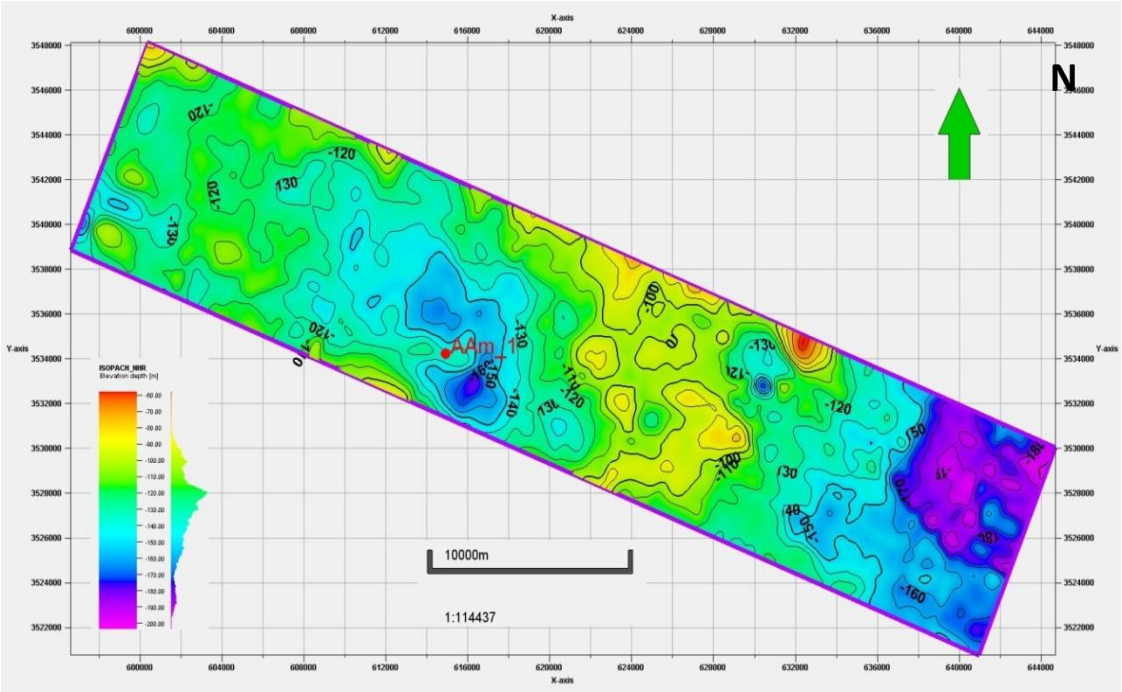


Figure 9- 2D Isopach map of Nahr Umr Formation at Abu Amood oil field.

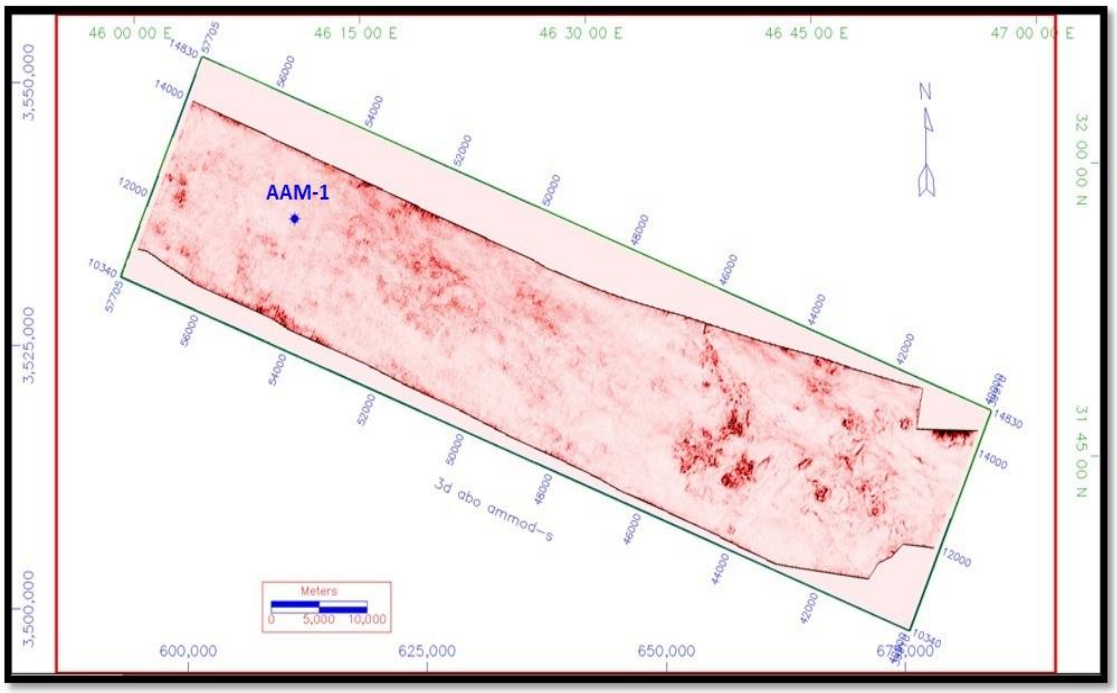


Figure 10-Variance attributes at 1800 milisecond, describe generally the fault not effect at Nahr Umr reflector .

2- Instantaneous Phase Attribute

Instantaneous phase (degree) is the argument of the analytic signal:

$ph(z) = \frac{180}{\pi}\ arctan\left[\frac{g(z)}{f(z)}\right]$……..where

z: is either time or depth.

$g(z)$: is the real components of the complex trace.

$f(z)$: is the imaginary components of the complex trace .

Instantaneous phase is measured in degree (-π, π). It is independent of the amplitude and shows continuity and discontinuity of events. It shows bedding very well, and it′s useful as: [16]

- Best indicator of lateral continuity .
- Shows discontinuity, but may not be best. It is better showing continuities sequence boundaries.
- Detalied visualization of bedding configurations.
- Used in the computation of instantaneous frequency .

The 3D seismic cube was processed and converted from seismic signal in time domain to phase attribute view to explain the lateral variation of phase for Nahr Umr reflector Figure- 11(A) In general, instantaneous phase sections view rotation in phase through changing in color verticaly and laterally from violet to pink, especially in the elliptical shape that related to features of mounds (Rudist accumulations) within Nahr Umr Formation as shown in the seismic section of the studied reflectors that picked and terminated to detect on these sections. Figure- 11(B), shows the phase attribute of Nahr Umr Formation which represented by dim spot and this clearly points to the presence of gaseous hydrocarbons because this unit is sandstone [14].

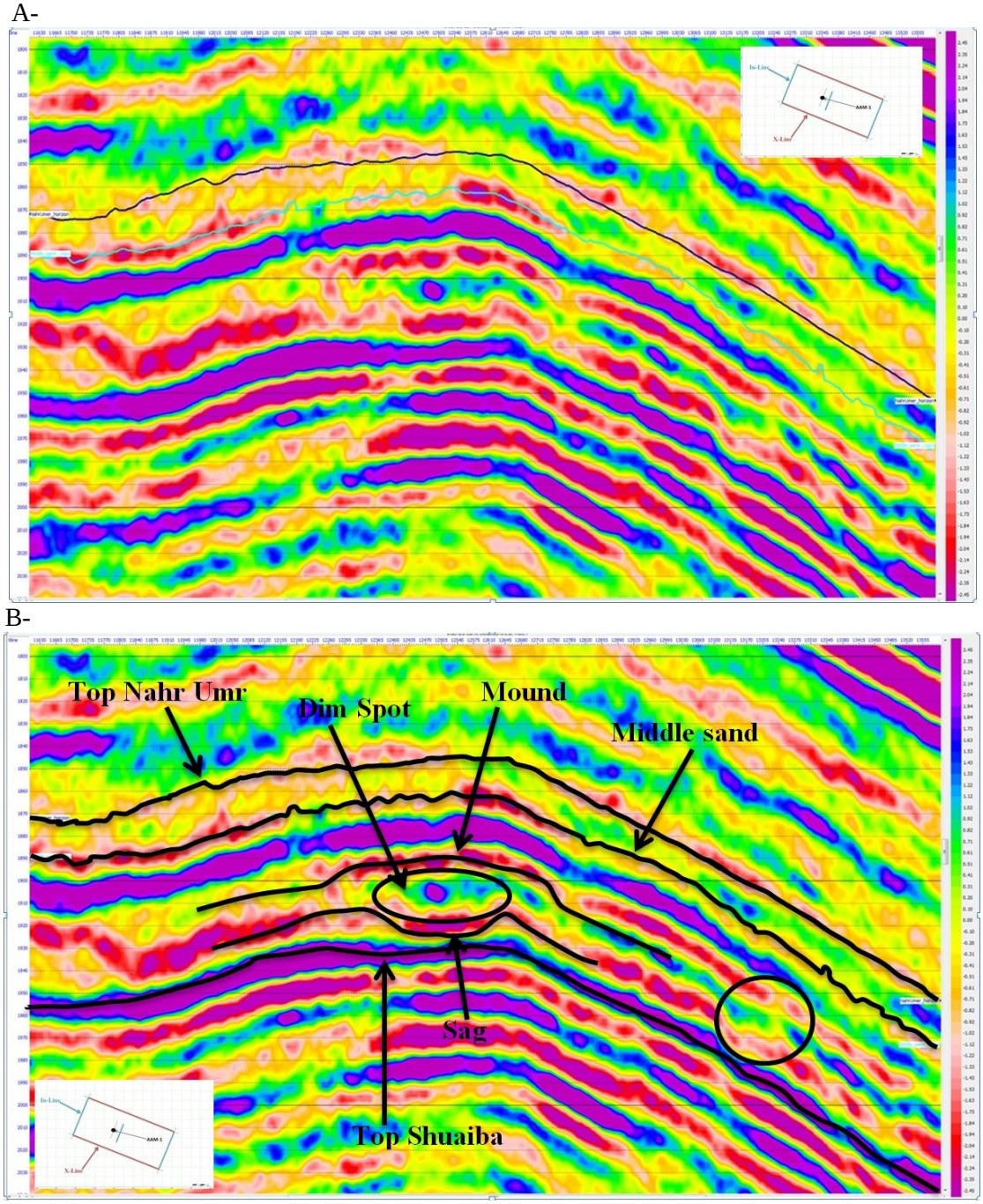
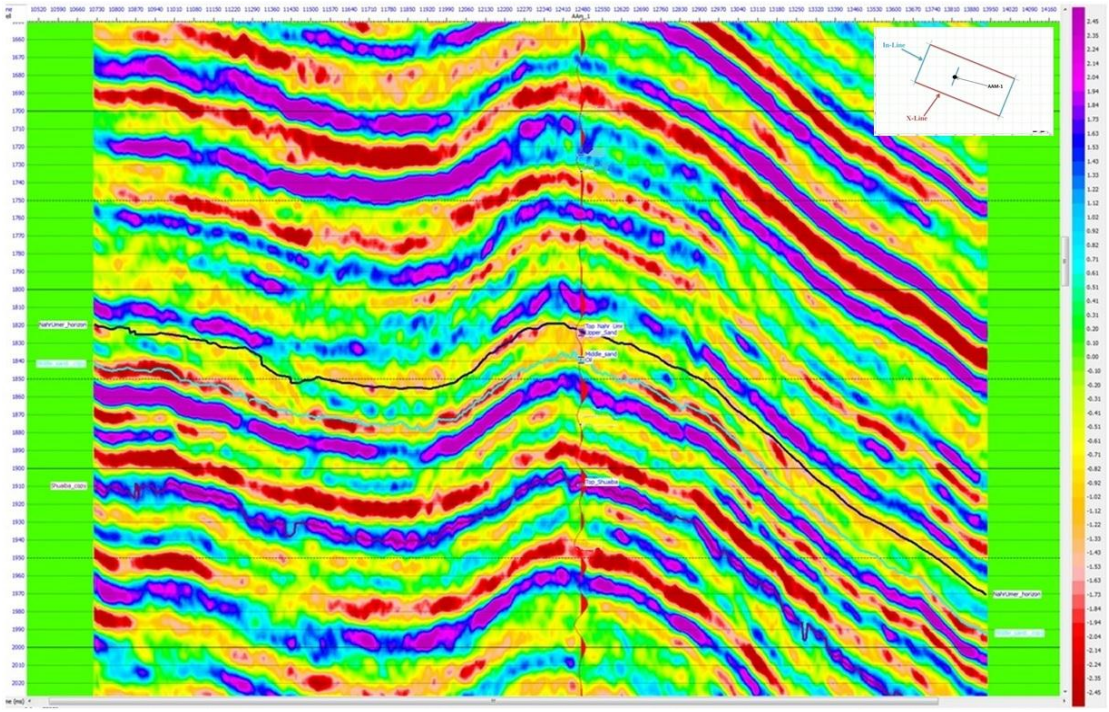


Figure 11- In-Line 51500 3D seismic instantaneous phase section at Abu Amood oil field.

A- Represent lateral variation of phase in Nahr Umr Formation, B-represent phase attribute in Nahr Umr Formation

A-



B-

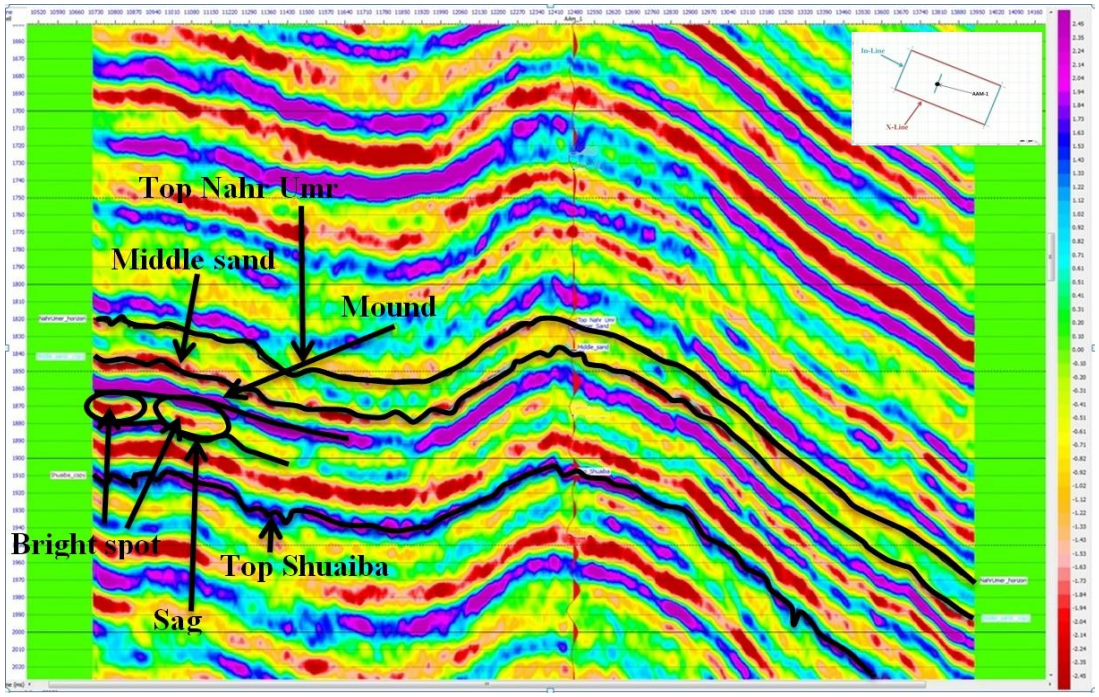


Figure 12- In-Line at AAM-1 well 3D seismic instantaneous phase section at Abu Amood oil field. A-Shows frequency attributes at Nahr Umr Formation, B-shows the bright spot and mound at Nahr Umr Formation.

3- Istantanouse frequency attribute

Instantaneous frequency is the time derivative of the phase, i.e., the rate of change of the phase ; its values are in cycles/second (Hertz). Instantaneous frequrncy represents the mean amplitude of the wavelet, it′s useful as;

- Indicates the edges of low impedance thin beds.
- Hydrocarbon indicator by low frequency/wave number anomaly.
- Fracture zone indicator appears as low frequency/wave number zone.
- Chaotic reflection zone indicator.
- Bed thickness indicator. Higher frequency indicate sharp interface or thin shale bedding; lower frequencies indicate sand rich bedding.
- Sand/shale ratio indicator [14]

The 3D seismic volume was processed and converted from seismic signal in time domain to frequency attribute view Figure- 12 (A), to explains the lateral variations to frequency at reservoir reflector when the low frequency (Red color) especially in the elliptical shape that related with feature of mounds within Nahr Umr Formation which represent by bright spot as show in Figure -12 (B),consequently, the studied reflectors picked and dark color areas within Nahr Umr reflector packge detect on this section [17].

Conclusions

According to seismic processing and interpretation of the current research we can list the following conclusions:-

1- The Top of Nahr Umr reflector was picked in the study area which represents Lower Cretaceous age .

2- The TWT maps of Top of Nahr Umr reflector showed the value of TWT less at the AAM-1 well which a part of this study indicates that the top of dome at AAM-1 increase toward the north western part of the Abu Amood oil field and also toward east and south Eastern part of this field.

3- The average velocity maps showed the value of velocity increase toward the north western part of the Abu Amood oil field and toward the South Eastern part of this field.

4- The depth map of Nahr Umr reflector shows that the structural picture of Abu Amood field was structural dome Semi-symmetrical, the value of depths increases toward the north western part of the Abu Amood oil field and also toward south Eastern part of this field.

5- Isochrone and isopach maps display the thikness of Nahr Umr reflectors which that these map high deposited in NE limb part of the study area, the thikness of Nahr Umr Formation gradually increase W and NW and SW part of the study area and more gradually increase in the E and NE part of the study area.

6- From studying the seismic sections and applying the seismic attributes represent by instantaneous phase, instantaneous frequency and variance attribute it was discovered the presence of Direct Hydrocarbon Indicator it dim spot and bright spot which refers to gaseous hydrocarbon accumulation.

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