ISSN: 0067-2904

# Subsurface Investigation of Merjan oil field Depending on 3D Seismic Reflection Central Iraq

**Salman Z. Khorshid[1], Haitham Dawood Alki[2] , Abdalkarim Mohammad Zaid[1*]**

[1]Department of Geology, College of Science, University of Baghdad, Baghdad, Iraq.
[2]Oil Exploration Company, Iraqi Oil Ministry, Baghdad, Iraq.

**Abstract**

The study deals with 3D seismic reflection in the central Iraq within Merjan oil field which is located approximately (130 km) to the southwest Baghdad and south of Razaza. The 3D seismic survey was interpreted; the results showed that the oil is found within Hartha Formation as stratigraphic traps and with the absence of structural traps. The major normal faults picked are trending N-S direction. There are also minor faults observed using the instantaneous phase and frequency sections, they proved the presence of the faults and showed that the ending of the Safawi reflector toward the north and northeast to the south and southeast and near the western border of fault because of the facies change in the area. The reflector shows a structural nose extend in NW-SE trend and plunges to the south-east. The seismic attributes show that (Me-1) well is a stratigraphic trap and (Wk-1) well is a wildcat. The phenomenon of gas was shown clearly at the west of well, (Me-1) in seismic attribute and section.

**Keywords:** seismic structural interpretation, seismic stratigraphy and faults of Merjan oil field.

# دراسة تحت سطحية لحقل مرجان في وسط العراق باستخدام المعلومات الزلزالية ثلاثية الابعاد

**سلمان زين العابدين خورشيد[1]، هيثم داود علكي[2]، عبدالكريم محمد زيد[1*]**

[1]قسم علم الارض، كلية العلوم، جامعة بغداد، بغداد، العراق.
[2]شركة الاستكشافات النفطية، وزارة النفط العراقية، بغداد، العراق.

**الخلاصة:**

يتضمن البحث دراسة زالزالية ثلاثية الابعاد لحقل مرجان الذي يقع جنوب –غرب بغداد بمسافة 130 كيلومتراً وجنوب بحيرة الرزازة. تم تفسير المسح الثلاثي الابعاد وقد بينت النتائج بأن الحقل هو ضمن تكوين الهارثة ونوع المصيدة هي طباقية كما لوحظ عدم وجود مصائد تركيبية. تم التقاط فالق رئيسي في المنطقة باتجاه شمال–جنوب كما لوحظ في اعلى منطقة الدراسة بأن الفالق يتجه الى الشمال الشرقي وايضا هناك بعض الفوالق الثانوية التي لوحظت في التردد الاني والطور الاني التي اثبتت فيها وبينت ايضا ان تكوين صفاوي في منطقة الدراسة ذا انتشار محدود حيث يتلاشي في الشمال والشمال الشرقي الى الجنوب والجنوب الشرقي عند الحدود الغربية للفالق بسبب التغير السحني في المنطقة. تشير العواكس الملتقطة الى وجود أنف تركيبي يمتد من الشمال الغربي– الجنوب الشرقي كما ان ميل الطبقات في اتجاه الجنوب الشرقي. وفي دراسة الملامح الزالزالية بينت ان حقل المرجان مصيدة طباقية في بئر مرجان–1 وان بئر غرب الكفل–1 غير منتج للنفط . وشوهد شذوذ غازي يقع غرب بئر مرجان–1 ولقد ظهر ذلك بوضوح في ملامح التباين.

*Email: karemmohammad61@gmail.com

## Introduction

The role of seismic reflection gives more direct and detailed picture of the subsurface geological structures. The seismic sections, time and velocity contour map are used to determine a structural trap and seismic stratigraphy as well as seismic facies [1]. The ratio of the reflected energy to the incident energy is the reflection coefficient [2].

Successive reflection coefficients on the surfaces of separation between the layers (interfaces) the reflection function of the reflection coefficient or log are called. This log is derived from the acoustic impedance log. The reflectivity function is the property at land that we are looking for [3]. Merjan oil field is located approximately (130 km) to the southwest of Baghdad and south of Razaza, Figure-1 within the tectonically stable Mesopotamian between the Zagros belt and Arabain shield and thus the study area is located between stable zone and unstable zone.

The main purpose of this paper is interpret the structural setting of Merjan oil field using the 3D seismic data and distribution of the Safawi Formation. According to geological map of Iraq, issued by the State Establishment of Geological Survey and Mining in 2014, More than 80% of the map area is covered by Quaternary deposits [4]. Pre-Quaternary rocks are (Eocene-Miocene) represented by Dammam, Euphrates, Fatha (Lower Fars), Injana (Upper Fars), Zahra and Dibdibba Formations. Except the lower unit of Euphrates Formation, the Lower and Middle Miocene rocks positions (according to Formations) has been changed which refer to the recently gained results, Figure 2. The lithology of the subsurface layers of sedimentary rocks, mostly limestone and some levels of sandstone and shale with clay [4].

$$Rc=\frac{Ar}{Ai}=\frac{Z2-Z1}{Z2+Z1} \quad \ldots\ldots 1$$

$$Rc=\frac{(V2\times\rho2)-(V1\times\rho1)}{(V2\times\rho2)+(V1\times\rho1} \quad \ldots\ldots 2$$

Where:

Rc: is reflection coefficient.

Ai: is consequent amplitude of the incident energy.

Ar: is consequent amplitude of the reflected energy.

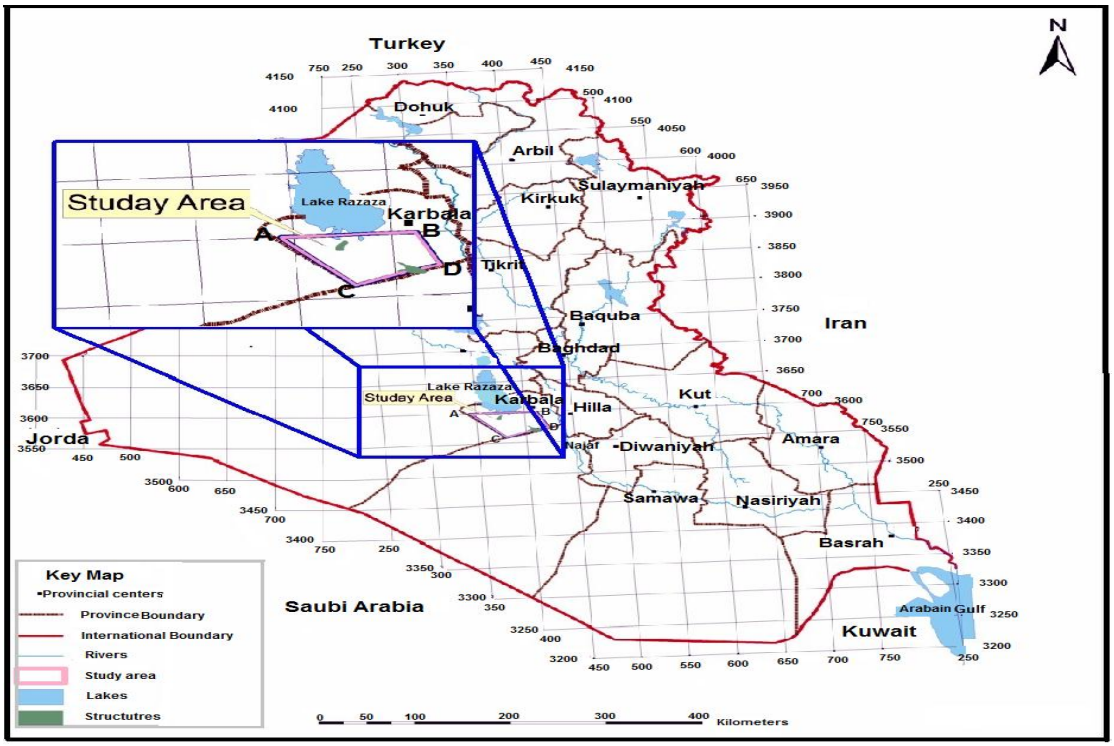


**Figure1-** Location maps of the study area.

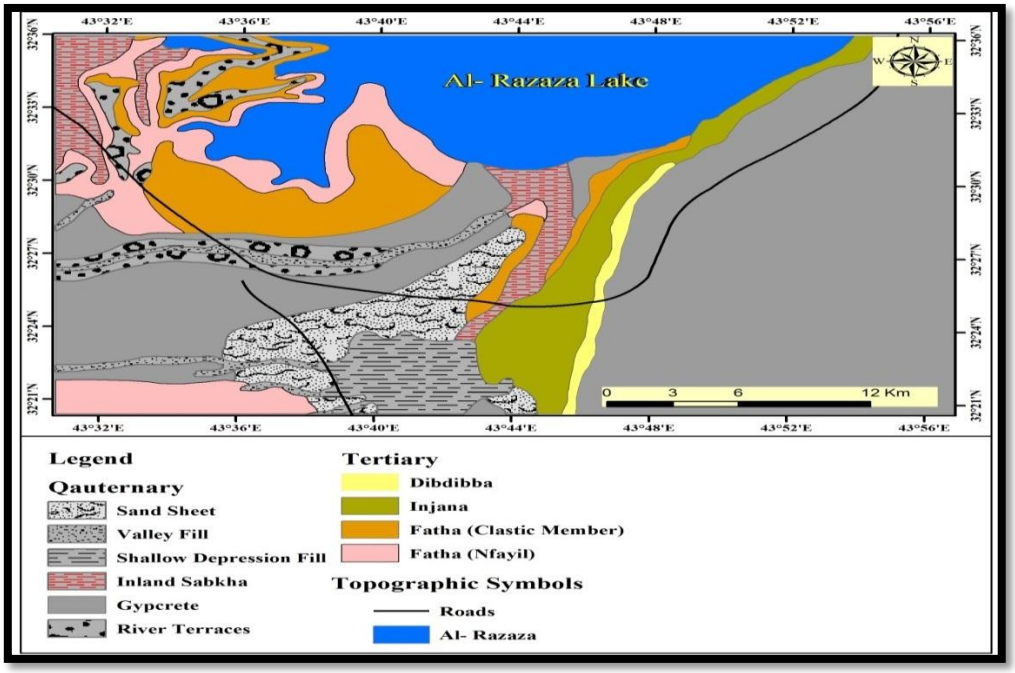


**Figure 2-** Geologic map of the study area and surroundings [4].

**Data Acquisition**

**A- Base map preparation**

The 3D data cube was loaded on Geoframe in time domain by seismic interpretation program IESX and in SEG-Y- format. This process is called (project creation) for achieving the interpretation process on an interactive workstation. After that, the base map of the study area is constructed, Figure-3. Processing has done in the oil exploration company using the Omega system.

**B- Synthetic seismogram**

Synthetic seismogram studies have spanned many decades from the earlier days of 1-D modeling [5] to the most recent descriptions of finite-difference anisotropic viscoelastic modeling as described in [6]. The reflectors have been defined depending on synthetic seismograms for wells Me-1 and Wk-1. The Synthetic seismograms were determined by multiplying the information of Sonic Log and well velocity survey after calibration procedure which is needed to get the smallest details, Figures-4 and 5, show the top of the main reflectors on the synthertic seismograms which are:

1- Top of Hartha Formation
2- Top of Safawi Formation
3- Top of Zubair Formation

We cannot distinguish Safawi Formation in Wk-1 synthetic seismograms because it is limited in distribution in the region.

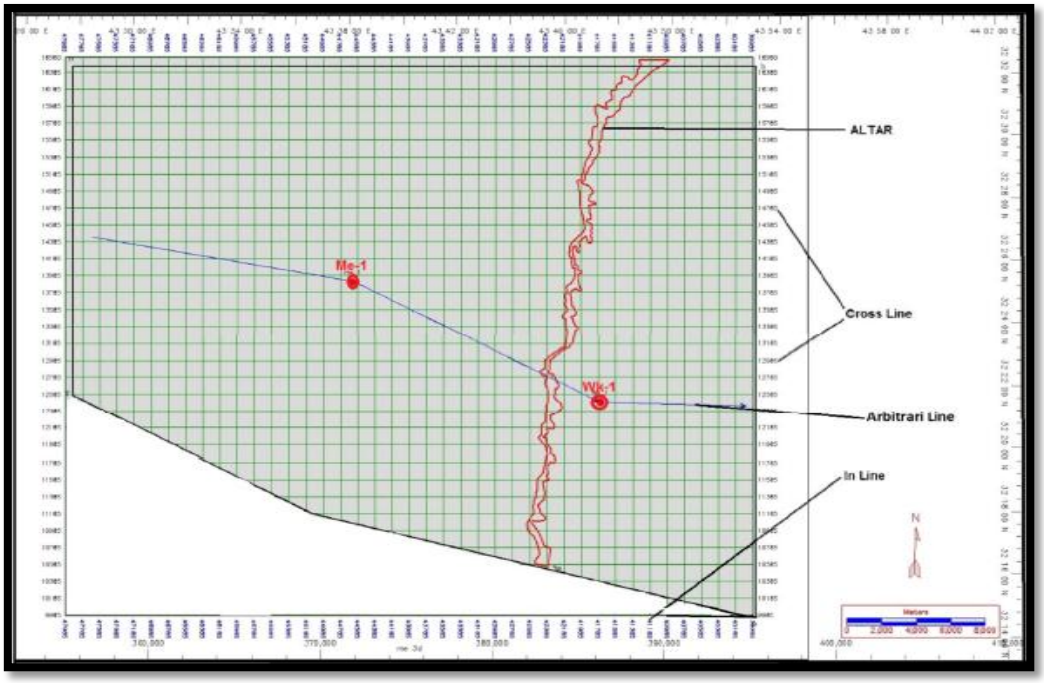


**Figure 3-** Base map for the study area.

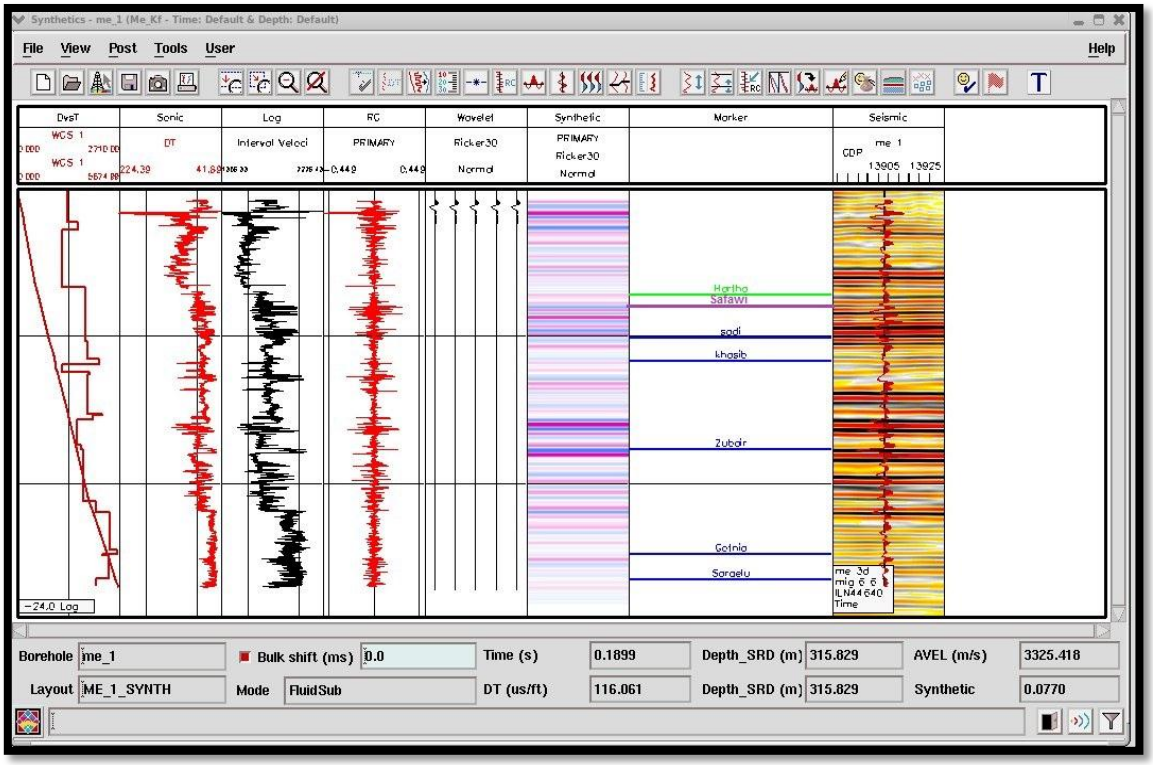


**Figure 4-** Synthetic seismogram for Me-1.

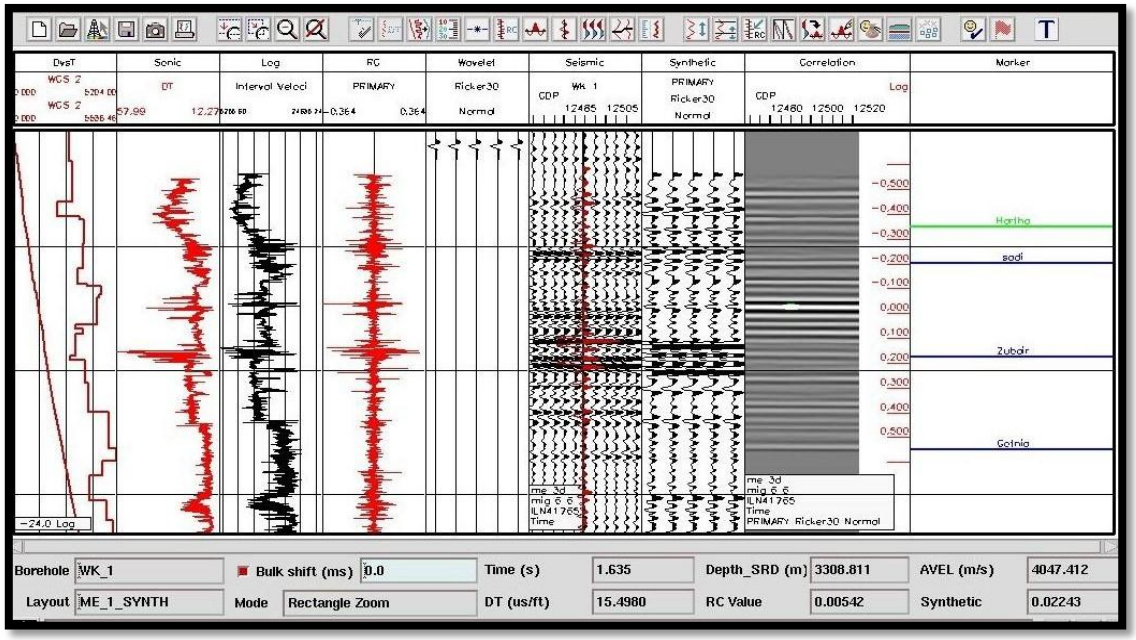


**Figure 5-** Synthetic seismogram for Wk-1.

**The recognition of fault and general stratigraphic interpretation**

The fault determination was achieved according to the principal indications of faulting on reflection sections as following, [1]:

1- Discontinuities in reflections falling along an essentially linear pattern.
2- Misclosures in tying reflections around loops.
3- Divergences in dip which not related to stratigraphy.
4- Diffraction patterns, particularly those with vertices which line up in a manner consistent with local faulting.
5- Distortion or disappearance of reflections below suspected fault lines.

The study area affected by the main fault extends from the north to the south but in the northern part it trends to the northeast direction. A set of normal faults called Altar as major faults as well as the presence of small faults, Figure- 6. In general stratigraphic interpretation in the region of Hartha Formation has been divided into three units, A, B and C. At unit B the oil were observed because the mound is clear in the seismic section, Figures-7 and 8, show the Zubair Formation level which shows the features top lap ,down lap and on lap.

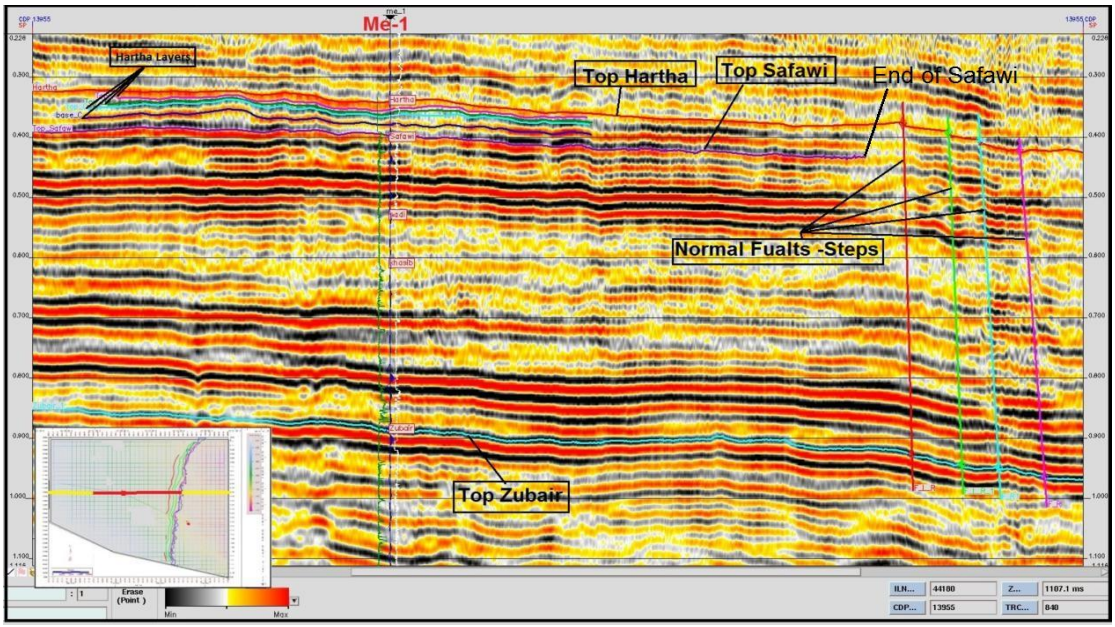


**Figure 6-** Seismic section shows the faults.

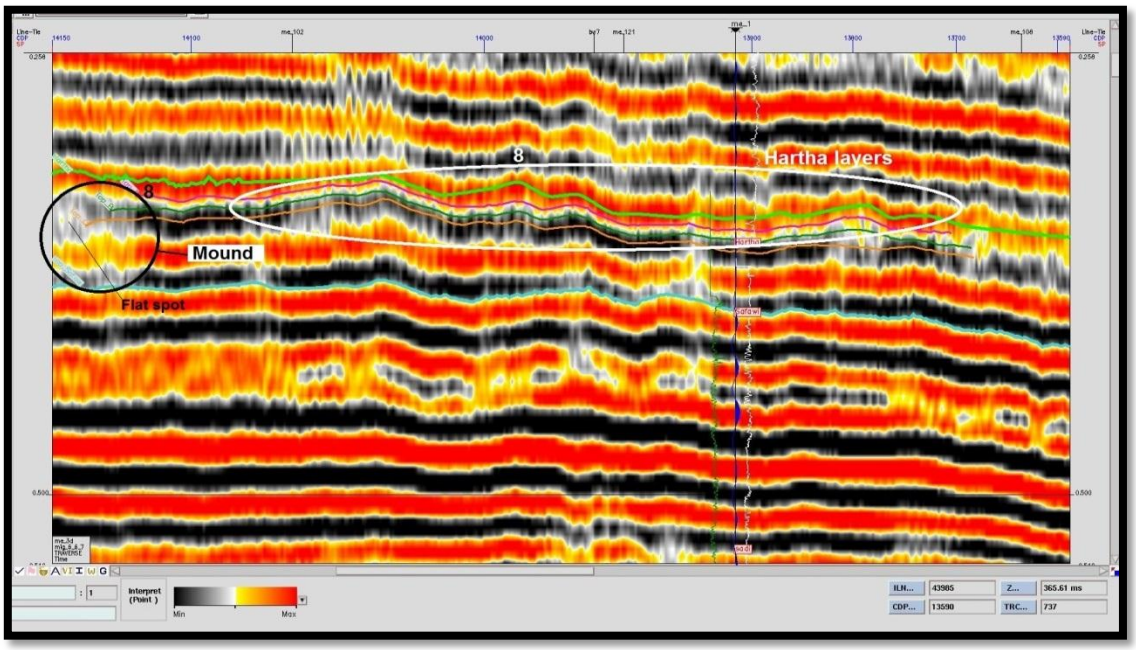


**Figure7-** Seismic section shows the layer of Hartha Formation.

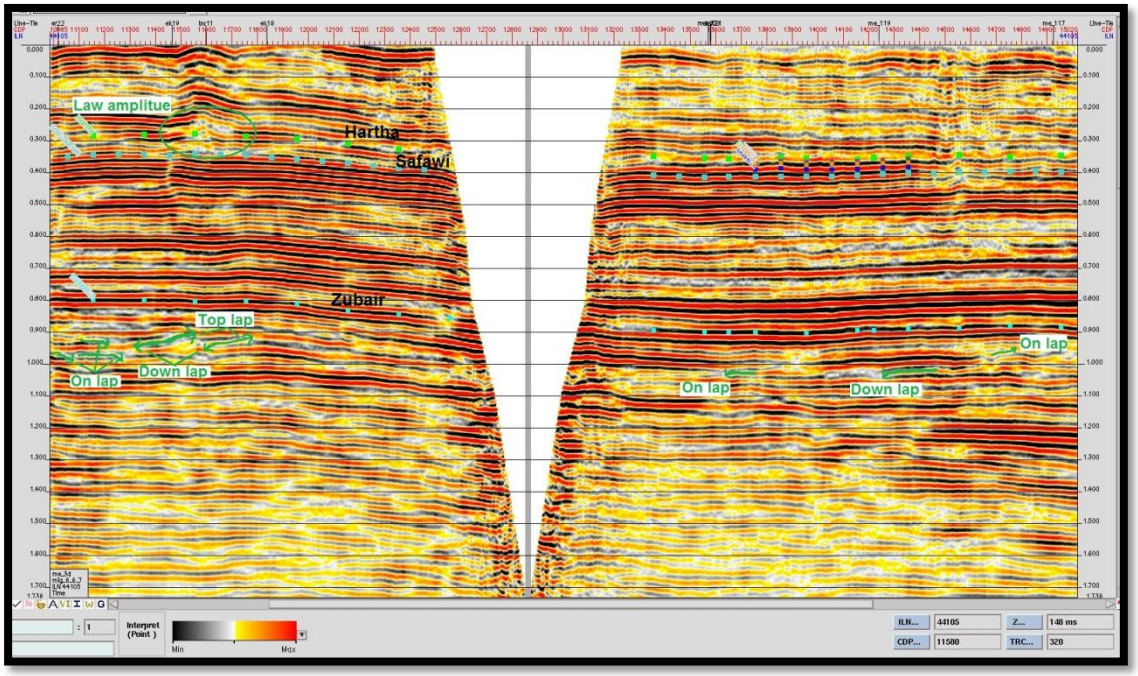


**Figure 8-** Seismic section shows the stratigraphic features of Zubair Formation.

**Seismic Interpretations**

Seismic interpretation is directed to the understanding of the geological subsurface geologic image; delineates structural traps by mapping the top of a reservoir. Seismic interpretation provides an evaluation of the hydrocarbon potential of a prospect as low and identifies the best location for drilling wells [7]. After definitions by using synthetic seismograms for wells (Me-1&Wk-1), these reflectors were picked on seismic cube and mapped to top of Hartha, Safawi and Zubair Formations in time domain, then converted to structural maps in depth domain by using average velocity of these reflectors. Sea level is used as reference datum to all maps. Many previous studies were performed by Oil Exploration Company that deal with the interpretations of Merjan oil field [8]. The interpretations of Merjan oil field was made by using Geoframe Software which is available in oil exploration Company to get the subsurface structural images by using:

**A-** TWT made to show the main structures on the studied Reflectors.

**B-** Using seismic attributes like instantaneous frequency, phase section and variance to get primary picture of the existing structures.

**A- Time Maps**

Three maps have been prepared representing the top of main Formations (Hartha, Safawi, Zubair), with a contour interval of (10ms.).Time maps showed that the general tendency of the layers toward the east.

1- **Time map of top Hartha Formation**: This map shows three enclosure domes, the first one is located west of the well (Me-1) dimensions of (1.4 km ×0.8km ×10 ms) TWT. There is also a structural nose to the westward. Figure-9.

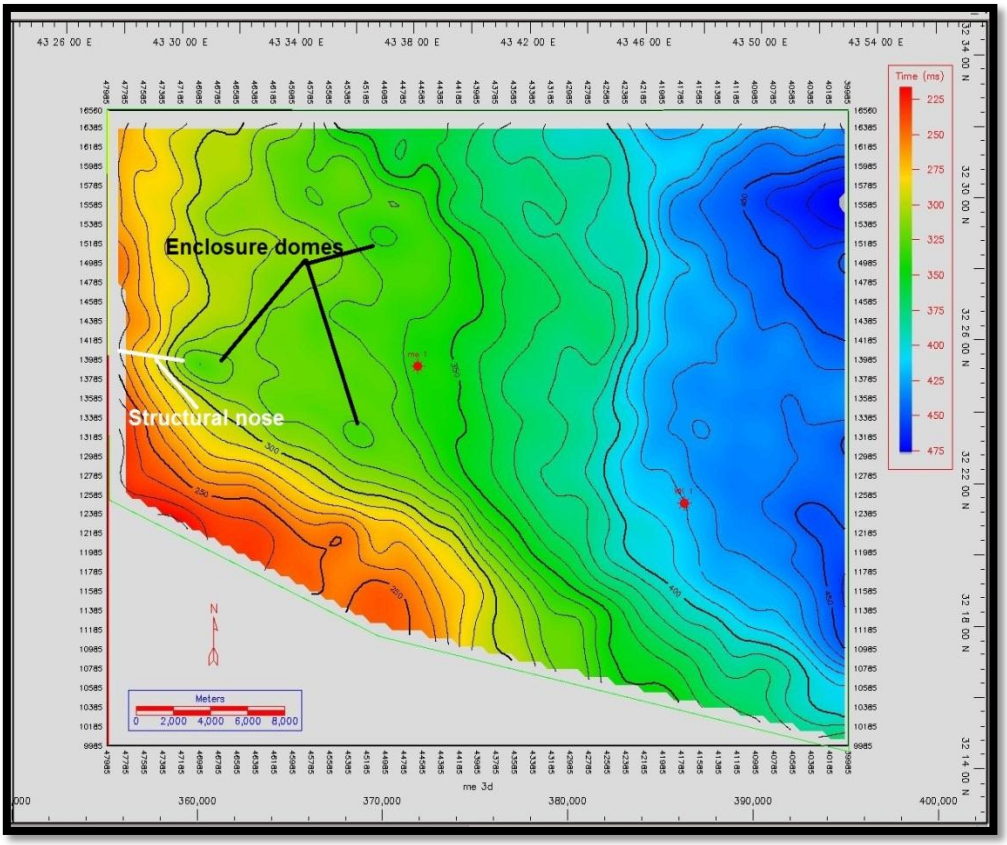


**Figure 9**- Shows TWT map to the top of Hartha Formation.

2- **Time map of top Safawi Formation :** This map shows the enclosure domes, located north-west of the well (Me-1), with dimensions (1.2km ×1.2km ×10 ms) TWT , and with a structural nose is trending NW, the map shows fade of the Safawi reflector in all direction except the west, because of the variation of the facies. Figure-10.

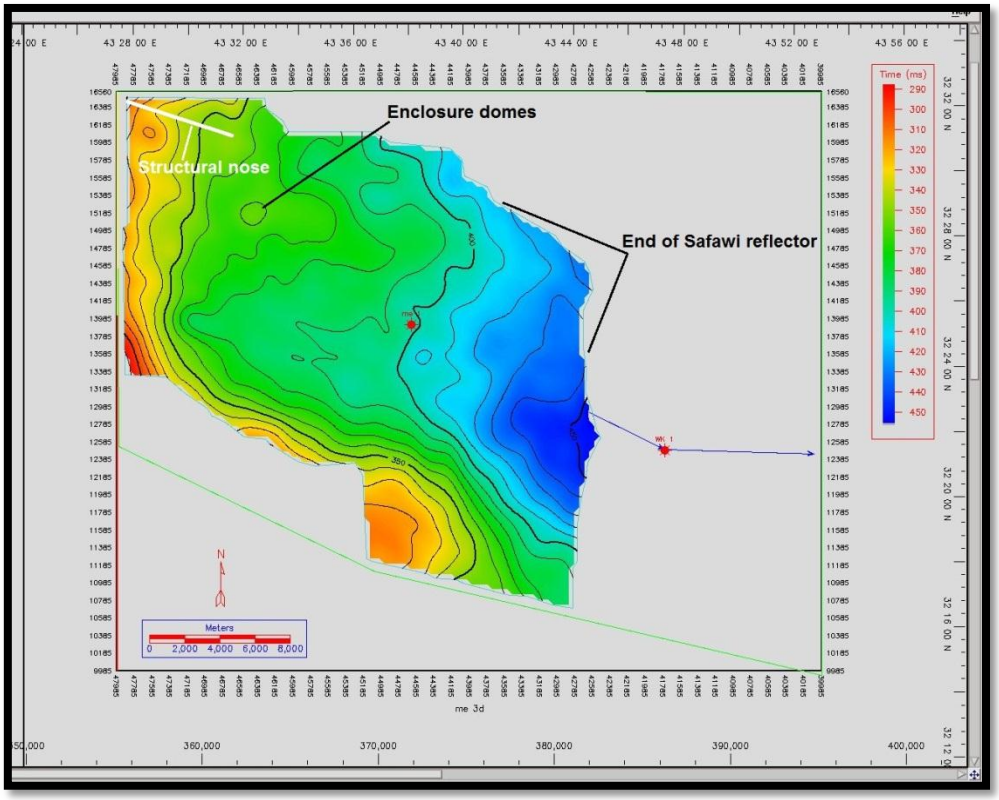


**Figure 10**- Shows TWT map to the top of Safawi Formation

3- **Time map of top Zubair Formation:** This map shows the absence of any enclosure domes, only showed the presence of a structural nose towards the north-west as well as the map showed the influence of the reflector with four normal steps faults trending to the north-south and at the northern part of the area the faults direction changed to NE. Figure-11.

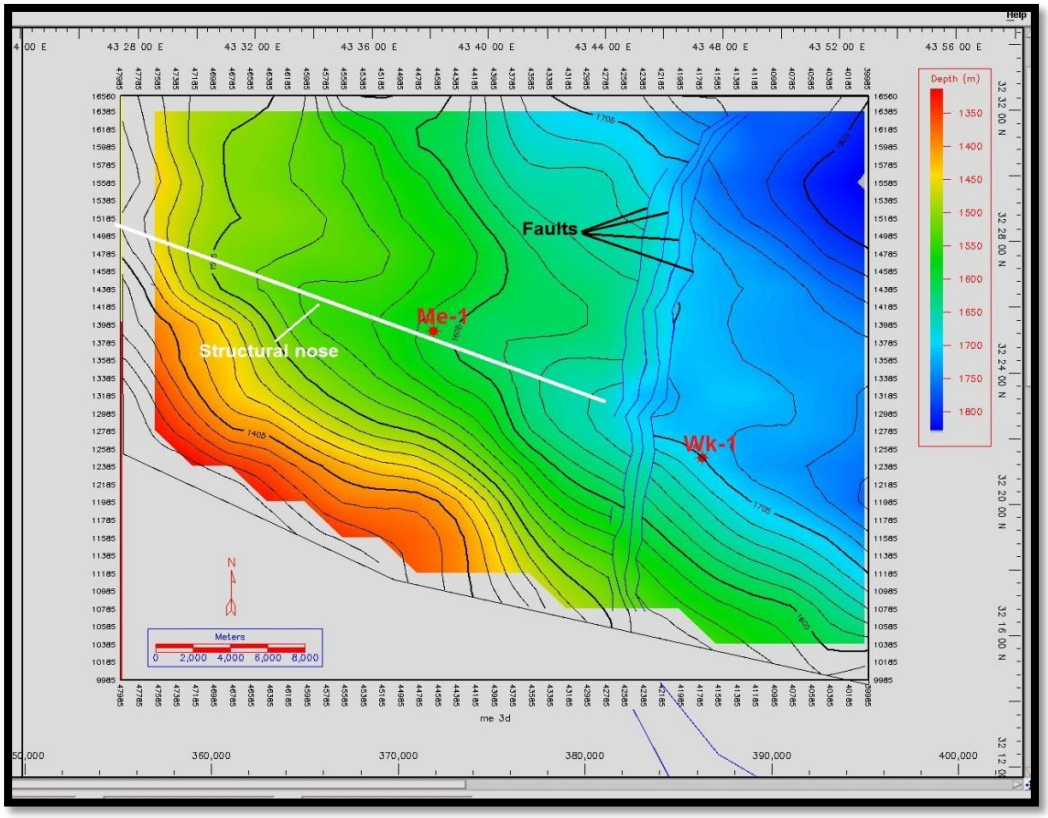


**Figure 11-** Shows TWT map to the top of Zubair Formation.

## B- Seismic Attributes

The purpose of study the seismic attributes is to use as a direct attempt to know and guess the presence of gatherings of hydrocarbon and distribution facies, as well as to identify the presence of faults and their systems, the conversion of seismic data to the seismic attributes have a large number of seismic features of the approved and used to determine geological phenomena [9]. In this study the instantaneous frequency with instantaneous phase and variance attribute were used as following:

### 1- Instantaneous Frequency

It is a description of the waveform shape and corresponds to the total envelope of energy displayed at any given instant along a seismic trace. The derivative of the instantaneous phase is a measure of the frequency of the waveform at every sample and it depends on reflection magnitude, weak events and noise , which all are equally weighted in the display,[10]. With frequencies low-lying low-frequency areas gatherings hydrocarbon regions are linked and has been observed a matching between the low-lying frequencies regions and communities hydrocarbon (red means high frequencies and blue color mean low frequencies) at Hartha Formation with gatherings hydrocarbons potential areas around the well location are shown, the other part shows the existence of some low-lying frequencies. The section shows the frequencies of the units' reservoir distribution. These units generally have low frequencies, with some of the highest frequencies at small spots. Figure-12.

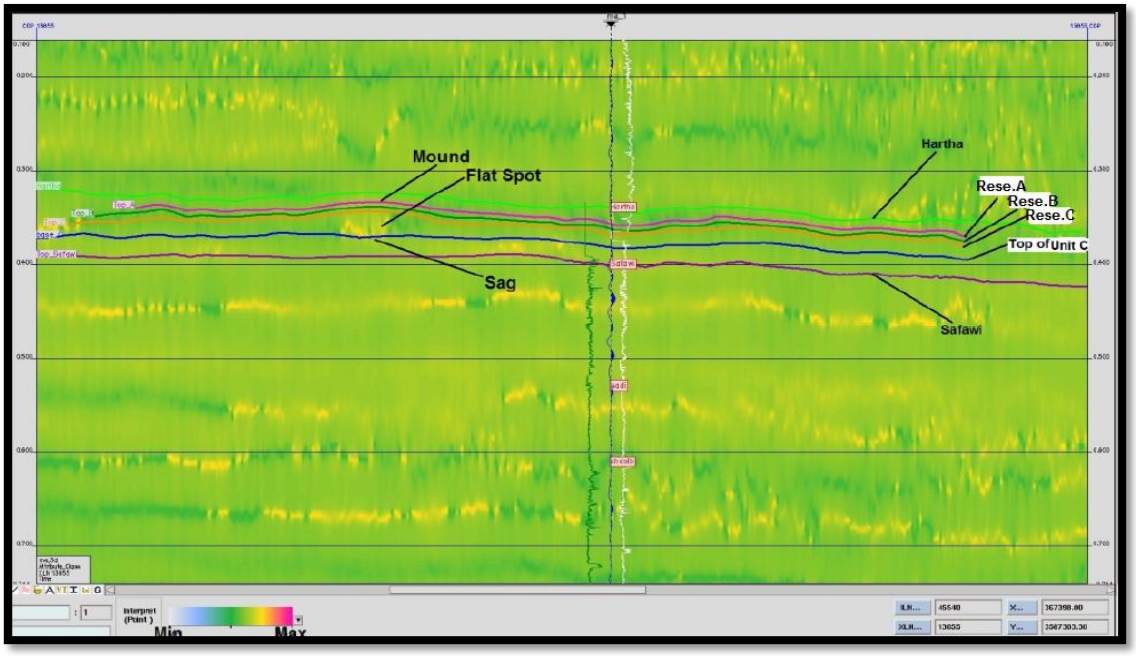


**Figure 12-** instantaneous frequency section shows the Hartha layers and mound feature.

**2- Instantaneous Phase**

Is a measurement of the position on the waveform selecting instantaneous phase in the available operation. Instantaneous phase is useful to show the discrimination ends of reflective surfaces because it does not depend on the severity of the reflection, it shows bedding very well, and it is useful as:Best indicator of lateral continuity.Shows discontinuities, but may not be the best. It is better to show continuities sequence boundaries.Detailed visualization of bedding configurations.Used in the computation of instantaneous frequency [11].

After its application to seismic sections it is observed that the termination of the reservoir units to form Hartha Formation units, (A-B and C), and also fading the end of the Safawi Formation where confirms vanishing site with zero Instantaneous phase value, and notes for phasic reversal when locations facies changes. The elliptical shape that related to features of mounds and the faults was clear in the instantaneous phase. Figures-13 and 14.

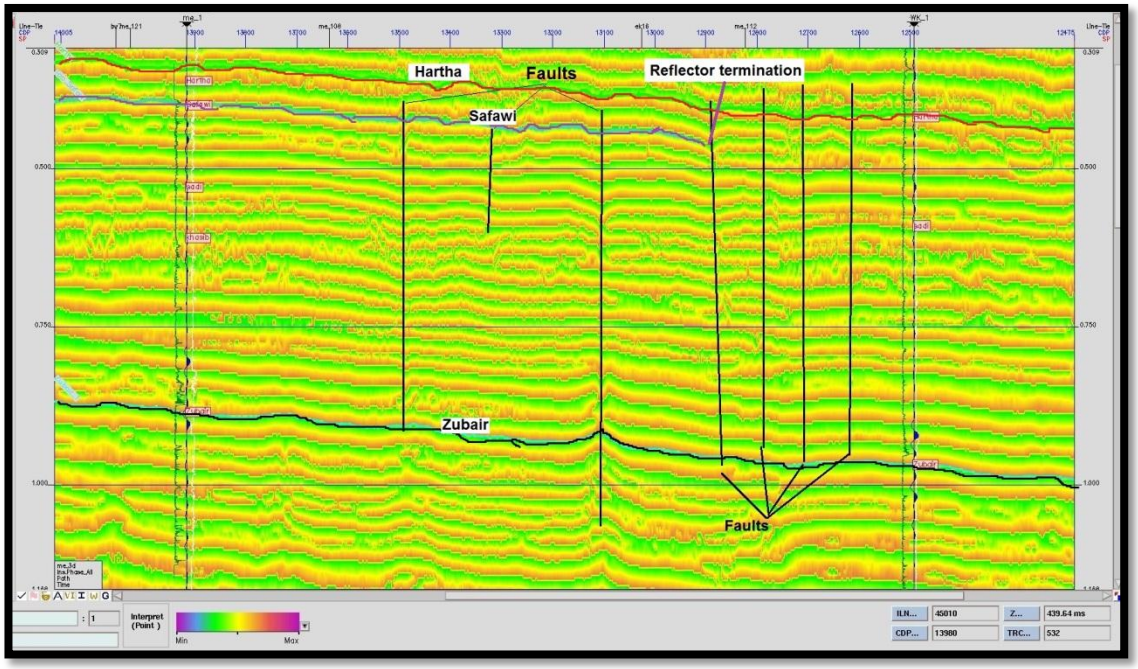


**Figure 13-** Arbitrary 3D seismic instantaneous phase section passes through (Me-1) and (Wk-1).

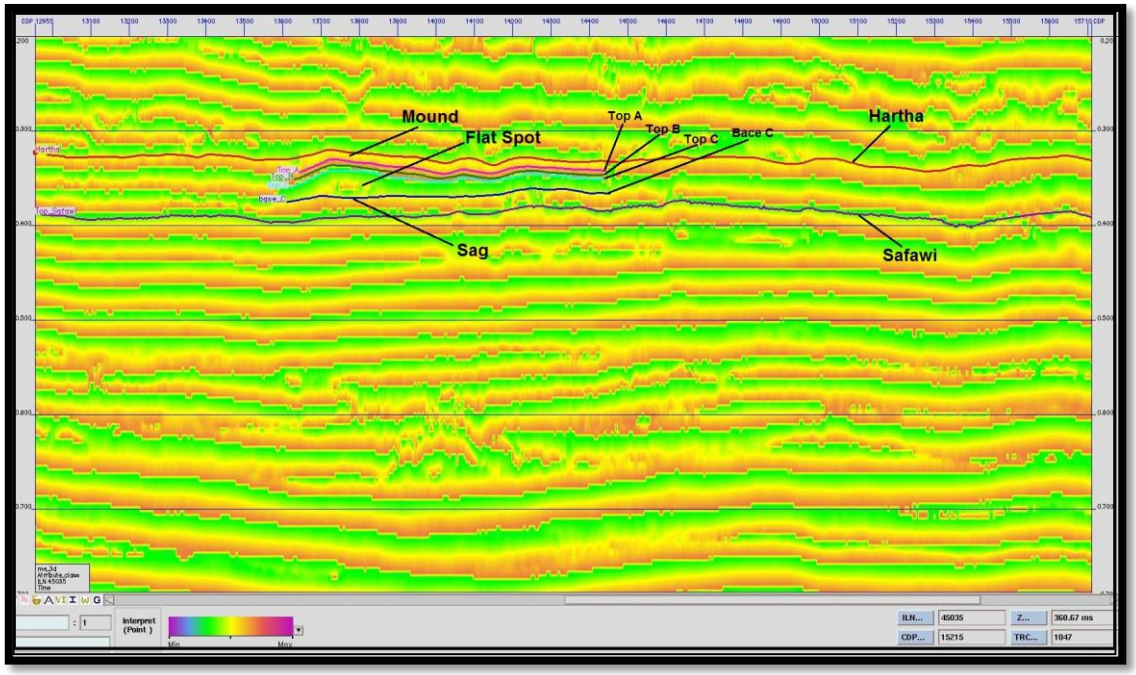


**Figure 14-** In line 3D seismic instantaneous phase section shows Hartha layers.

**3- Variance Attribute**

The variance cube operation highlights faults are linear stratigraphic features in a 3D seismic volume. Possible adoption of this attribute to learn about the sharp discontinuities and sudden variation in the continuity of seismic reflectors and this is evidence of the presence of faults with high displacements, or buildings biogenic irregular, [7]. Applying this feature to the study area, the time span was underscored by the presence of normal faults which are affected by the reflectors of Hartha and Zubair Formations. The presence of anomaly located west of well Me-1 near the area of Ain al-Tamur area, as observed this the phenomenon has to be the gas leak and caused deformation of the seismic reflectors inside the phenomenon, which has a probability of this oil trap. Figure-15.

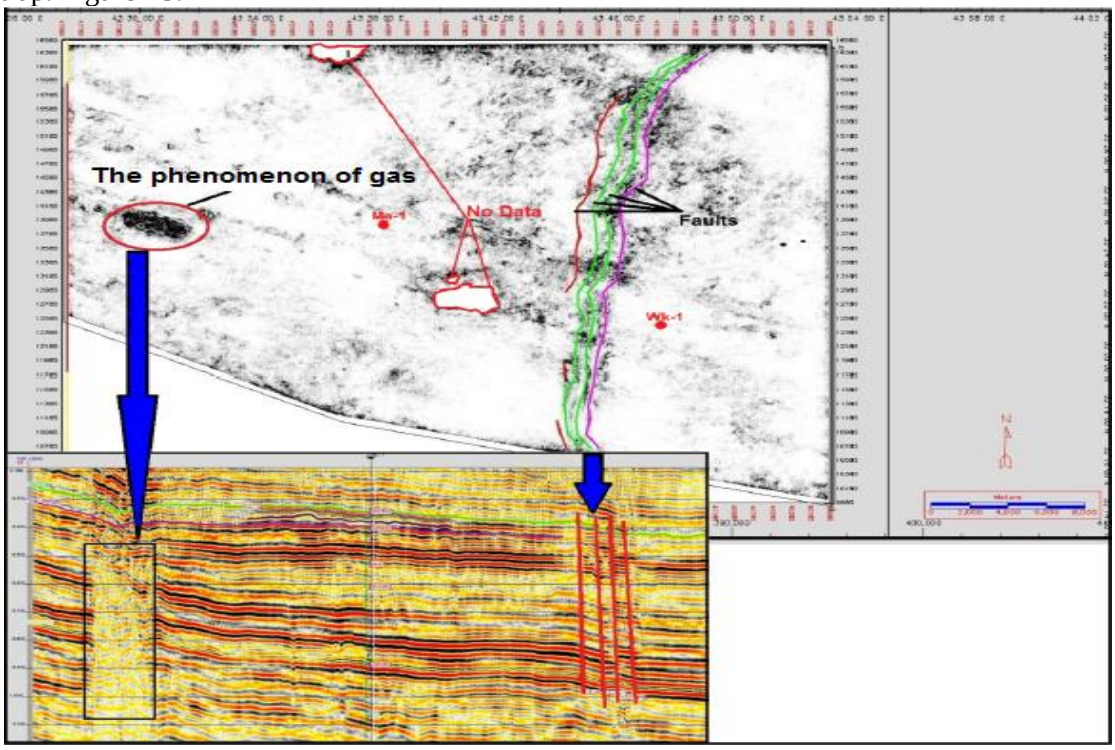


**Figure 15-** The variance shows the phenomenon of gas and faults.

**Conclusions and Recommendations**

The structural maps for the top of the Hartha, Safawi and Zubair Formations in time and depth domains showed the dip of layers tends to East, and also noticed two enclosure for the top of the Hartha Formation and one enclosure for the top of the Safawi Formation and absence of any enclosure domes for the Zubair Formation in time domains. Seismic attributes on 3D seismic sections show decreasing in frequency values within the reservoir units of the Hartha Formation and the area surrounding the well (Me-1). The instantaneous phase observed termination of reservoir units form Hartha Formation of units, (A-B and C), and also fading the end of the Safawi Formation and mound within the Hartha Formation. The phenomena of gas is showen in both sections and time slice variance, the evidence in this feature is gas: Continuity of reflectors on both sides of the phenomenon and the fading within phenomenon, their specifications agree with presence of specifications of gaseous when applying variance attribute, the presence of a gas leak on the surface in the western side of the study area near in Ain al-Tamur area. The variance attribute also shows the faults. Sedimentary layer patterns and regions of onlap ,toplap and downlap patterns are shown in the Zubair level. After showing the structural images using TWT maps and seismic attributes it is recommended to drill an exploration well that penetrates the phenomena of gas.

**Reference**


1. Dobrin, M.1976. *Introduction to Geophysical Prospecting*. 3rd ed., McGraw Hill. Int. co., International Student Edition, 386 p.
2. Kleyn, A. **1983**. *Seismic Reflection Interpretation*. Elsevier Applied Science Publishers, pp: 269.
3. Lindseth, R. **1979**. Synthetic sonic logs – a process for stratigraphic interpretation: *Geophysics*, 44, pp: 3-26.
4. State Establishment of Geological Survey and Mining (GEOSURV). **2014**.Geological Map of Iraq, printed and published by the GEOSURV, Baghdad, Iraq.
5. Milsom, J. **2003**. *Field Geophysics*, 3rd Ed. London University, 232 p.
6. Robinson, E. A., and Treitel, S. **1980**.*Geophysical Signal Analysis*: Prentice-Hall, Englewood Cliffs, N.J.,431P.
7. Gadallah., M.R. and Fisher, R. 2009. *Exploration Geophysics*, Springer Verlag Berlin Heidelberg, 120p.
8. Oil Exploration Company. **1994**. *Study of stratigraphic trap in Iraq*. 40p
9. Brown, A.R., **2004**. *Interpretation of Three Dimensional Seismic Data*, AAPG Memoir 42, 6th ed., Tulsa, Oklahama, 535p.
10. Schlumberger Information Solution, **2004**. *GeoFrame Fundamentals*, Training and Exercise Guide, Version 4.0.1, 102p.
11. Hart, B. S. **2004**. *Principle of 2D and 3D seismic interpretation*, McGill University.261p