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Subsurface Investigation of Oligocene Geologic Formations Age, East Baghdad Oil Field

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Abstract

An investigate of the subsurface of East Baghdad Oil field South-1 and South-2, by using the interactive workstation Geoframe. The study is interested with Oligocene Formations which is an extension of Kirkuk group. Synthetic seismogram is generated from data of EB-15 well. Base of Lowe-Fars reflector is picked and identified because it is close to Jeribe Formation that was deposited in the same depositional environment of Kirkuk group. The seismic sections and time slice maps confirmed that the Oligocene age was not affected by faults and the signs or indicators of faults started from Hartha Formation and continue to the deeper formations with increasing intensity, where the variance attribute section was applied on time slice and shows that the area was affected by listric growth normal fault parallel to the structure of the field trends (NW-SE) and affected by number of transverse faults trend (E-W) and (NE-SW). Time map, velocity map and depth map of base Lower-Fars reflector depending on data from (EB-2, EB-4, EB-5, EB-6, EB-15, EB-24), the maps was showed the structural picture of East Baghdad that formed structural nose opened toward NW and trending (NW-SE) that confirmed by 3D volume which prepared for the studied area. By studying the seismic sections and applying seismic attributes (instantaneous phase, reflection magnitude, and variance attributes) discovered the presence of Direct Hydrocarbon Indicator at shallow depth in Oligocene age represented by flat spot at Bajwan/Baba Formation and dim spot below Dhiban/ Euphrates Formations in locations inlines 49235, 49225, 49190, and 49095, cross line 11700. Further confirmation on the presence of Direct Hydrocarbon Indicator is outlined from the application of flattening technique on seismic and attributes sections. Finally the surface area of the spreading of spot has been calculated in MESA expert 11.02 program that reaches approximately 13.47 km².

Keywords: Structural and Direct Hydrocarbon Indicator study-Oligocene age-East Baghdad oil field.

استقصاء تحت سطحي لتكاوين عمر الاولييكوسين في حقل شرق بغداد النفطي

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الخلاصة

تم اجراء استقصاء تحت سطحي لحقل شرق بغداد بجزئيه south-1 و south-2 باستخدام محطة العمل التفاعلية Geoframe. و كانت الدراسة مهتمة بتكاوين عمر الاولييكوسين التي هي امتداد لمجموعة كركوك. تم عمل الاثر المصنع من بيانات البئر EB-15 حيث تم التقاط عاكس قاعدة الفارس الاسفل لانه قريب من تكوين الجريبي الذي ترسب في نفس البيئة الترسيبية لمجموعة كركوك. اكدت المقاطع الزلزالية و خرائط الشرائح الزمنية ان تكاوين عمر الاولييكوسين غير متأثرة بالفوالق و ان الدلائل على الفوالق بدأت من تكاوين الهارثة و استمرت الى التكاوين العميقة مع زيادة شدة التفلق و عند تطبيق التابع الزلزالي variance

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attribute بين ان المنطقة متأثرة بفالق listric باتجاه موازي لمحور تركيب شرق بغداد (NW-SE) و متأثر بعدد من الفوالق المستعرضة باتجاهات (E-W) و (NE-SW). خرائط السرعة و الزمن لعاكس (الفارس الأسفل الفتحة) التي استخدمت بيانات من ابار. (EB-2,-EB-4,EB-5,EB-6, EB-15,EB-24) وضحت ان الصورة التركيبية للحقل عبارة عن خشم تركيبى مفتوح باتجاه NW و انحدار (NW-SE) و تم تأكيد ذلك من خلال عمل مكعب زلزالي ثلاثي الإبعاد. و من خلال تطبيق و دراسة التتابع الزلزالية (instantaneous phase, reflection magnitude, and variance attributes) تم التوصل الى وجود دلائل مباشرة للهيدروكربونات DHI في تكاوين الاوليكوسين متمثلة ببقعة مستوية في تكوين بجوان/بابا وبقعة معتمة اسفل تكوين ذبان/الفرات في المواقع inline 49235, inline 49225, inline 49190, inline 49095, crossline 11700. و تم تأكيد ذلك من خلال تطبيق تقنية ال flattening و من ثم حساب المساحة السطحية لانتشار البقعة باستخدام برنامج MESA expert 11.02 حيث بلغت تقريباً 13,47 كم².

Introduction

The geophysical techniques most widely employed for exploration work are the seismic, gravity, magnetic, electrical, and electromagnetic methods. Some of these are used almost entirely in the search for oil and gas [1]. Seismic methods are the most effective, and the most expensive, of all the geophysical techniques used to investigate layered media [2]. Seismic reflection surveying is the most widely used and well-known geophysical technique [3]. , and gives more direct and detailed picture of the subsurface geological structures. It is more suitable in areas where the oil is in structural traps, but it is also useful for locating and detailing certain types of stratigraphic features [4]. This information could be used to determine the internal stratigraphic geometry interpretation in terms of environmental deposition paleogeography and analysis of sedimentary basin [5]. If amplitude anomalies at target level are seen to be correlated with overlying or underlying changes (high or low amplitudes due to lithology or gas effects, or overburden faulting, for example) then they should be treated with suspicion. Such correlation might have a genuine geological cause, but careful thought was needed to establish that the effect is not-an artifact. Following the amplitude anomaly through the seismic processing sequence from the raw gathers may be helpful; this may reveal an artifact being introduced in a particular processing step to recognize hydrocarbon effects (Direct Hydrocarbon Indicators, DHIs) for what they are [6].

Location of the Study Area

The studied area (East Baghdad oil field south-1 and south-2) is located in the middle parts of Iraq to the south of Diyala river within the boundaries of Al-Madaen province that belong to Baghdad governorate on the eastern side of Mesopotamian basin and within the administrative border of the province of Bahdad/Diyala.Lies within the tectonically stable Mesopotamian basin between the Zagros fold belt and the Arabian shield Figure-1.

Loading of 3D Seismic Data

Processed seismic data are loaded in the interactive workstation Geoframe of interpretation in SEG-Y format and before starting; special subprograms must be operated to define the required data for loading. This process is called (project creation) for achieving the interpretation process on an interactive workstation, loading of 3D seismic data in pre stacks and post stack time migrated format. After that, the base map of the study area is constructed with global coordinate's browser WG 1984 UTM system. This process includes entering the first and last inline number, the first and last cross line number, the separated distance between bin size along inline direction and cross line direction Figure-2.

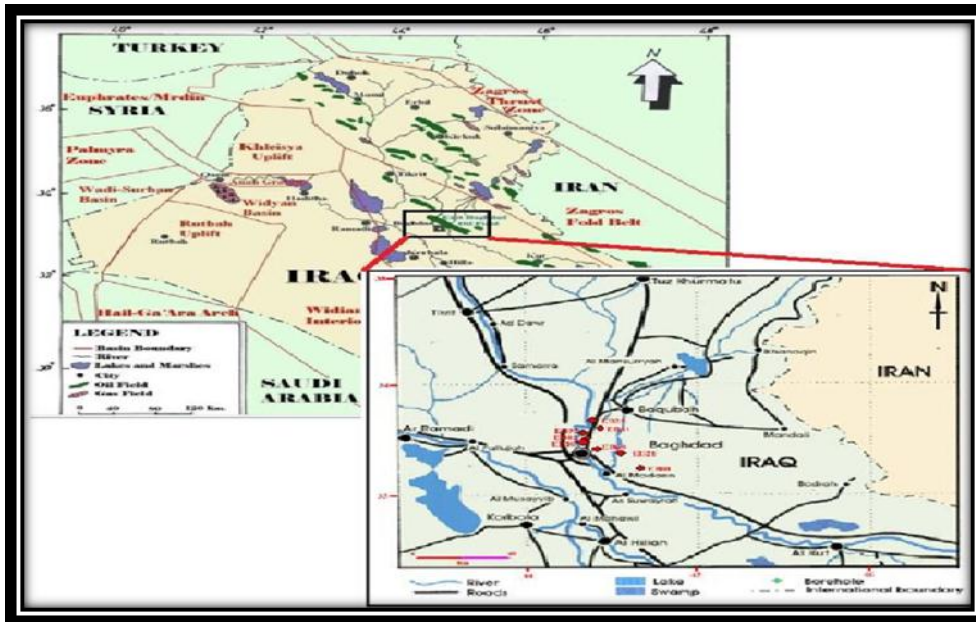


Figure 1- Location map of the study area [7]

Check-Shot Survey

The most direct procedure for velocity measurements is to explode charges of dynamite near the surface along the side of a deep borehole and to record the arrival times of waves received by geophone suspended in the borehole at a number of depths distributed between its top and bottom of the formations. The data can then be correlated to surface seismic data by correcting the sonic log and generating a synthetic seismogram to confirm or modify seismic interpretations.

A process of calibration of time curve with depth for sonic and velocity logs for the purpose of correcting time values of sonic log according to the field velocity survey of EB-15 well Figure-3.

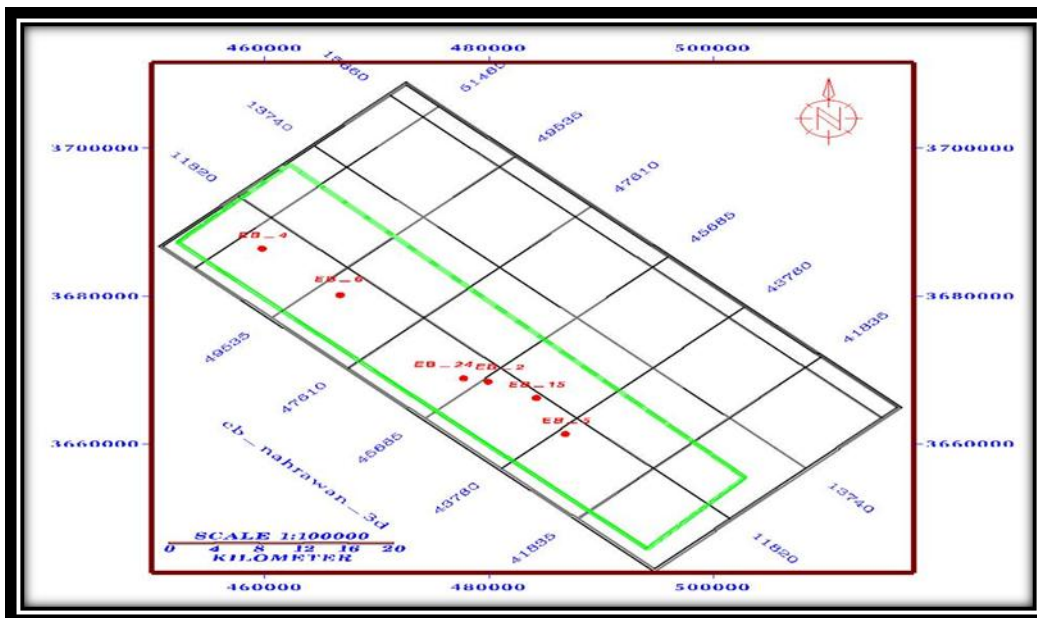


Figure 2-Base map of the study area.

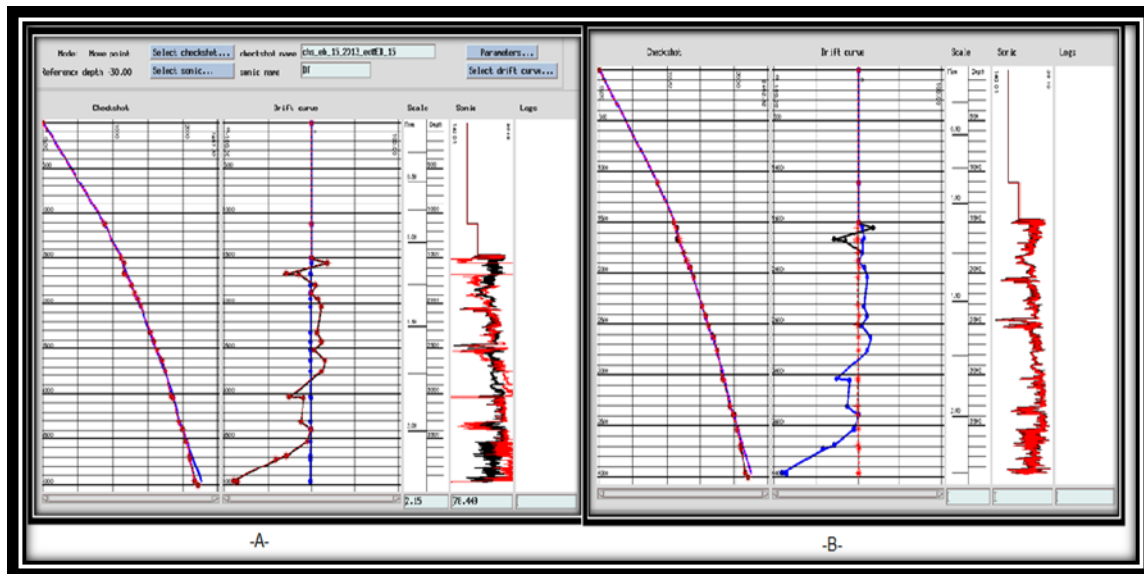


Figure 3A- Shows the time-depth curves before calibration of check-shot curves for East Baghdad well-15. **B-** after calibration.

Synthetic Seismogram Generation

Synthetic seismograms are generated for East Baghdad well-15 using GeoFrame software package Figure-4. The main steps for generation of the synthetic seismogram is referred by [8] which they are:

1-Computing the acoustic impedance = $(\rho \times v)$ Where:

v : is seismic velocity. ρ : is density measured from log.

2-Computing the reflection coefficients of the vertical incident wave on reflector separating two series time intervals such as (i) and $(i+1)$ that have values of acoustic impedance $(\rho_i v_i)$ and (ρ_{i+1}, v_{i+1}) respectively. According to [8] we can compute the reflection coefficients as the following:

- Computing the acoustic impedance $Z = \rho v$.

$$RC_i = \frac{(\rho_{i+1})(v_{i+1}) - \rho_i v_i}{(\rho_{i+1})(v_{i+1}) + \rho_i v_i}$$

Where:

(ρ_i, ρ_{i+1}) the density at two successive layers $(i), (i+1)$.

(v_i, v_{i+1}) the velocity at two successive layers $(i), (i+1)$.

The convolution process between the reflection coefficients and experimentally selected wavelet is made to obtain the synthetic seismogram. The sonic log data are compared with the well velocity survey which represents the direct method to obtain the geological velocity (average velocity) of geological strata. The synthetic seismogram traces of the East Baghdad well-15 are generated using programs within the IESX (synthetic programs). These have ability to extract the relation between the time and depth functions in the well location. This relation is very important in determining the reflection on a time axis of seismic section and synthetic trace against the require bed in the well. The sonic logs are transformed from the depth to the time domain using the check shots that are provided and used to make synthetics from the computed reflectivity series convolved with a Ricker and extraction wavelet to match the dominant frequency of reprocessed 2D seismic data. After that calibration must be done on seismic section of the synthetic as shown on Figure 4. The continuity of reflectors, seismic section (VA) which is passing through well EB-15 that is matching the synthetic trace very well is shown in Figure-5.

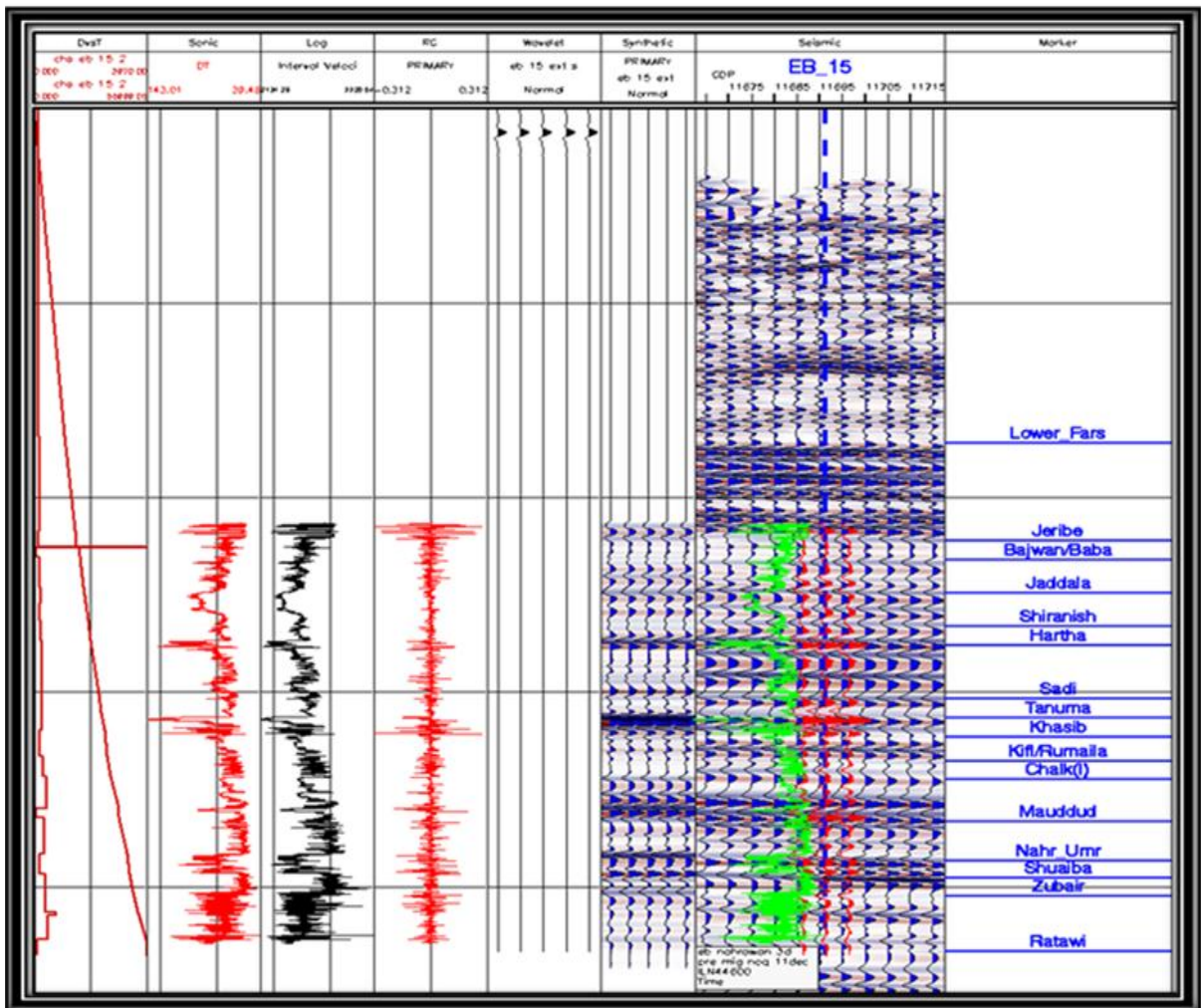


Figure 4- Illustrates the synthetic seismogram of EB-15

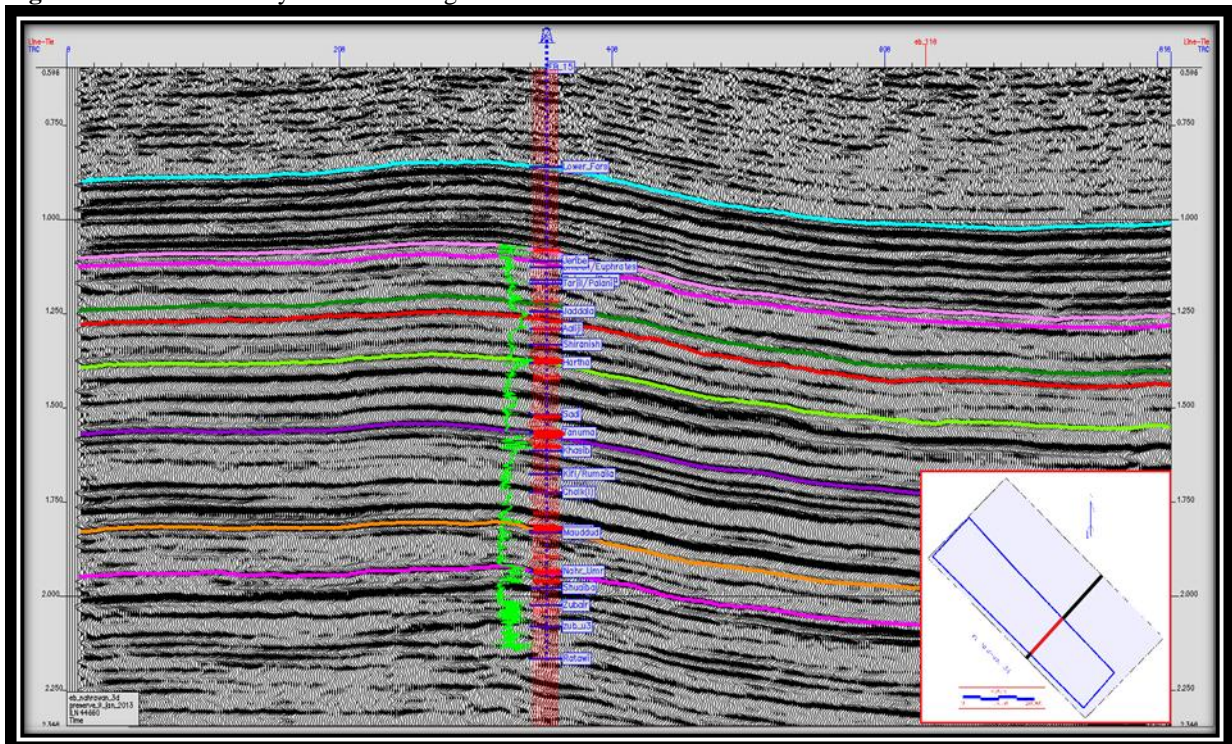


Figure 5- Seismic section (VA) shows the continuity of reflectors passing through well EB-15 that is matching the synthetic trace very well.

The match between seismic traces and synthetic traces is good. The picked reflectors wavelets appeared as peaks on synthetic trace (positive reflection) but in different intensity.

Structural Picture of Base of Lower-Fars

1-Time map

Time map of base of Lower- Fars (AL-Fatha) have been prepared with reformatted scale (1/100000) by using special mapping (CPS3) program and period level (10) millisecond, reference surface represent sea level. The TWT map of base lower-Fars showed that East Baghdad structure is a structural nose opened toward North West, The closure did not appear because of the missing of data survey due to the presence of Diyala river. Note that TWT values are few in the north western part of the study area and gradually increase in the north eastern and eastern parts this indicates that the thickness of sediments was high in the top of structural nose as anticline trends north west- south east and descend to the east and north eastern part of the study area so the observed the TWT values are high in these parts, also from TWT map and can deduces that the effect of faults did not reach to the formations of Oligocene age Figure-6.

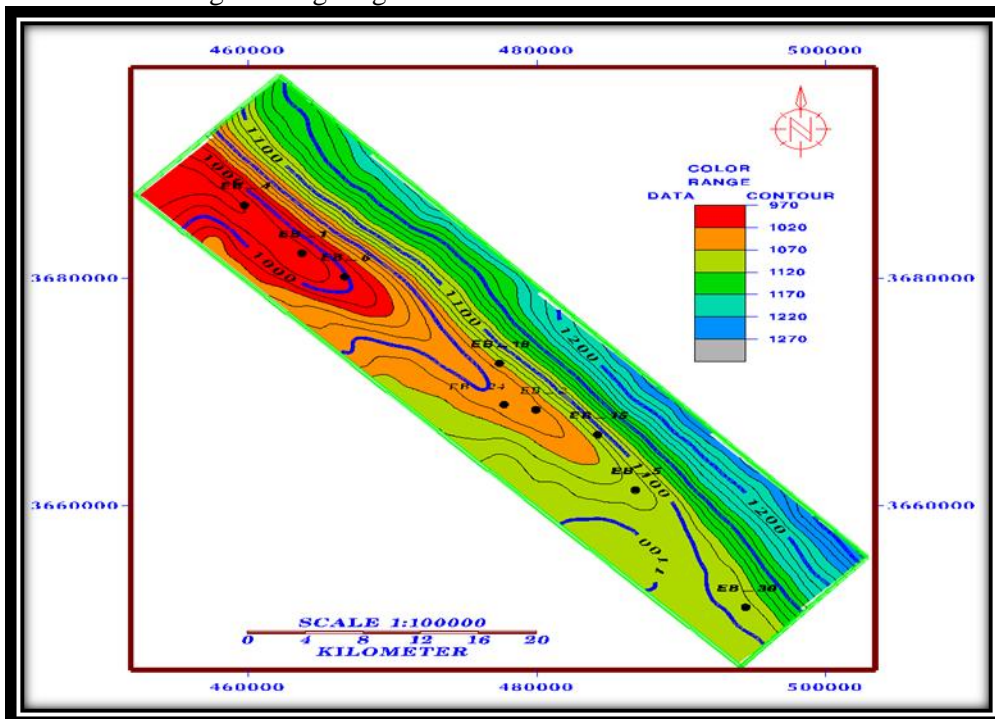


Figure 6- Two Way Time map of the base of Lower-Fars (AL-Fatha).

2-Velocity map

In the current research average velocity from wells (EB-2, EB-4, EB-5, EB-6, EB-15, EB-24) have been used because they are the suitable velocities which are used to convert the TWT maps to depth maps. It is considered the more accurate velocity type used in seismic methods and can be computed directly from well velocity survey (check shot) (9). Velocity map has been prepared for base of lower-Fars with scale (1/100000), contour interval of (50) m/sec. and reference surface is sea level. The base lower-Fars velocity values increased in the eastern part of the study area making local closure near EB-15 and decrease gradually toward North West, south east, and south west Figure-7.

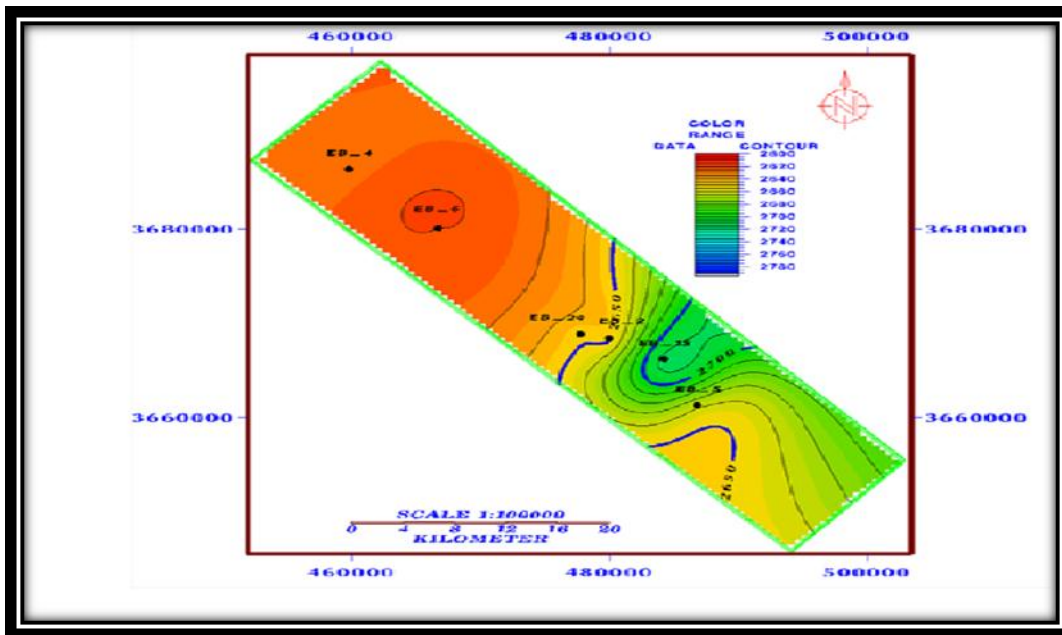


Figure 7- Velocity map of the base of Lower-Fars (AL-Fatha).

3-Depth Map

Using time maps and average velocity maps above to prepare the depth map of base lower-Fars reflector with reformatted scale (1/100000), contour interval (20) m, and reference surface is sea level. In seismic methods, the depth map is obtained by using the time map of a given reflector with its velocity map, as follows :

Depth at any point = (Average velocity × one way time) at this point.

The depth map in seismic reflection method is reflection of the subsurface picture to time map. Thus, the depth maps also show the same picture of the studied formations, but the difference lies in the closures dimensions, number of contour interval between these maps, faults displacements and difference in number of minor faults. Depth map confirmed that East Baghdad structure within survey area (South-2) south of Diyala river appears as structural nose trending north west-south east, note that depth values are decrease toward south east and north east parts of the study Figure-8.

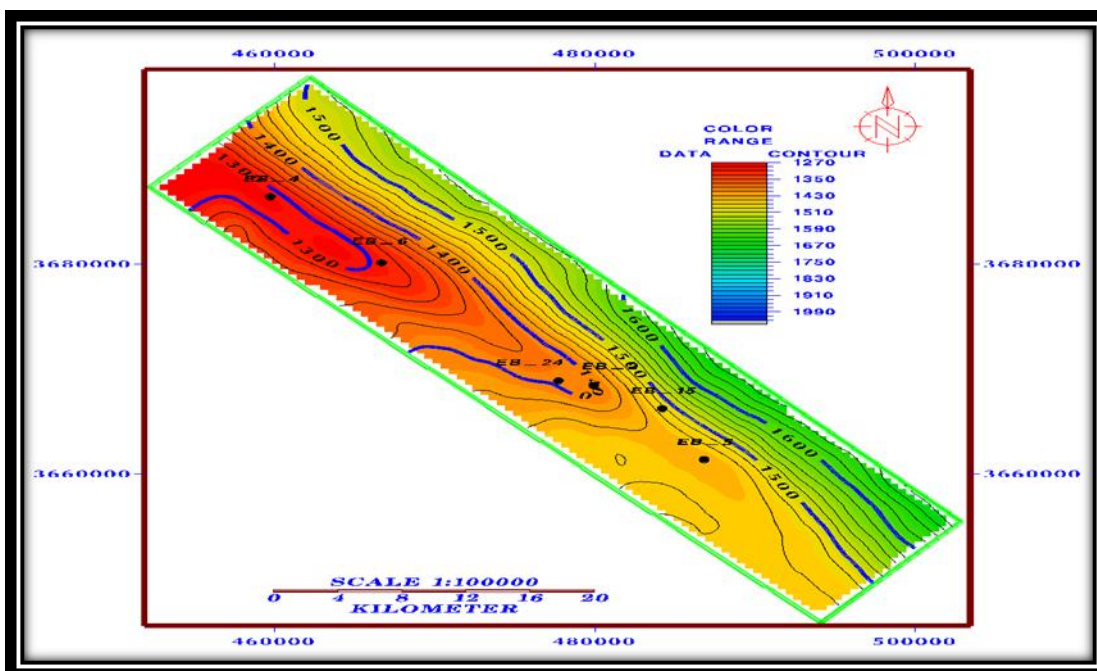


Figure 8- Depth map of base Lower Fars (AL-Fatha).

The Used Seismic Attributes

1-Instantaneous Phase

The information of instantaneous phase is very important in showing and distinguishing the ends of the continuity of reflective surfaces. The instantaneous phase does not depend on reflection strength, therefore, it is used for the purpose of discrimination and showing the cases of layers termination. From studying the instantaneous phase in Figure-9 showed the presence of phase reversal on Bajwan/Baba Formation represented by flat spot this is clearly points to the presence of gaseous Hydrocarbons.

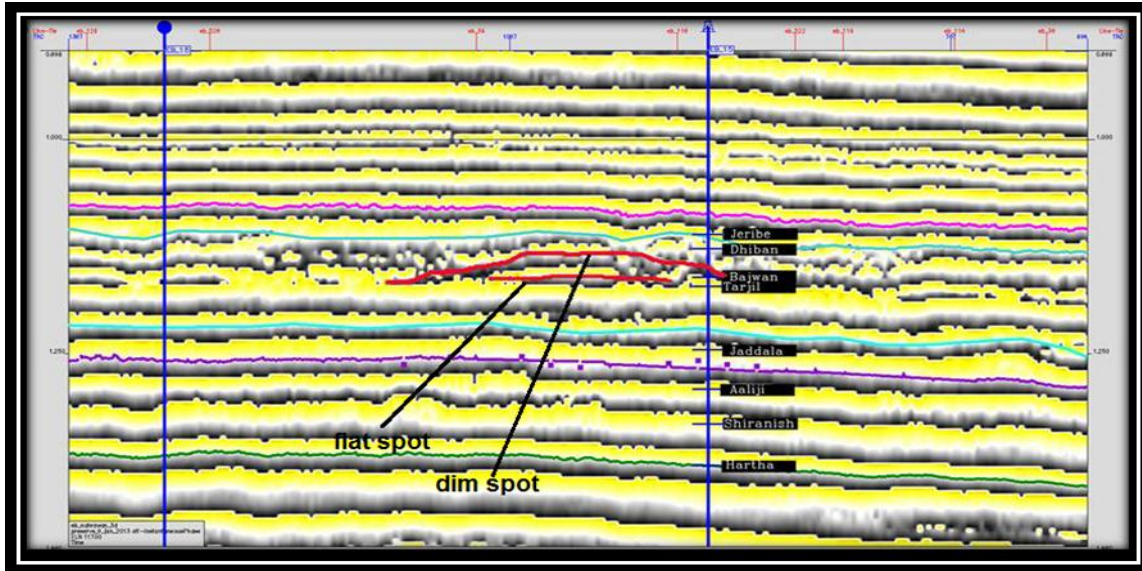


Figure 9- Instantaneous phase section, showing the flat spot with it is interpretation, along cross line 11700.

2-Reflection Magnitude

The reflection strength is associated with the main geological changes as unconformity surfaces or gas content in the rocks was referred by [10]. Figure-10 illustrates reflection strength composite section, from studying reflection magnitude which showed the presence of high reflection strength in Bajwan/Baba and Tarji/Palani Formations where found that there is a matching between high reflection strength and the presence of hydrocarbons in this area.

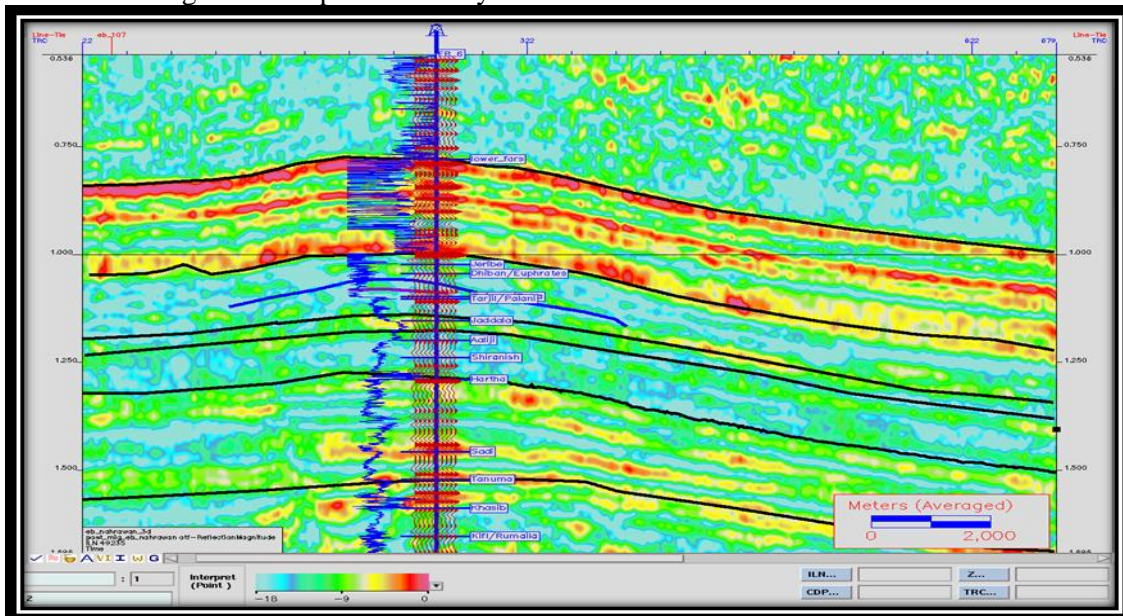


Figure 10- Reflection magnitude composite section with interpretation in 49235 inline, with well

3-Variance Attributes

Variance attributes is based on the change in amplitudes of reflected waves and it is used to determine the distribution of the mound which indicated by dim spot on the basis that the amplitude in areas of hydrocarbon accumulation is weak and differ from neighboring amplitudes, variance attribute was applied on time 1068 millisecond and showed that the areas of different amplitudes that selected by polygon that is refers to gaseous hydrocarbon accumulation Figure-11.

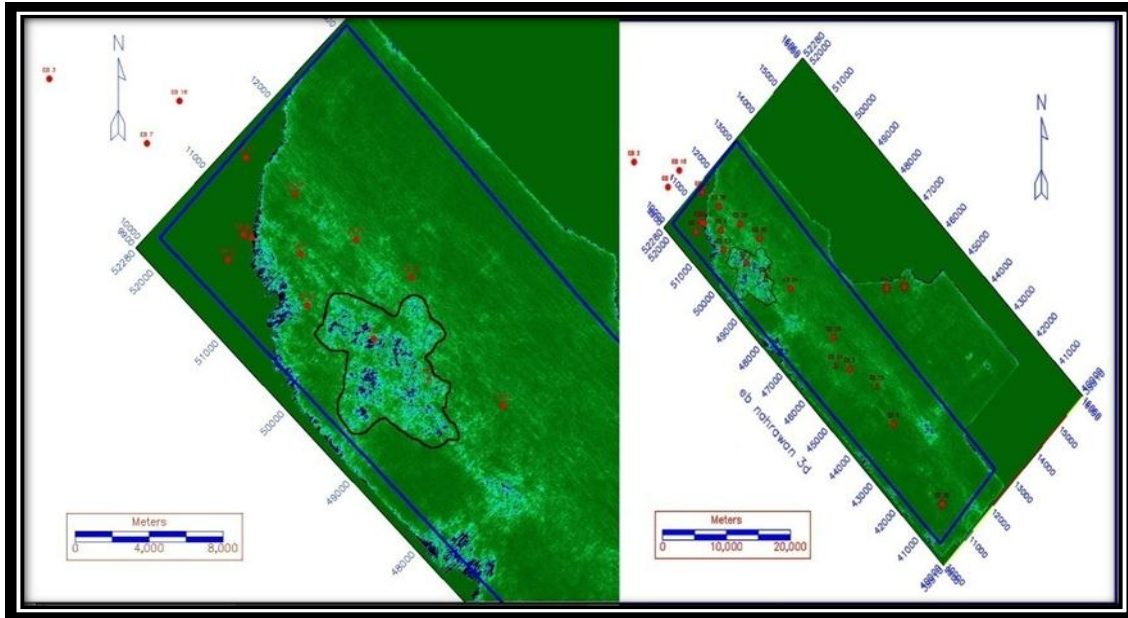


Figure 11-Variance time slice at 1068 millisecond time shows the distribution of flat spot.

Applying Flattening Technique

Seismic image flattening attempts to reverse the effects of geologic processes by removing all of the geologic structure present in the image and thereby transforming the image into layers as they were deposited in geologic time; i.e., flattening transforms a seismic image to make the structural features in the image flat. In the current research flattening technique are applied on the sections to prove the presence of Direct Hydrocarbon Indicators represented by dim spot which refers to the presence of gaseous hydrocarbon accumulation Figure-12.

Calculation the Surface area of Mound Distribution

After displaying the area of mound distribution on variance time slice at 1068 millisecond Figure-14 then by using MESA Expert 11.02 program the surface area was calculated from making a digitization in Petrel program to obtain the real coordinates of the polygon. Then, taking the coordinates by MESA program, that calculate the area of polygon which approximately 13.47 km² Figure-15.

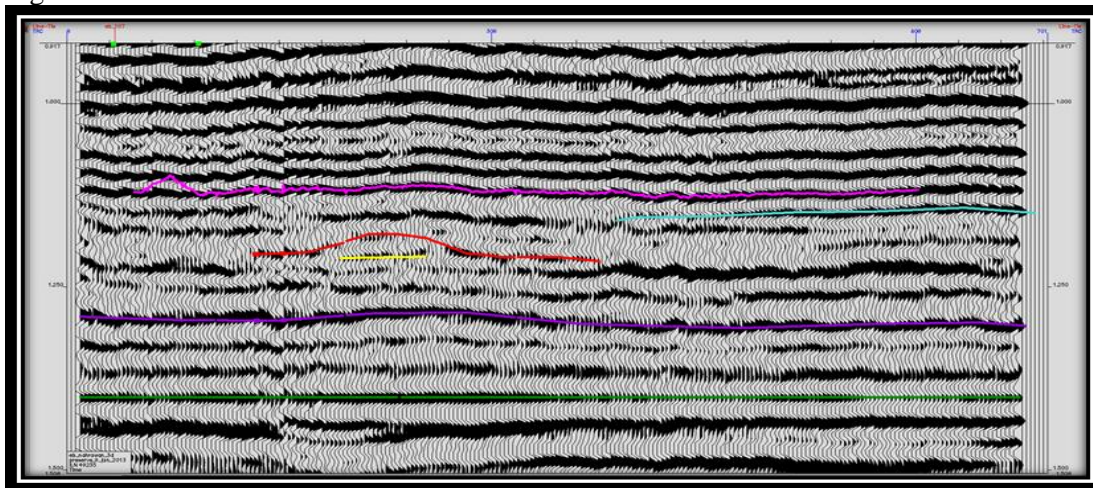


Figure 12- Seismic section that display variable area/positive fill, inline 49225, showing the dim spot with application of flattening technique on the reflector.

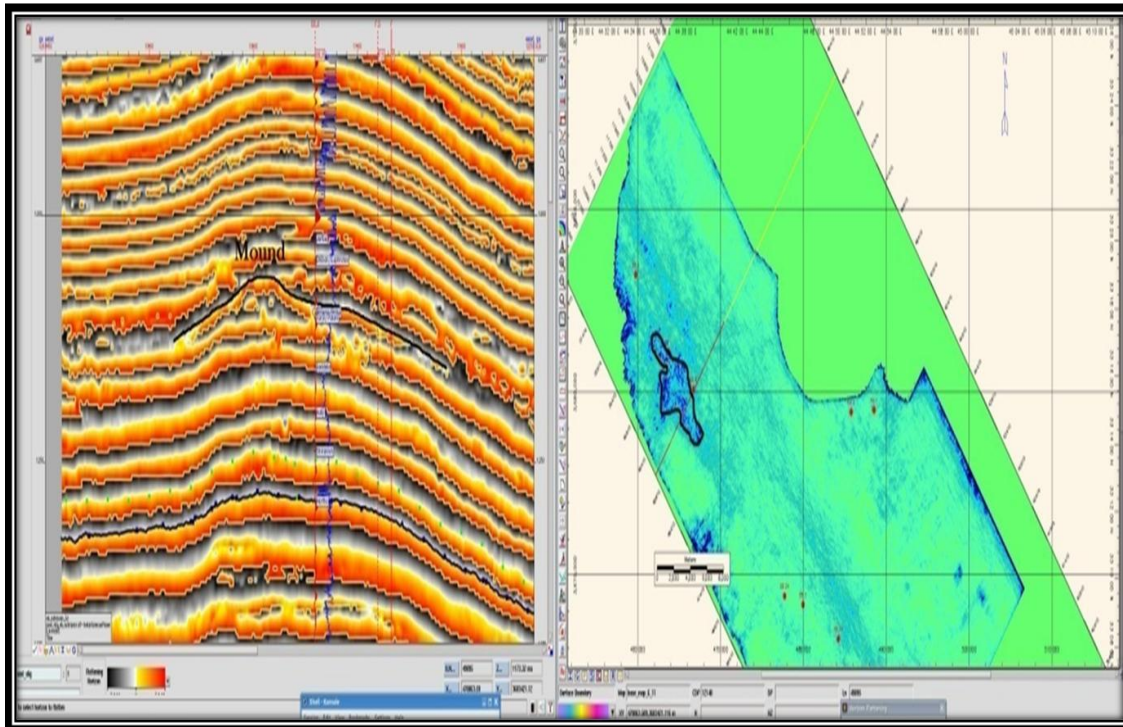


Figure 13-The left figure is instantaneous phase showing the mound at inline 49095, the right figure is variance time attribute at time 1068 millisecond with selection the surface area of mound distribution.

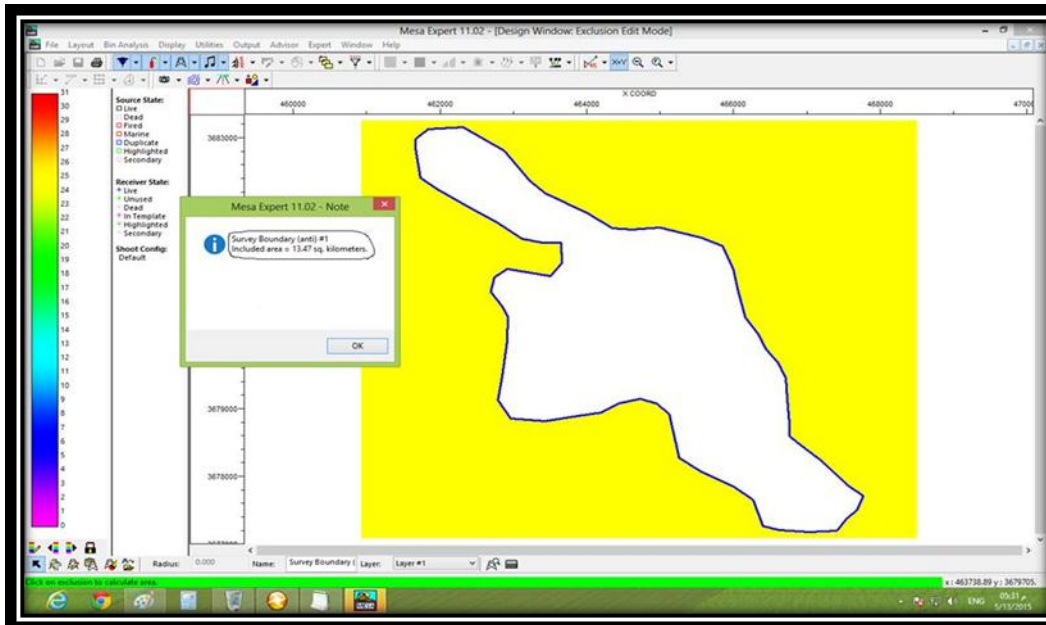


Figure 14-Illustrate the calculation of the area of the polygon in MESA expert 11.02 which was reached approximately 13.47 km².

Conclusions

According to seismic processing and interpretation of the current research following conclusions can be listed:-

1. Synthatic seismogram was generated from EB-15 well to identify the formations; it showed very good matching between the seismic trace and synthetic traces.
2. These reflectors were mapped in time domain then converted to structural maps in depth domain.
3. Time slice map of base of Lower- Fars showed the absence of faults in Oligocene formations and the seismic sections was showed the effect of faults on deeper formations, therefore these formations was studied and identified because may have impacts on Oligocene formations.

4. The TWT and depth maps of base Lower Fars reflector showed that the structural picture of East Baghdad field was a structural nose opened toward NW and Oligocene formations was not affected by faults, the values of TWT was small at the NW parts of the study area this indicates that the thickness of sediments was high at the top, if the structural nose and descend toward the east and south eastern part therefore observed high TWT values in this parts, that was confirmed by depth map.
5. Average velocity has been used from wells (EB-2, EB-4, EB-5, EB-6, EB-15, EB-24) to prepare velocity map of base of Lower Fars that showed the values of velocity was increases in the eastern part of the study area making local closure near EB-15 well.
6. From studying the seismic sections and applying the seismic attributes represented by instantaneous phase, reflection magnitude, and variance attribute it was discovered locations considered Direct Hydrocarbon Indicator, type dim spot and flat spot which refers to gaseous hydrocarbon accumulation, the locations are as follows:-
Inline 49235, 49225, 49190, 49095, Cross line 11700.
7. Flatening technique has been applied on the seismic and attribute sections to confirm the presence of dim spot and flat spot as hydrocarbon water contact.
8. The surface area of spreading of the spot was 13.47 Km². That was calculated by MESA expert 11.02 program.

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