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Sub-Surface Investigation of Khashim Al-Ahmer Gas Field Using Seismic Reflection Data

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Abstract:

This paper is carried out to detect the subsurface structures that have geological and economical importance by interpreting the available reflection seismic data of an area estimated to be about (740) km^2. The Khashim Al-Ahmer structure is partial of series structures of (Injana – Khashim Al-Ahmer – Mannsorya) from the (NW to the SE), it is located within for deep faulted area. The component of the one elongated dome of asymmetrical of structure which has(SW) limb more steeper than the (NE) limb.Twenty three seismic sections had been interpreted for two seismic surveys and the total length of all seismic lines is about (414.7) Km. Interpretation of seismic data was focused on two reflectors (Fatha and Jeribi) Formations which belong to Lower and Middle Miocene age. The reflectors were picked and identified by tying them directly to well Khashim Al-Ahmer-2, the Lower Fars(Fatha Formation) reflector was picked at TWT ranging from (0.3-1.7) sec while the Jeribi reflector was picked at TWT ranging from (0.83- 2) sec. The depth map showed that the depth of the Jeribi Formation ranges between (1100 - 2000) m, and the velocity maps of studied reflector showed increase of velocity values to the south east and there is a local closure in the north east of the study area and decrease to the north west and the velocity values decrease and give closure situated below well KA-2.The magnitude of velocity values ranges in Jeribi velocity map from (3100 to 3400 m/sec). Seismic attributes techniques (instantaneous phase) is important to detect the hydrocarbon accumulation on seismic sections. Major faults (reverse and thrust) were picked along study area on instantaneous phase sections. These faults extend in NW-SE trend and the displacement of the fault ranges between (400-660) m. The velocity, time and depth maps were drawn by the aid of GeoFrame and petrel software.

Keywords: Sub-Surface Investigation Khashim Al-Ahmer Gas Field.

استقصاء تحت سطحي لحقل الخشم الاحمرالغازي باستخدام المعلومات الزالزلية الانعكاسية

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الخلاصة

في هذا البحث تم تحديد التراكيب تحت السطحية ذات الاهمية الجيولوجية والاقتصادية وذلك من خلال تفسير المعلومات الزالزالية الانعكاسية المتوفره في المنطقة ، والتي تقدر مساحتها حوالي (740) كم^2 .ان تركيب خشم الاحمر هو جزء من سلسلة تراكيب (انجانة– خشم الاحمر – المنصورية) ابتداءآ من الشمال الغربي نحو الجنوب الشرقي، ويقع التركيب ضمن نطاق الفوالق العميقة ، ويتالف التركيب من قبة غير متناظرة سفحها الجنوبي الغربي اكثر ميلاناً مقارنة مع سفحها الشمالي الشرقي .لقد تم تفسير ثلاثة وعشرين مقطعاً زلزالياً ممثلةً لنوعين من المسوحات الزالزالية

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وبلغت اطوال الخطوط حوالي (414.7) كم .تفسير المعلومات الزلزالية تركزت على عاكسين هما تكوين الفارس الأسفل(الفتحة) والجريبي العائدين الى المايوسين الاسفل والاوسط . تم التقاط العاكسين من خلال ربطهما ببئر خشم الاحمر 2- وحسبت القيمةالزمنية المضاعفة (TWT) لعاكس الفارس الاسفل تراوحت من (0.3-1.75) ثانية بينما القيمة الزمنية المضاعفة لعاكس الجريبي تتروح بين (0.83-2) ثانية. والخريطة العمقية وظهر ان عمق تكوين الجريبي يتروح بين (1100-2000) م ، والخريطة السرعية بينت ان السرعة تزداد بقيمتها باتجاه الجنوب الشرقي وفي انغلاق محلي في الجزء الشمال الشرقي في منطقة الدراسة وتقل السرع باتجاه الشمالي الغربي . ان قيمة السرع تقل في منطقة الانغلاق تحت بئر خشم الاحمر 2- وان قيمة السرعة لعاكس الجريبي تتروح بين (3100-3400) م/ثانية.وقد استخدمت تقنية الملامح الزلزالية (instantaneous phases) وهي مهمة وذلك لتحديد التجمعات الهيدركاربونية في المقاطع الزلزالية، وتحديد الفوالق الرئسية (الفوالق العكسية والدسرية) التي التقطت علئ طول منطقة الدراسة علئ مقاطع(instantaneous phases)، وهذه الفوالق تمتد من الشمالي الغربي الى الجنوبي الشرقي وإزاحة الفوالق تتراوح مابين (400-660)م ،الخرائط السرعية والزمنية والعمقية رسمت بواسطة برنامج(GeoFrame and petrel).

Introduction

Seismic method is the scientific study of the earth using techniques of physics; The elasticity is one of the rocks physical properties which can be utilized in geophysical Investigation, especially in seismic method [1].The geophysical exploration technique that depends on the anomaly located in the information obtained from the field. This anomaly serves as the starting point cares about geophysical with a view to reach reason for the presence of anomaly which often comes from the underground. The most important anomalies affecting seismic signal are geometrical shape of structure, depth of geological anomaly, physical properties of rocks, mineral content, fluid content, and compaction pressure [2,3].The importance of the seismic methods lays above all other geophysical methods in the fact that the seismic data yield more detailed information (high accuracy, high resolution, and great penetration) [4,5] .

Location of The Study Area:

The Khashim_AL_Ahmer Gas field located to the north-East of Baquba city Iraq within Diyala province and is part of the Jebal Hamrin and is located between the southern edge of the folded zone (Hamrin _ Makhoul belt) and unfolded zone the (Tigris belt) with a surface length (36.6) km and width (19.3) km shown Figure-1.

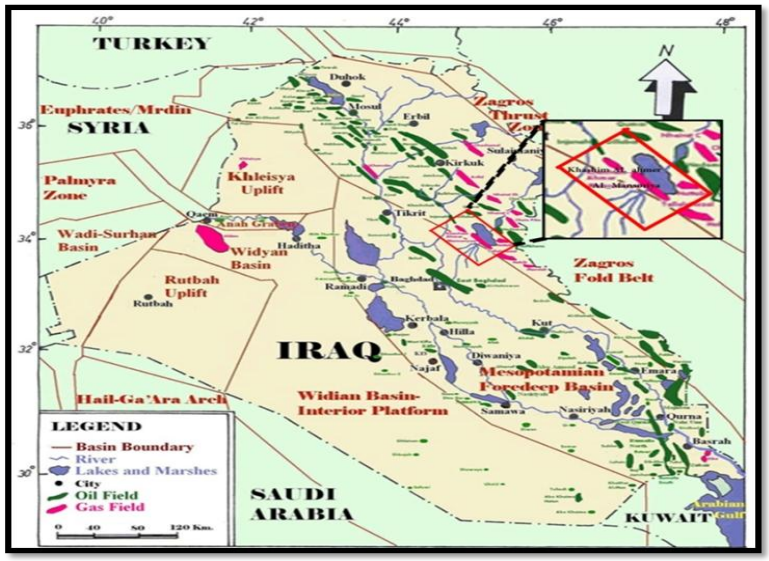


Figure 1- Location maps of study area [6].

The Aim of the Study

The previous seismic interpretations of the seismic data in Khashim AL-Ahmer applied to determine of a structural traps only, and using old software (VAX AND LAND MARK SYSTEMS), while in this research and according to modified software, the reinterpretation of data is done to determine the following:

1- Structural hydrocarbon traps and showing the seismic structural picture for the Jerbie Formation in the area which is covered by two dimensions survey using all the available data of the Oil Exploration Company.
2- Using the seismic instantaneous phase attributes which disposed within the new software interpretation system (GeoFrame), to predict the hydrocarbon accumulations that may present in Jerbie Formation.

All these goals will be done using new software interpretation systems (GeoFrame and petrel).

Computer Interpretation and the Used Programs:

The interactive workstation (GeoFrame) available in OEC is used to achieve the interpretation. (GeoFrame) software provides a comprehensive solution for integrated seismic, geological mapping, and petrophysical interpretation. It is an electronic computer uses (Red hat) as operating system. The latter is a copy of UNIX (operating system). At the heart of GeoFrame software is a shared project database capable of managing tens of thousands of wells, hundreds 3D seismic surveys, and thousands of 2D seismic lines. Advanced workflow techniques—such as AVO interpretation, volume interpretation and GIS—give geoscientists an advantage in prospect generation and field development. Coupled with easy access to the Petrel E&P software platform, interpretation risks are reduced even further [7]. Figure-2 is a window which displays the main application of GeoFrame system. The GeoFrame integrated reservoir characterization system delivers the tools needed to increase productivity and efficiency in seismic interpretation work. With the GeoFrame Geophysics modules, all of the pre-stack and post stack seismic interpretation tools are integrated in one database, allowing to do more in less time.

Base Map Preparation

Processed seismic data are loaded in the GeoFrame workstation of interpretation in SEG-Y format and before starting; special subprograms must be operated to define the required data for loading Figure-3.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. This process includes entering the first and last inline number, the first and last cross line number, also includes definition of the geographic coordinates in UTM coordinates system of study area.



Figure 2-Illustrates the main window interactive interpretation work-station (GeoFrame software system).

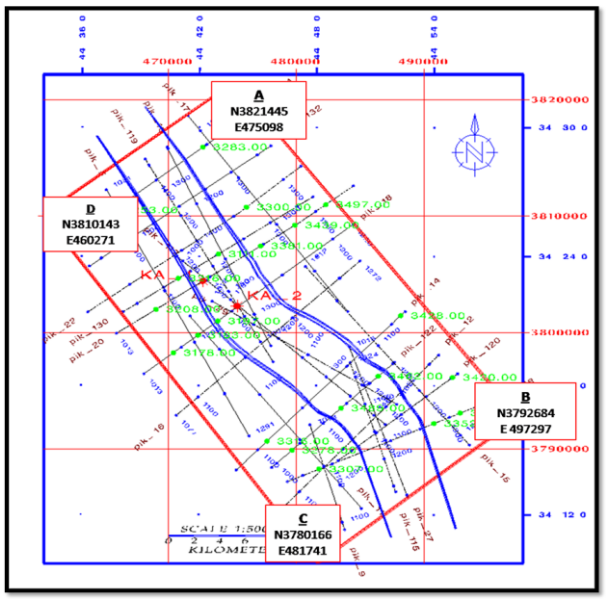
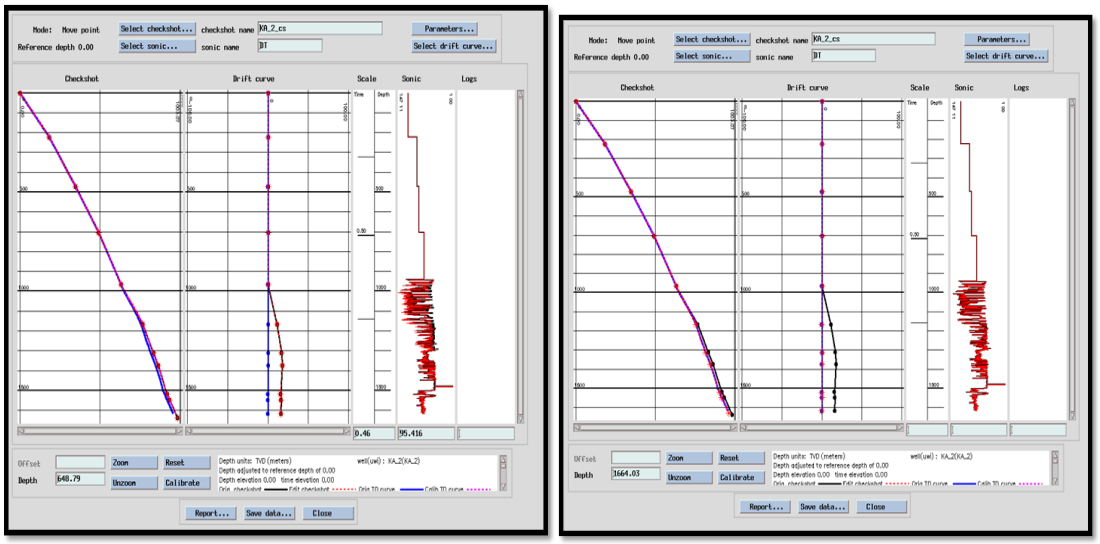


Figure 3- Base map for seismic line of the studied of the area interpreted by Geoframe software.

Check – Shot Survey

The most direct procedure for velocity measurements is to explode charges of dynamite near the surface along side 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. 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. Figure-4 shows a check-shot to Khashim Al-Ahmer well-2.



-A- -B-

Figure 4- Shows the time-depth curves A-before calibration, B-after calibration of the check shot curves for the Khashim Al-Ahmer well-2.

Synthetic Seismogram Generation

The interpretation requires comparison between the TWT reflection in the seismic section and the logs, of the well velocity survey. The synthetic seismogram provides useful manner for definition of the reflectors in the seismic section in term of the separated boundaries between the different lithologies horizons.

(The synthetic seismogram represents sampled record for the assumed seismic wave reflections through series time intervals that have different reflection coefficients) [8,9]. Synthetic seismogram was generated for KA well-2 using GeoFrame software package [10,11] referred to the main steps for generation of the synthetic seismogram. They are:

- Computing the acoustic impedance Z=ρv. Where

ρ=density is measured from density log.

V=seismic velocity

-Computing the reflection coefficients of the vertical incident wave on reflector separating two series of time intervals such as (i) and (i+1) that have values of acoustic impedance (ρi vi) and (ρi+1, vi+1) respectively. According to [10] the reflection coefficients computed as the following [12,13]:

$$Rc_i = \frac{(\rho i+1)(vi+1) - \rho i\ vi}{(\rho i+1)(vi+1) + \rho i\ vi}$$

Where:

$(\rho i\ \rho i+1)$ are the densities at the intervals (i), (i+1).

$(vi\ vi+1)$ the velocities at the intervals (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 Khashim Al-Ahmer well-2 were generated using programs within the IESX (Interpretations Extracts Seismic Xtrem) (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 were transformed from the depth to the time domain using the check shots that were provided and used to make synthetics from the computed reflectivity series convolved with a Ricker wavelet 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.

Figure-5 represents the traverse seismic sections passing through the well locations and synthetic traces of reflectors are displayed. This section shows a good relation and match between seismic traces and synthetic traces.

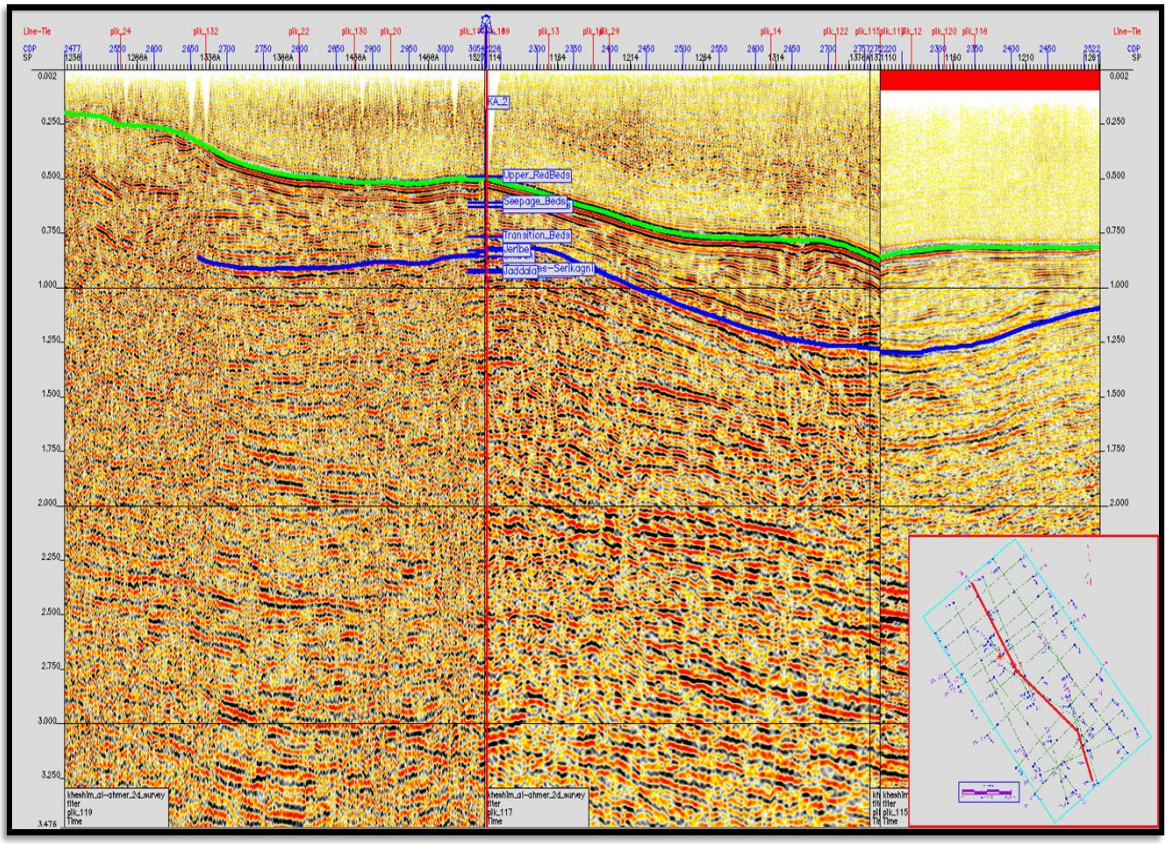


Figure 5-Shows traverse seismic sections illustrate the correlation between lines synthetic trace. (PIK-119,117,115).

Seismic to Well Tie: Synthetic seismograms were generated for Khashim Al-Ahmer well-2 using GeoFrame software package. The sonic and density logs were transformed from the depth to the time domain using the check shots that were provided and used to make synthetic from the computed reflectivity series convolved with a Ricker wavelet of 30 HZ dominant frequency deemed appropriate to match the dominant frequency of reprocessed 2D seismic data.

The Iraqi and American, polarity convention was adopted is states that an increase in acoustic impedance is represented by positive amplitude and is displayed as a black peak. The synthetic seismograms for the Khashim Al-Ahmer well-2. Figure -6 illustrates the strong reflection coefficients that were predicted for the Transition bed and base of the Jeribi and Eupharates-Serikagni levels with weaker reflection coefficients at the Jaddala and Upper red bed (Fatha Formation) levels. These should correspond to events on the seismic data. The embedded wavelet was estimated from the seismic over a window from 500 ms to 2000 ms and achieved an excellent tie;

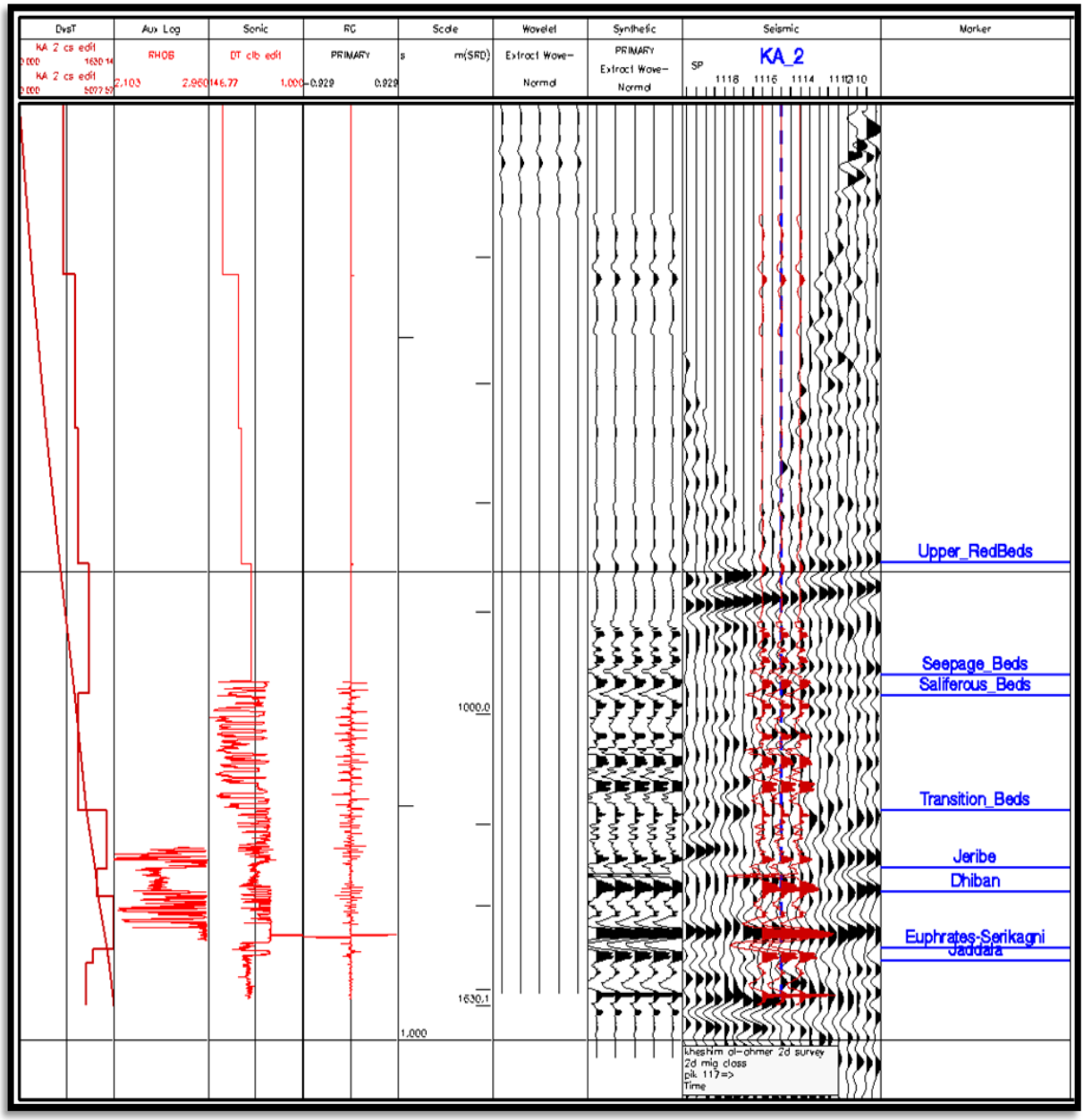


Figure 6- Shows the seismic sections seismogram of Khashim Al-Ahmer well-2

Structural Pictures of The Picked Horizons

After definition of the studied reflectors by using synthetic seismograms in time domain for well KA-2 the reflectors were picked in all area and mapped the Jeribi reflector in time domain, which are later converted to structural maps as a domain using velocity data of this reflector. The datum plane that are used in study is (100) m (amsl) and used for maps.

Time Map of Jeribi Reflector:

This reflector shows the time map of Khashim Al-Ahmer field at this level, a component of the one elongated dome of asymmetrical structure which have(SW) limb is more steeper than the (NE) limb, this dome has been affected by the reverse fault crossing the foot of this structure(NW-SE). These faults extends in parallel to the axis of the field that takes direction of (NW-SE)and displacement of the fault ranged between (400-660) m. and takes form of linear and narrow band, Figure-7 The 3D view of TWT map of Jreibi reflector which was constructed . For clarifying the structural distribution more obviously, Figure-8.

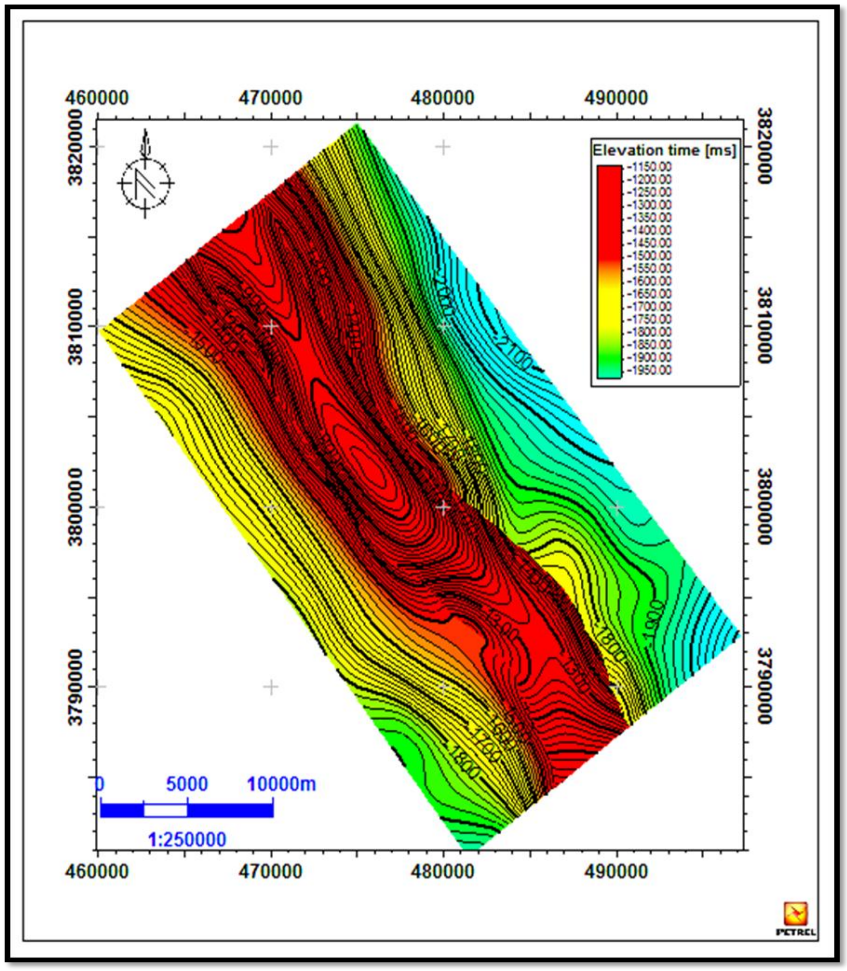


Figure 7-Shows the top of Jeribi TWT map.

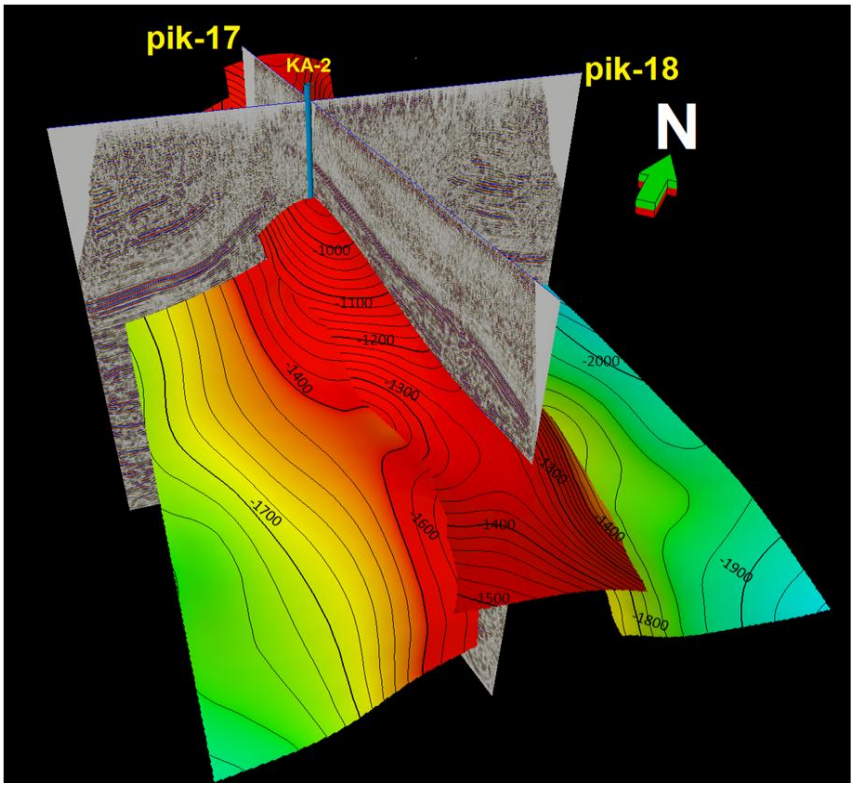


Figure 8 -Shows the 3D view TWT map of the Jeribi Formation and intersection with PIK (Pulkhana – Injana – Khashim –AL-Ahmer) 17&18 with well KA-2.

Velocity Map

-Velocity map of Jeribi reflector:

The velocity map of Jeribi reflector, as shown in Figure-9 was constructed from the calculated stack velocity. The complexities of the subsurface structures below the study area have great effects on the velocity distributions, so the velocity map of Jeribi reflector normally influenced by the major subsurface structure.

The Jeribi velocity values increase in the south east and there is local closure in the south east of the area representing increase in velocity values, and decreasing velocity value in north west shown as closure in the area and this closure situated below well KA-2.The magnitude of velocity values ranges in Jeribi velocity map from (3100 to 3400 m/sec).

The velocity map was drawn by the aid of GeoFrame software with the suitable contour interval of (20) m/sec and selected datum plane was (100) m above sea level.

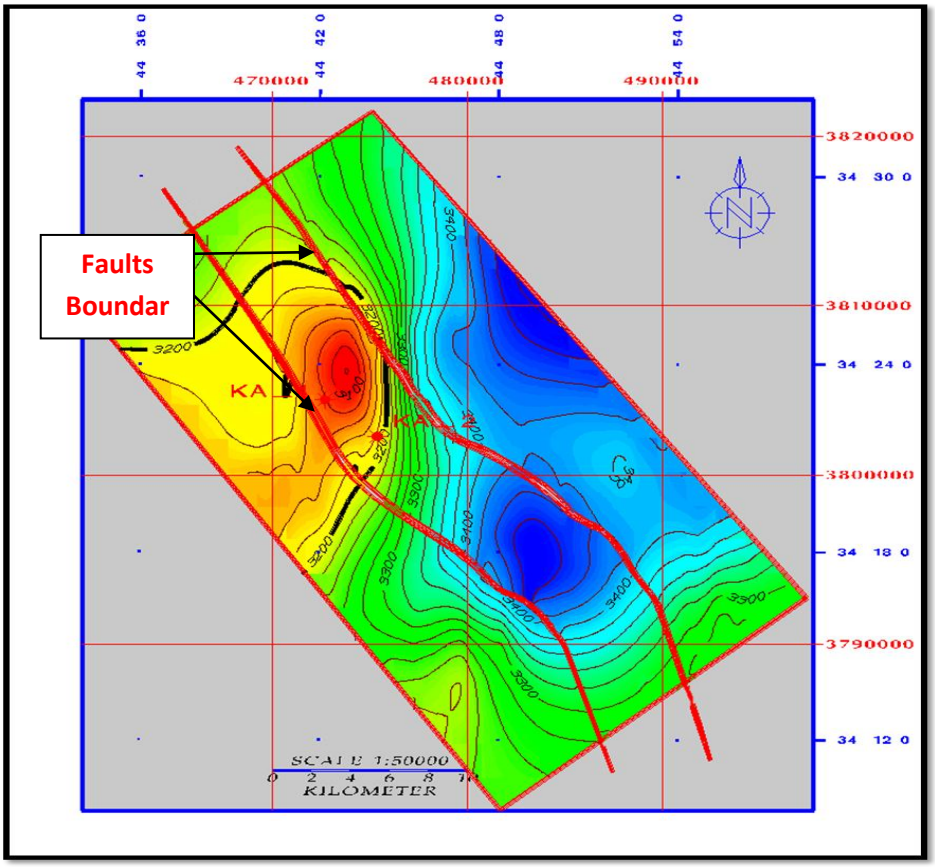


Figure 9-Shows Jeribi stack velocity map.

Depth Map

The depth map construction is considered as an important task in seismic interpretation, because it gives an obvious picture of the subsurface geology and structural phenomena of the area.Constructing depth map in this study performed by the traditional way, which depends on both time map and velocity map. The two-way- time map is superimposed over the average velocity map and at the intersection points of the contour lines one can determine at that point by the multiplying velocity by one way time. , as follows:

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

Then these depth values were transferred to their proper position on base map and contoured for construction the depth map, as well as the faults location is also plotted on the depth map. The depth map accomplished by using petrel software program and using contour interval (50) m and the datum level 100 m above sea level. The depth map to the top of Jeribi Formation was shown in Figure-10.

The 3D view depth map of the top of Jeribi reflector was constructed so as to clarify the structural distribution more obviously, Figure -11 represents 3D depth map of the top of Jeribi reflector.
-Depth map of Jeribi reflector:

Depth map of Jeribi Formation has the same structural picture that appeared in time map where the depth map shown at the level of this formation that Khashim Al-Ahmer field component from one dome asymmetrical slope where the limb of SW is steeper from the limb of NE, which have been affected by this dome by two reverse faults which incised foots field (NE-SW). All of these faults extend parallel to the axis of the field which takes direction (NW-SE) and the field is takes the shape of linear and narrow band.

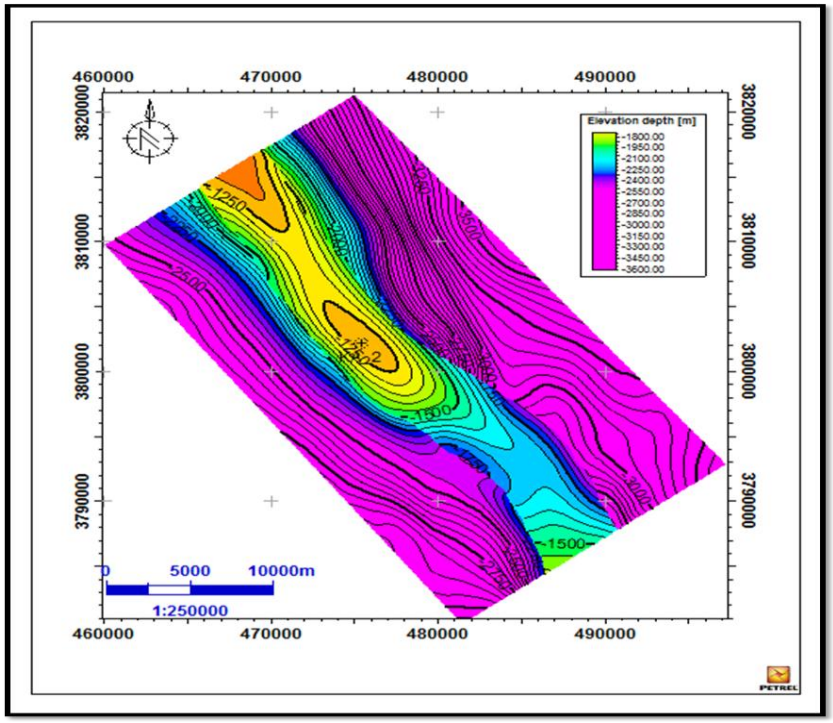


Figure 10- Shows top of Jeribi depth map.

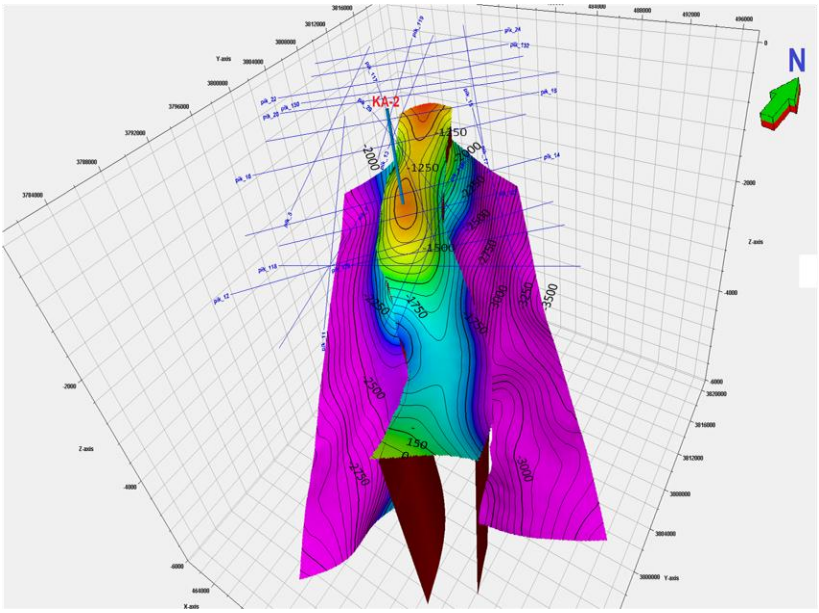


Figure11-Shows the 3D view depth map of Jeribi Formation with two faults.

Seismic attributes

Seismic attributes techniques were applied on Khashim Al-Ahmer 2D seismic volume, which include instantaneous phase. This type of attribute is important to detect the hydrocarbon accumulation on seismic sections[14,15]. Furthermore, the instantaneous phase and variance attributes were used in the faults interpretation.

-Instantaneous phase attribute

Instantaneous frequency is the time derivative of the phase; which represents the mean amplitude of the wavelet and used a differentiating the following.

1-Instantaneous frequency can indicate bed thickness and also lithology parameters.
2-Corresponds to the average frequency (centroid) of the amplitude spectrum of the seismic wavelet.
3-Seismic character correlator.
4- Indicates the edges of low impedance thin beds,
5-Hydrocarbon indicator by low frequency anomaly.
6-Unconsolidated sands due to the oil content of the pores.
7-Fracture zone indicator, appears as lower frequency zones
8-Chaotic reflection zone indicator.
9-Bed thickness indicator. Higher frequencies indicate sharp interfaces or thin shale bedding, lower frequencies indicate sand rich bedding.
10-Sand/Shale ratio indicator.

Figure-12 shows cross line ties of well KA-2. It explains the lateral variations of phase at reservoir reflectors. In general, the frequency color becomes green at well locations as a result of the decrease in frequency values and a brown color when it is away from well locations.

The rocks density reduces due to presence of fluids, thus, the seismic velocity is decreased. Consequently, the green color reflects rocks of low velocity; this indicates hydrocarbon accumulation areas. The brown color refers to rocks of high velocity, which indicate weak probability of hydrocarbon accumulations [4]. Because of the gas field, the seismic attribute is very clear and so as to empathetic fluid.

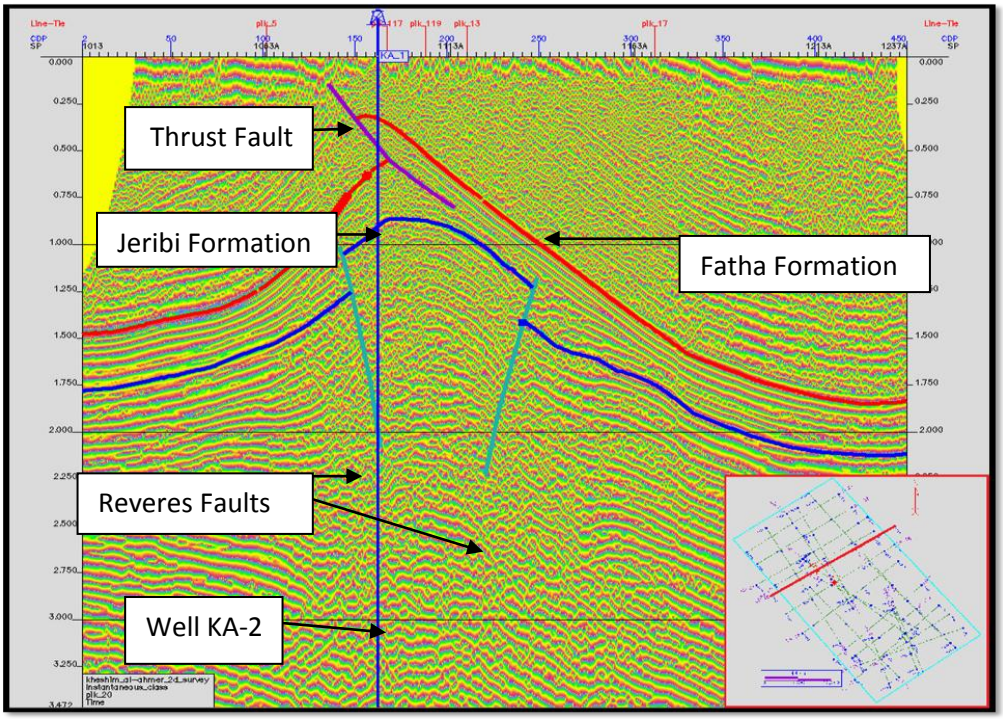


Figure 12-Cross line tie seismic section shows the variation in instantaneous phase of studied reflectors, of well KA-2.

Conclusions

1-The top of the Jeribi Formation was identified and picked at the TWT that range between (0.83-1.21) sec. This is supported also on Khashim Al-Ahmer well-2.

2-Jeribi, Fatha wavelets appeared on synthetic seismograms as peaks but in different intensity, because they have higher density than the above and below the reflector densities.
3-The seismic sections passing through the well locations show good relationship and matching with synthetic traces PIK (115,117,119).

4-Seismic attributes techniques (instantaneous phase) is important to detect the hydrocarbon accumulation on seismic sections.
5- Major faults were picked along study area on instantaneous phase sections, these faults extend in NW-SE trend. They affect on Cretaceous rocks and underlying layers.
6-The time map of jeribi reflector showed existence of several structural features at the time domain, such as closed contour of high and low time values as well as the locations of faults.
7- The velocity maps of studied reflector showed increase of velocity values to the south east and there is a local closure at the north east of the study area and decrease to the north west. The velocity values decrease and give closure situated below well KA-2.The magnitude of velocity values ranges in Jeribi velocity map from (3100 to 3400 m/sec).
8- The depth map of Jeribi Formation is the same as structural picture which appeared in time map where the depth map showed at the level of this formation that Khashim Al-Ahmer field component is asymmetrical dome of SW limb which is steeper than the NE limb.
9- The dome of Khashim Al-Ahmer was affected by two reverse faults which trend (NW-SE).
All of these faults in the study area extend parallel to the main axis of the structure which trend (NW-SE) direction with linear and narrow band.
10- Finally, 3D view depth and seismic time model of the top of Jeribi reflector for Khashim AL-Ahmer field shows alignment toward major fault and anticline with seismic line and intersection of PIK-17 and 18 with the well KA-2.

References

1. Sharma, P.V.**1986**. *Geophysical methods in geology*, second edition, Elsevier science publishing co., Amsterdam,442 p.
2. Gabriel Al varez.**2002**.*Toward subsurface illumination –based on seismic survey design*, Stanford Exploration project Report 111.,PP.307-325.
3. Dobrin, M.**1976**. *Introduction to Geophysical Prospecting*, 3rd ed., McGraw Hill. Int. co., International Student Edition 386 p.
4. Yilmaz, **1987**. *Seismic data Analysis, processing, Inversion and Interpretation of seismic data*, SEG, V.1, Tulsa, Oklahoma, 836 p.
5. Cordsen ,A.,Galbraith,M., and Peirce, J. **2000**. *planning land 3-D seismic surveys.,Geophysical development series*.,no-9.Society of Exploration Geophysicists.
6. Al-Ameri, T.K., Pitman, J., Naser, M.E., Zumberge, J., and Al-Haydari, H.A. **2010**. *Programed oil generation of the Zubair Formation, Southern Iraq oil fields*. Arab Journ.Geosc.P.4.
7. Schlumberger Information Solution. **2004**. *GeoFrame Fundamentals*, Training and Exercise Guide, Version 4.0.1, 102p.
8. McQuillin, r., Bacon, M, and Barclay, W. **1984**. *An Introduction to Seismic Interpretation, Graham and Trotman*, 287 p.
9. Lrgch, T., and Sacchi, M. **2005**. *Information –based Inversion and processing with applications*, hand book of Geophysical Exploration Vol.36.Elsevier publishing company.437 p.
10. Lindseth, R. **1979**. *Synthetic sonic logs – a process for stratigraphic interpretation*: Geophysics, 44, 3-26.
11. Veeken, P.C.H. **2007**. *Seismic stratigraphy, Basin analysis and reservoir characterization* ,hand book of Geophysical Exploration Vol.37.Elsevier publishing company., 523p.
12. Gadallah, M.,R., and Fisher,R.**2009**, (*Exploration Geophysics*),Verlag Berlin Heidlberg.274p.
13. Galbraith.M. **2004**. Design of land 3-D surveys., search and Discovery article no.40139.
14. Donias, M.,David,C.,Berthomieu,Y.,Lavialle,O.,Guillon,S.,and Keskes,N. **2007**. (*New fault attribute based on robust directional scheme*) Geophysics Vol.72,No4.PP(39-46).
15. Aktepe, S., Marfurt, K.J.,and Perez,R. **2008**. *Attribute expperession of basement faulting –time versus depth migration* ,The Leading Edage ,PP.(360-367).