Seismic Structural –Stratigraphic Study of Dhufria Area (Mid -Iraq) Using (3D) Techniques

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Abstract
This study deals with the seismic reflection interpretation of lower Cretaceous Formations in Dhufria area, including structural and stratigraphic techniques. In the interpretation process, the 3-D seismic data volume and well logs have been used. Based on well logs and synthetic traces two horizons were identified and picked which are the top and bottom of Zubair Formation. These horizons were followed over all the area in order to obtain structural setting as well as studying Kirkuk group Formation of Tertiary age which represents highstand progradational seismic facies**.**

Keywords: seismic structural interpretation, seismic stratigraphy, progradation, highstand.

دراسة زلزالية تركيبية. طباقية لمنطقة الظفرية باستخدام تقنية الابعاد الثلاثة

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الخلاصة:
ان هذاالبحث يتعلق بالتفاسير الزلزالية الانعكاسية (تركيبية وطباقية) لتكاوين الكريتاسي لمنطقة الظفرية الواقعة في وسط العراق ضمن محافظة واسط اذ تم التفسيرباستخدام المعلومات الزلزالية بثلاثةابعاد وكذلك مجسات الابار. لقد تم تعريف عاكسي اعلى واسفل الزبير من مجسات الابار والاثار المصنعةومن ثم متابعتهماعلى مستوى المنطقة وذلك لمعرفةالوضع التركيبي لمنطقة الدراسةوكذلك اجراء دراسة طباقية لتكاوين مجموعة كركوك والتي مثلت سحنات زلزالية تقدمية.

Introduction:

The study area of a (366.6) sq.km is located in the middle part of Iraq within the administrative boundaries of Wassit province where the city of Kut is situated in the center of the region. figure 1.Dhufria field is located near the northeastern side of Al-Ahdab field of about 28 km far from it. Both of these fields are located in the flanc basin of Mesopotamia near the Arabian platform toward the axis NW-SE.They are located within the unstable shelf of Mesopotamia zone within Tigris subzone and Tikrit-Amara subzone [1] According to Iraq geological map, issued by the State Establishment of Geological Survey and Mining .[2], the surface of the study area is flat land with some simple uplands which range in altitude from (11-24) m. ASL. The area covers current Mesopotamian deposits, which characterized by the agricultural regions where it has many orchards on both sides of Tigris river, irrigation projects, marshes and swamps as well as the presence of residential civilian areas.

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Dhufria area is covered by recent and Pleistocene sediments represented by depressions internal and alluvial fan deposits. Generally, the lithology of these formations consist of clay and sand (Alluvium) deposits.[3]

The generalized stratigraphic column of the Dhufria area which is a Sequence of sedimentary rocks of about 10 Km thickness. It consists mostly of calcareous rocks with some sequences of sandstone and shale. [3]. Wells data shows clearly the most known geologic Formations of the region, besides the presence of good amounts of oil within the Cretaceous Formations .Since the drilling depth is not too deep, our knowledge about the geologic Formations below cretaceous rocks still little.

From structural point of view, it consists of two domes one at the north and the other at the south. The northern dome, is at far distance of about 13 km to the north of the city of Kut, whereas the south-eastern dome far distance is of about 12 km north-east of the city of Kut.In the southern dome, only two wells were drilled which are Dhufria (1and2), meanwhile there is no drilling of wells achieved in the northern dome.

Moreover, the drilling of Dhufria wells is performed according to the available information of 2D-seismic data. Recently, 3D-seismic survey was accomplished, so it's very important to make a new interpretation which might give a new image of the structural and stratigraphic features.[4].The data were processed by the Processing Center of Oil Exploration company (OEC) using (focus) software program while the interpretations is made up using Geoframe system (IESX).

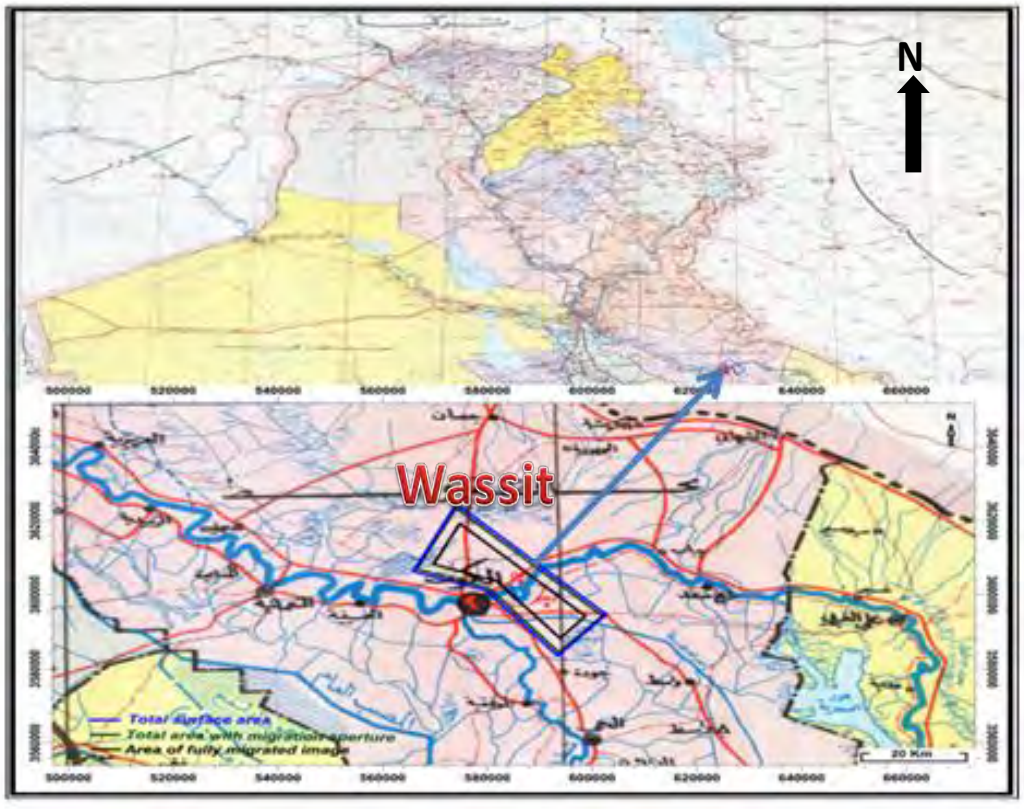

Figure 1- Location map of the study area. After the State Establishment of Geological Survey and mining in 1990.

Acquisition and processing of data

The 3D field survey of the Dhufria area was used specific design that ensures easy of execution with good quality of recorded data through the determination of the suitable parameters. These parameters are recording requirements, spread patterns, source points, CDP- bin volume, offset, migration aperture and coverage degree.

The main objectives of the survey are:

1- To know the structural picture of the Formations and reservoirs in the field.

2- Make a stratigraphic analysis of the sequences in the field.

For this purpose, some seismic attributes of the picked events in addition to the routine approaches were used in 2D survey.

The seismic data were processed in the processing center of oil Exploration Company. The primary objective is to enhance the quality of the recorded data with special regard to the 3Ddata through noise attenuation and enhancing of the recorded signal .This leads to improve reflection continuity and enhance our ability to compute seismic attributes and then facilitate the structural and stratigraphic seismic interpretation.

Basically, the main steps in the processing include editing and muting, gain recovery, static correction, velocity analyses ,dynamic correction, deconvolution, and migration…etc. An additional processing steps are used in analyzing the 3D data for the aim of obtaining a 3D cube of data of the whole area.

3D seismic volume of the Dhufria survey didn't cover all the study area because both of the natural and industrial obstruction limited the acquisition of data to 366.66 Km^2 while the initial planned program include 557.26 Km^2.Additionally, 1835 contiguous lines of data are missing from the volume, resulting gap in the data from inline 40150 to inline 41985 .

Two exploration wells (Dh-1 and Dh-2) were drilled in the field, whereas, sonic logs and density logs information were available for all wells with some missing intervals of gammray logs, also check shot surveys were limited for wells Dh-1, 2.

Interpretation of data:

The interactive workstations available in OEC apply a new software interpretation system (Geoframe) which used to perform the seismic interpretation. The workstation is an electronic computer uses (Red hat) as operating system, the later is a copy of UNIX (operating system). Geoframe software includes several specialized programs operating with this interactive workstation such as geology, seismic, reservoir engineering and Petrophysics programs [5].

Many previous studies were performed by OEC, which deals with the interpretation and re-interpretation of the 2D seismic data of Dhufria area.[6]

Using the seismic programs of Geoframe software, we have interpreted a (3-D) seismic data available in Oil Exploration Company for surveys carried out in Dhufria field for developing the field through the following approaches:

1- Structural pattern evaluation.

2- Seismic Stratigraphic study which includes analyzing of seismic sequences and facies changes between the Jeribe and Dammam-Jaddala Formations (Kirkuk group) , and other stratigraphic in the area.

3- Application of seismic attributes like amplitude, frequency that disposed within the new software interpretation system (GeoFrame), to predict the hydrocarbon accumulations that may present in Zubair Formation.

1- Structural Interpretation Works

A- Base map preparation

Abase map of the study area is constructed using the processed seismic data which was loaded in the interactive workstation of interpretation in SEG-Y format. Two types of perpendicular lines are assigned which are termed inline and cross lines.

The numbering of inline profiles is ranged between (39950) and (48258) with a constant increasing in numbering of (5) between each two successive profiles. This means that there are 1661-inline profiles. Also, the numbering of cross line profiles is ranged between (9930) and (13835) figure 2 shows the base map of the study area.

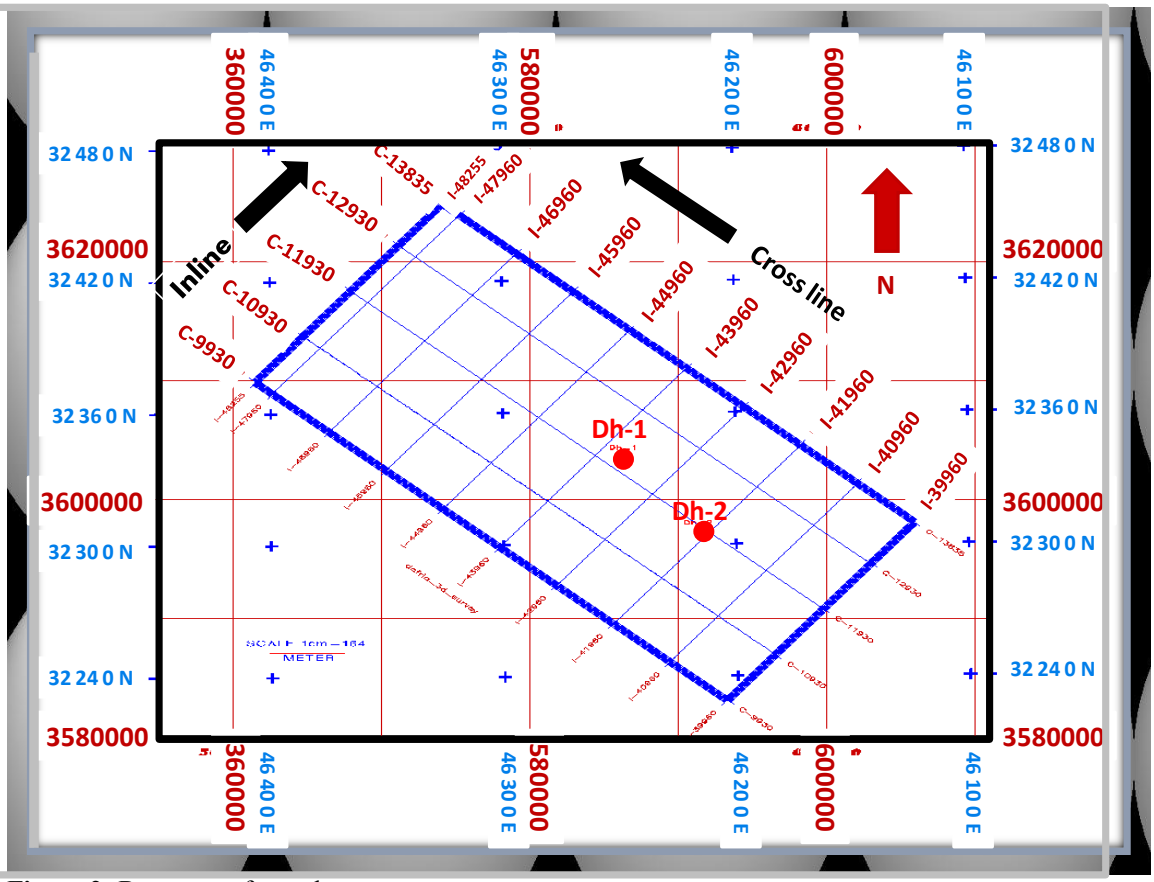

Figure 2- Base map of a study area.

B- Generation of Synthetic seismograms and identification of reflectors

[7] Mentioned the main steps for generation of the synthetic seismogram. These are:

1-computing the acoustic impedance, Z ($Z = \rho \times v$) Where:

$\boldsymbol{v}$: is seismic velocity, ρ: is density measured from log.

2-computing the reflection coefficients(**R**) of the vertical incident wave on reflector separating two series time intervals such (i) and (i+1) that have values of acoustic impedance (ρi, vi) and (ρi+1, vi+1) respectively. According to [7] we can compute the reflection coefficients as the following:

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

Where:

(ρ *i*, ρ*i*+1) are consequently the bulk densities of the intervals**(*i*), (*i*+1)**

(*vi*,*vi*+1) are consequently the seismic velocities at the intervals **(*i*), (*i*+1)**

3- Using sonic log data, a convolution process between the reflection coefficients and experimentally selected wavelet is made up to obtain the synthetic seismogram. Moreover, we have used the well velocity survey of the drilled wells, which represents the direct method to obtain the geological velocity (average velocity) of geological strata.

Synthetic seismograms were generated for two wells (Dh-1 and 2) using GeoFrame software package figure 3. Examination of these displays, the logs reveals the lowering of density, velocity and then the acoustic impedance within Zubair Formation relative to the overlain Formation. A good reflection was noticed which corresponds to the top and bottom.

C- Structural images of the picked horizons

The available geologic data and the synthetic seismogram of the wells (Dh-1 and 2) are used to tie with the seismic data. This leads to recognize and following two reflectors over all the field, and then mapping in time domain. These two reflectors are top and bottom of Zubair Formation. Later these are converted to depth domain using the available velocity data. Examinations of these maps are described below where many structural anomalies are shown.

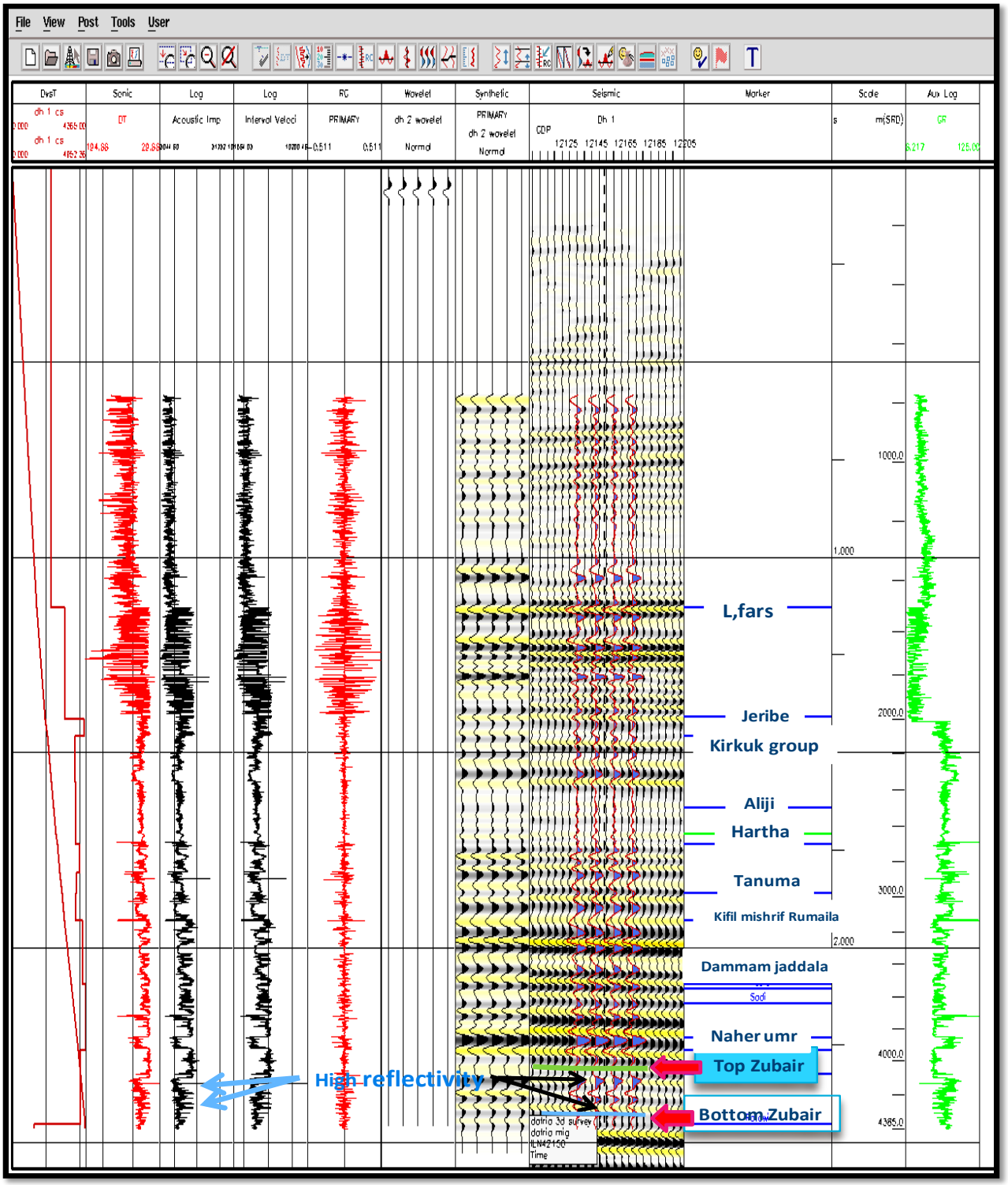

Figure 3- Synthetic seismograms of the well Dh-1.

1- Time maps

Top of Zubair time map

As shown in figure 4, the general trend of the time contour map is in the NW-SE direction. The values range between 2300 and 2460 msec where the high values are observed in the (NE-E) parts of the area where as the low values are shown NE-E. One anomaly is observed in the southern part

around the well Dh-2 and extended to the well Dh-1, where a contour line of 2310 msec pass. From structural point of view, this represents the highest point on the map.

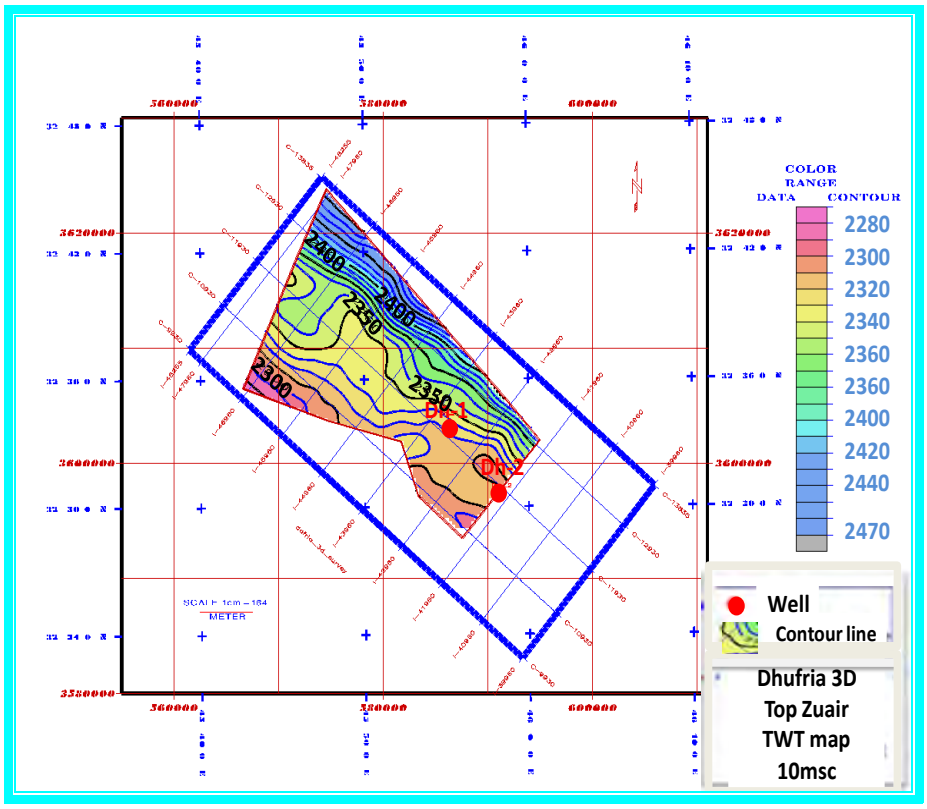

Figure 4- Top of Zubair two-way time map.

Bottom of Zubair time map

The two –way time map of Zubair reflector shows a nose structural feature having a SE-NW trend and dipping steeply to the NE. Anomaly of 2320 msec is noted around the well Dh-2 which extend to well Dh-1 where a contour line of 2310 msec pass through it. The structural schema may be clarified if the survey is extended to the west and south west of the area figure 5.

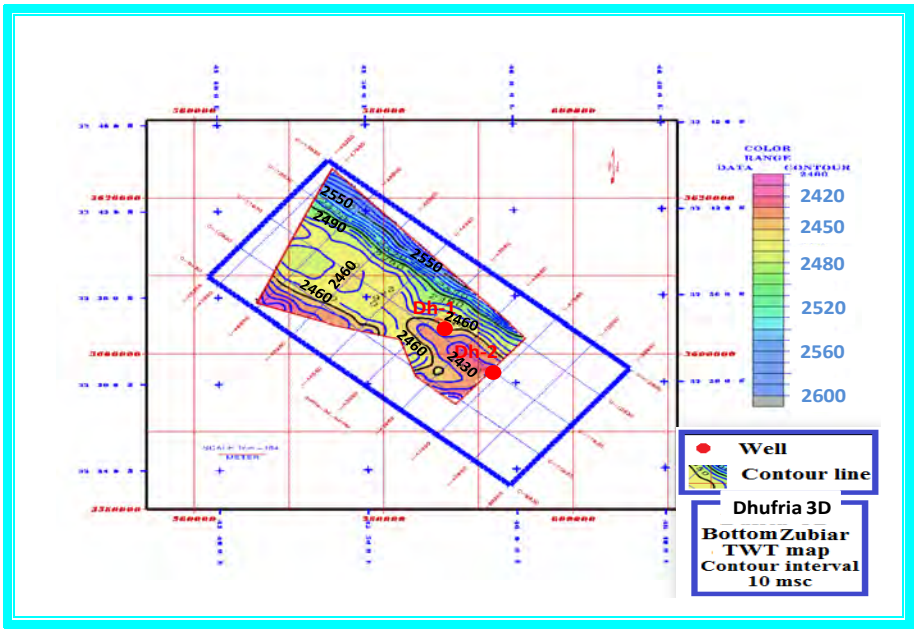

Figure 5- Bottom of Zubair two-way time map.

Velocity maps

Basically the transformation of seismic data from time domain to depth domain is carried by the aids of seismic velocity. The average velocity is the suitable one, which is used for this purpose. The velocity computed from well velocity survey is considered as the more accurate velocity type used in seismic prospecting.

In the present study we have used wells velocity data deduced from the wells Dh-1andDh-2 in addition to that of Ahdab wells (Ad-1,Ad-2,Ad-3,Ad-4,Ad-5andAd-6) located at the south west, and Badra well(Bd-5) at the east. These data are introduced to the seismic program of the Geoframe software to obtain the average velocity maps of the two studied reflectors and then the interval velocity map for the interval limited between them were constructed as shown in figure-6*.

Average velocity contour map of top of Zubair is presented in figure 6. It shows a general increasing from the SW to NE direction where the average velocity values ranges from 3480 to 3520 m/s.
This increasing is linked to the increasing of the depth of the studied reflector in the NE direction.
*one map is only permitted for publication by O.E.C

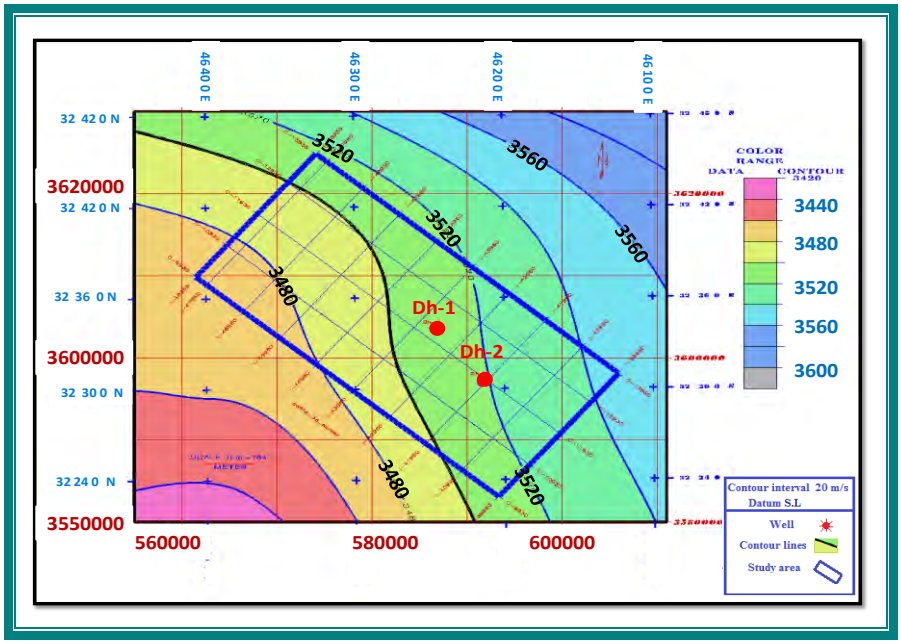

Figure 6- Oil member (top Zubair) velocity map.

Depth maps

Two depth maps are constructed to the top and bottom of Zubair Formation. The two average velocity maps were used in the conversion process of data from time to depth maps. This is carried out by a simple multiplication of the isochrons maps by their corresponding average velocity maps.

Top of Zubair depth Map

Examination of figure 7 reveals a structural feature having a general trend in the SE-NW direction.The minimum depth value of (3860) m is noticed at the W and gradually increase toward the E and NE till middle part of the structure.

Around well Dh-2 at the SE a closure of (4060) m occurs and decreases towards the plunge.
To the E and NE steeping of regional dipping is higher and deeping increases where a value of (4300) m is observed.

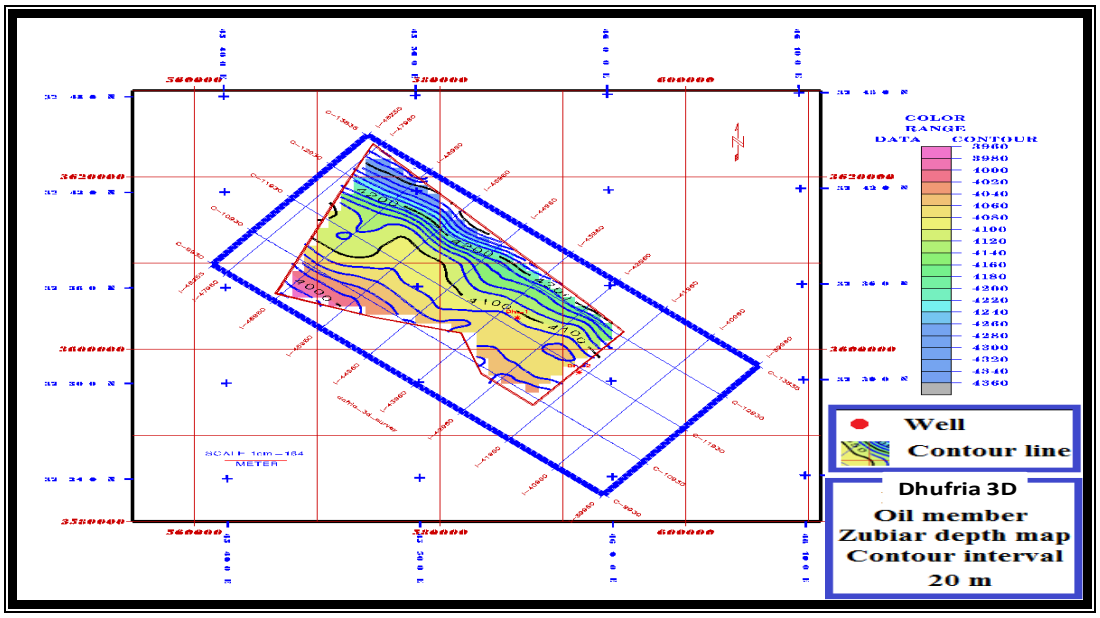

Figure 7- Top of Zubair depth map.

Bottom of Zubair depth map:

As shown in figure 8 the structural feature is similar to that of the top of Zubair.

A structural closure of (4380) m occurs at the SE of the structure around the wells Dh-1 and Dh-2 and some rises are shown to the NE of these wells.

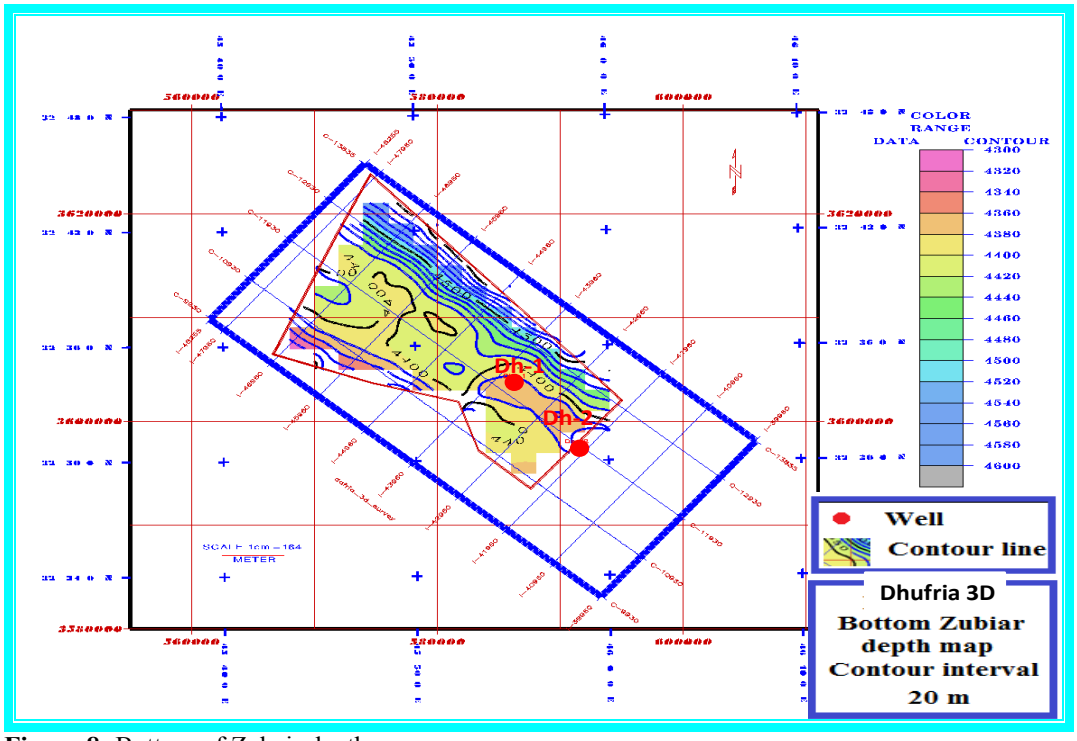

Figure 8- Bottom of Zubair depth map.

Stratigraphic Interpretation Works

Basically, seismic stratigraphay can add an important geological information and enhance the understanding of the depositional environments ,which may help in the understanding the origin, accumulation, and trapping mechanisms of the hydrocarbon deposits.[8]. For this reason, this interpretation technique in the actual study is used which includes the following:

Identification and picking of seismic sequences

Based on seismic character and reflections patterns two distinct intervals were observed and distinguished in the preview Dhufria 3-D seismic volume figure 9.These two intervals which are recognized and picked in the traverse lines, i.e. The inlines, cross lines and arbitrary lines, are the following:

1- An upper interval (or Kirkuk group) of semi-parallel slightly diverging reflections comprising the (Jeribe –Dammam Jaddala) Formations which represent the first sequence.

2- A basal interval of parallel folding reflections comprising the top Zubair to bottom Zubair Formations which represent the second sequence. This sequence separates middle cretaceous from lower cretaceous sequences figure 10.

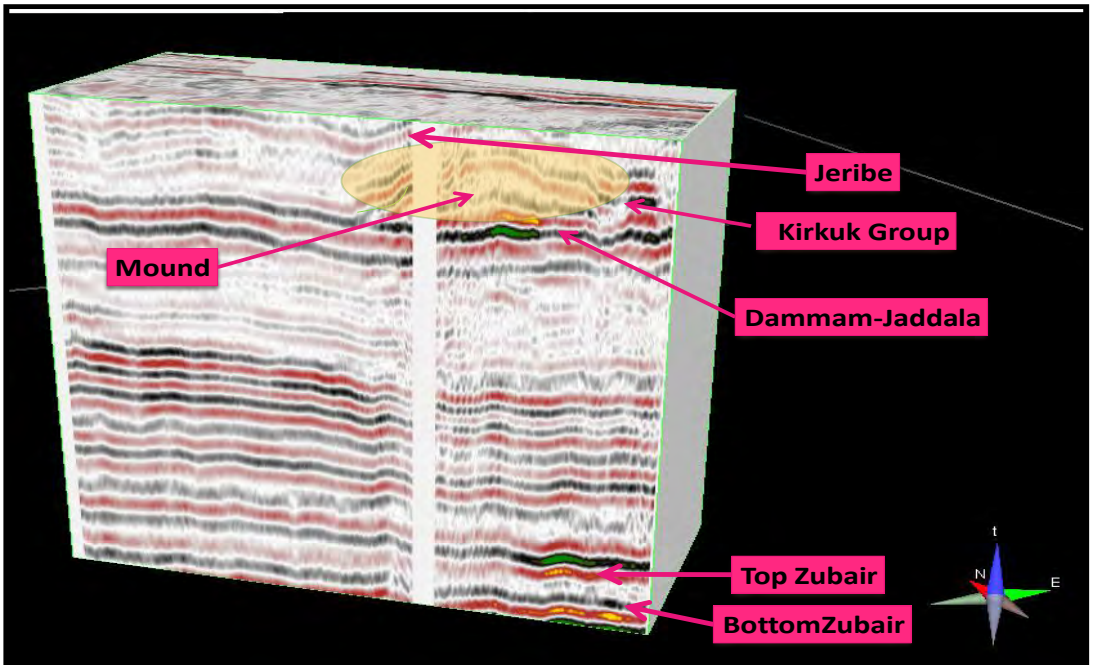

Figure 9- Preview Dhufria 3-D seismic volume.

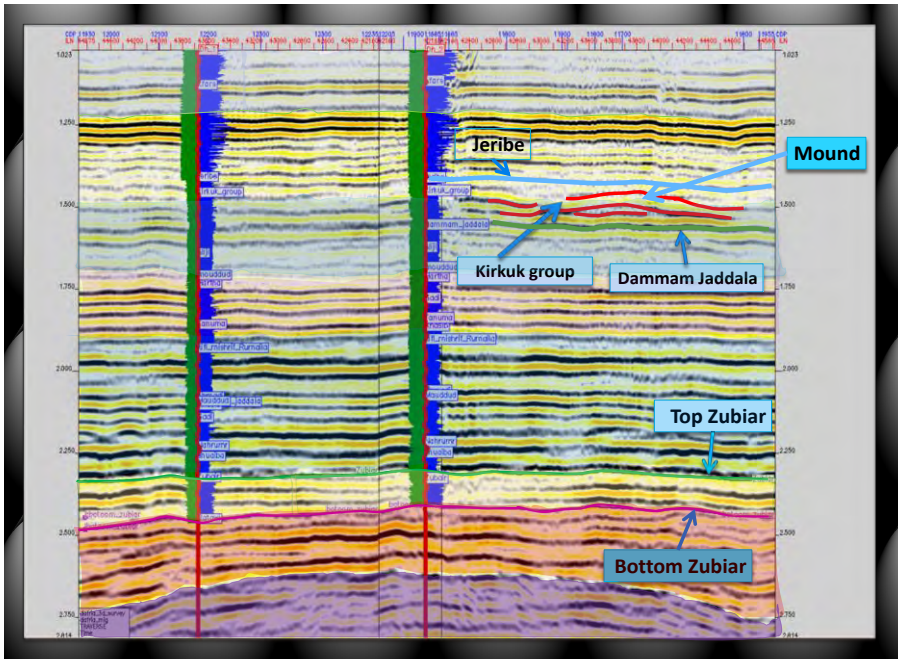

Figure 10- Composite seismic section passing through the drilled wells and showing the studied interval of Dhufria area.

Seismic Reflection Configuration

Basically, configuration of reflections provides the best guide to interpret carbonate seismic facies. For the interval (Kirkuk group), as shown in figure -10, the seismic reflection configuration is a prgradational type. The reflectors are characterized by moderate to high amplitude and continuity.

This configuration indicates sediments that have deposited within the unstable shelf. These deposits consist clastics and carbonates like shale and limestone while sandstone deposits are rare. The lithologic data of the two wells approve that the interval consists mainly of tight limestone and sandstone, which is an indicator of shallow water environment.

Two types of progradation configuration are observed which are:

1- Oblique progradation configuration, which are observed in inline seismic sections figure 11

2- Mound observed in cross line seismic section.

The occurrence of downlap reflection termination within the oblique configuration is normally associated with the high depositional energy.

Mound seismic configuration indicates a strata forming an elevation or prominence rising above the general level of the strata.

For the interval Zubair as shown in figure10, the seismic reflections are characterized by moderate to high amplitude and continuity. Also, these reflectors are generally parallel to sub-parallel and uniform over the study area. These characters may give an indication of the tectonically stable depositional setting.

Zubair facies are depositional on delta platform consisting of shallow-water, high energy marine (delta front) sandstone, shale delta plane, channel-fill sandstones and wide spread coal or lignite beds. These materials later on may be the source rocks, which have generated the oil in the Formation. Moreover, gamma ray logs of the wells Dh-1 and Dh-2 approved the increasing of shale ratio, which is the oil source.

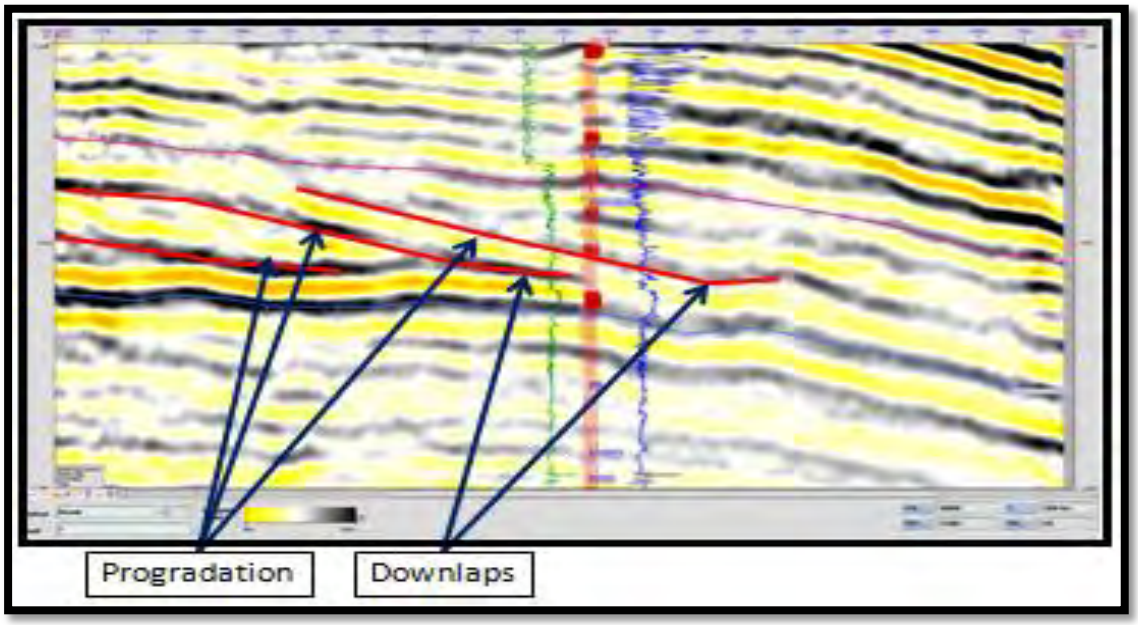

Figure 11- Clinoforms progradding pattern in Kirkuk group.

Conclusions and Recommendations

According the results given in this study, and by using advanced 3D digital processing and interpretation techniques, the following conclusions may be drawn:

1. Two depth maps represent the top and bottom of oil bearing Zubair Formation are constructed which lead to illustrate the structural configuration of Dhfria area. In general the structure which has a general trend in the SE-NW direction, while it shows a regional dipping toward the EandNE. Moreover, depth maps reveal that the minimum depth values are noticed at the west and gradually increase toward the east and northeast until the middle part of the axis where structural anomalies and rises are observed. Going further to the east and northeast directions, the depth increases which

reflects the transition from the continental slope towards the basin. This is confirmed by the behavior of the average velocity where it increases to confirm by the behavior of the average velocity where it increases to the NE.

2. Examination of the time and depth maps of top and bottom of Zubair Formation shows an incomplete structural image for the zone located to the south and south east of the wells Dh-1and Dh-2.Thus, it is suggested that an additional survey is necessary to know in detail the extension of the anomalies surrounding the wells.

3. Kirkuk group shows oblique progradational configuration type. This indicates that sediments have been deposited within unstable shelf margin. The occurrence of downlap reflection termination within the oblique configuration is closely connected to the high depositional energy situation.

4. Seismic facies of Kirkuk group shows a reflection configuration of mound type it is defined on grid of seismic sections.

5. For future work the use of seismic attributes displays is necessary because they are considered as an additional powerful tool to clarify the stratigraphic feature and hydrocarbon accumulations.

References

1. Jassim, Saad Z. and Goff, Jeremy C., **2006** *Geology of Iraq*, Czech Republic, ISBN 80-7028-287-8.
2. State Establishment of Geological Survey and Mining (GEOSURV), **1990**, Geological Map of Iraq, printed and published by the GEOSURV, Baghdad, Iraq. (Arabic ref.).
3. Al Joboury S.T., **2000**, Final well report of the Manali-Dufria area, Oil Exploration Company documents (O.E.C. doc.), 24p. (Arabic ref.).
4. Gerhardstein, A. C. and Brown, A. R., **1984**, *Interactive interpretation of seismic data, Geophysics*, V.49, No. 4, p. 353-363.
5. Schlumberger Information Solution, **2004**, GeoFrame Fundamentals, Training and Exercise Guide, Version 4.0.1, 102p.
6. Shamel J., **2001**, Re-interpretation of the seismic survey of the Manali-Dufria area, Oil Exploration Company documents (O.E.C. doc.), 22p. (Arabic ref.).
7. Lindseth, R., **1979**, Synthetic sonic logs – a process for stratigraphic interpretation: *Geophysics*, 44, 3-26.
8. Mamdouh R. Gadallah, Ray L. Fisher **2004**, *Applied seismology* , ISBN 1-59370-022-9,Tulsa Oklahoma ,473 p.
9. Al-Sadi, H., **1982**, Seismic Exploration: Technique and Processing, BirKhauser Verlag Basel, 215 p.
10. Dobrin, M., **1960**, *Introduction to Geophysical Prospecting*, 2nd ed., McGraw Hill. Int. co., International Student Edition 446 p.
11. Emery, D., Myers, K. J., *Sequence Stratigraphy*, **1996**, published by Blackwell Science Ltd., p. 297.
12. McQuillin, r., Bacon, M, and Barclay, W., **1984**, *An Introduction to Seismic Interpretation*, Graham and Trotman, 287 p.
13. Sheriff, R.E., and I.P. Geldart, **1983**, *Data processing and interpretation*, Cambridge Univ. press, *Cambridge, Exploration seismology*. Vol. 2.
14. Sheriff, R. E., **1984**, *Encyclopaedic Dictionary of Exploration Geophysics* (2nd ed.), SEG, Tulsa, 323 p.
15. Taner, M.T., Sheriff R.E., **1977**, *Application of amplitude*, frequency and other attributes to stratigraphic and hydrocarbon exploration. AAPG Memoir 26, p.(301-327)
16. Vail, P. R., R. G. Todd,and J. B. Sangree, **1977,** Seismic Stratigraphy and Global Changes of Sea Level: Part 5. Chronostratigraphic Significance of Seismic Reflections: Section 2. Application of Seismic Reflection Configuration to Stratigraphic Interpretation Memoir 26, Pages 99 – 116.
17. Vail, P.R.., **1987,**Sequence Stratigraphay interpretation using sequence Stratigraphay:in Bally, A.W., Ed. *,Atlas of seismic stratigraphy*,vol.1:*AAPG Studies in geology* 27,1-14.