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3D Seismic Structural Study of the Lower Cretaceous Sequence in Kifl oil field_ central Iraq

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Abstract

This research focused up on the Seismic reflection study of a 268.7 km^2 area located in the central of Iraq within the Karbala province (Kifl area). The seismic data were reprocessed by Anadarko Petroleum Corporation and its partners Dome International and Vitol with OEC in 2005, the result of processing works has improved the quality of seismic sections in most of the study area. The study area was interpreted by using 3-D seismic data from the Oil Exploration Company. By studying the seismic sections and applying seismic attributes (instantaneous phase) Faults were picked across 3D seismic volume of the studied reflectors. The study area affected by a major fault and minor normal faults, Two fault system has been observed in the study area; the major normal fault of (NW-SE) trending and minor normal faults of (NE-SW) trending, with a small displacement are influencing the studied reflectors (NahrUmr, Shuaiba, Zubair and Ratawi reflectors). Time, velocity and depth maps are prepared depending on the structural interpretation of the picked reflectors, The structural interpretation of these reflectors shows a structural anticline (Asymmetrical anticline) extending in NW-SE trend and plunges to the southeast with a dip angle about 5 degrees. and the general dip towards the east.

Keywords: Kifl oil field, 3D seismic of Kifl, structural anticline.

دراسة تركيبية زلزالية ثلاثية الابعاد لتتابع الطباشيري الاسفل في حقل الكفل النفطي_ وسط العراق

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الخلاصة

يمثل هذا البحث دراسة زلزالية تركيبية باستخدام طريقة المسح الزلزالي الانعكاسي بالابعاد الثلاثة لمنطقة ذات مساحة 268.7 كم2 واقعه في وسط العراق ضمن محافظة كربلاء (منطقة الكفل). تمت اعادة معالجة المعلومات الزلزالية لمنطقة الدراسة من قبل شركة انداركو الكندية وشركة الاستكشافات النفطية وذلك في سنة 2005، ادت اعمال المعالجة الى تحسين نوعية المقاطع الزلزالية في اغلب منطقة الدراسة. وتم تفسير منطقة الدراسة بأستخدام المعلومات الزلزالية ثلاثية الأبعاد المتوفرة في شركة الاستكشافات النفطية. تم التقاط الصدوع المؤثرة على العواكس الملتقطة (نهر عمر ،شعيبة ، زبير، رطاوي) وفسرت باستخدام تطبيقات الملامح الزلزالية (مقاطع الطور الاني) التي بينت تأثيرصدع رئيسي اعتيادي يمتد باتجاه شمال غرب– جنوب شرق وصدوع ثانوية اعتيادية تمتد باتجاه شمال شرق– جنوب غرب ذات امتدادات صغيره حيث تم التقاطها على عموم منطقة الدراسة. أعدت الخرائط الزمنية والسرعية والعمقية بالاعتماد على التفاسير التركيبية للعواكس

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المدروسة التي اظهرت الصورة التركيبية لمنطقة الدراسة وجود التحدب التركيبي غير متماثل الذي يمتد باتجاه شمال غرب– جنوب شرق ويغطس باتجاه جنوب شرق بمقدار خمس درجات كما اظهرت الصورة التركيبية الميل العام للتكوينات باتجاه الشرق.

Introduction

In view of the economic importance the lower Cretaceous Sequence, which is considered as an important stratigraphic unit that contains hydrocarbon accumulation in central and southern part of Iraq, This research comes as update to many of the studies carried out by a number of researchers, where it focuses on structure and stratigraphy analysis of the lower Cretaceous sequence, to improve and development the Kifl oil field by giving more accurate subsurface geological image.

Seismic reflections surveying is the most widely used geophysical techniques, and has been since 1930s. Its predominant applications are hydrocarbon exploration and research into the crustal structure with depth of penetration of many kilometers [1]. The basic idea is simple, low-frequency sound waves are generated at the subsurface by using high-energy source. They travel down through the earth, and reflected back from the tops and bases of layers of rock where there is a change in the properties of rocks [2], the reflected sound travels back to the surface and recorded by receivers microphones [3].

The study area

The Kifl oil field is located in south of Baghdad to the south -west of Hilla city at a distance approximately (35km), its area of 268.7 km^2. The study area lies in the middle of Iraq between Najaf and Karbala governorates (west of the Euphrates River) as shown in the Figure -1 It limits from east the Euphrates River to the north Karbala city and to the north-west of Razaza lakes.

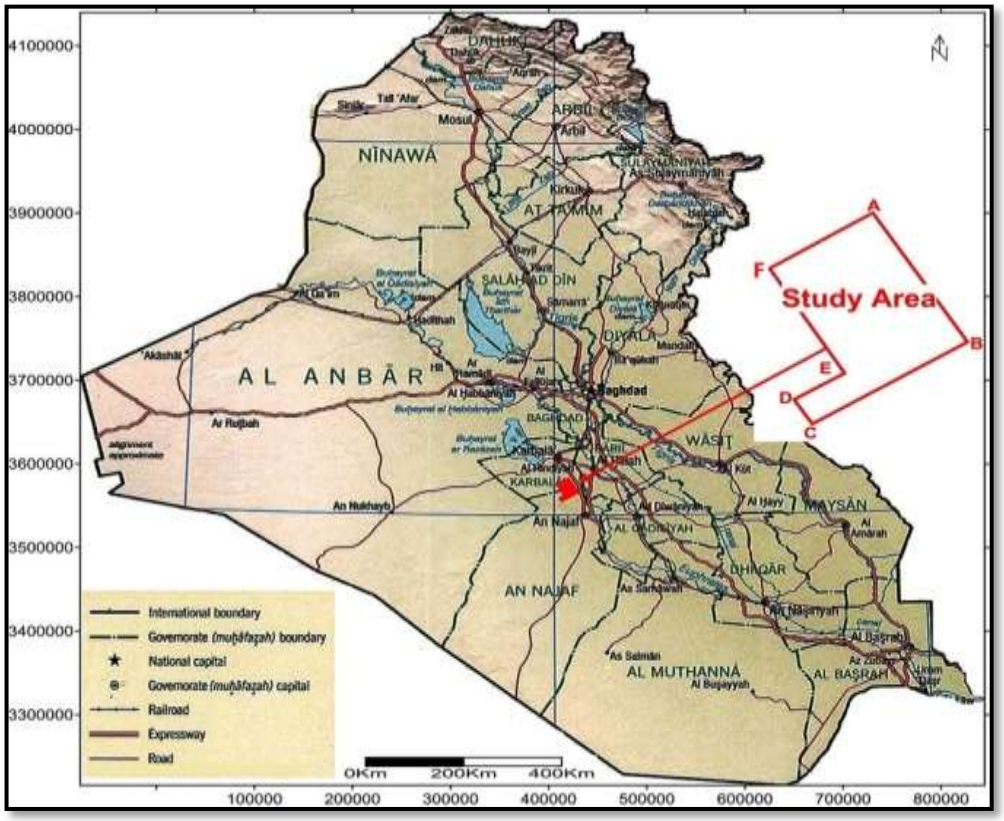

Figure1- Location map of the study area

Geologic Setting

The area characterized by numerous valleys and channels where seasonal water runs. The climate is of semi-arid nature. Elevations of the area ranges from (45-95)m above sea level. The study area is characterized by being flat and covered by Upper Miocene sediments represented by Dibdiba and Upper Fars Formations consisting mainly of clastic rocks and clay sediment [4]. Figure -2 shows the

generalized stratigraphic column of the Kifl area and adjacent areas as presented by [5]. There are four wells drilled in Kifl area in the southeast of area and West Kifl well along their length to the north-west about a distance of 50 kilometers [6]. The subsurface formations incline to the E and N-E trends, with a dip not exceeding 2 degree.

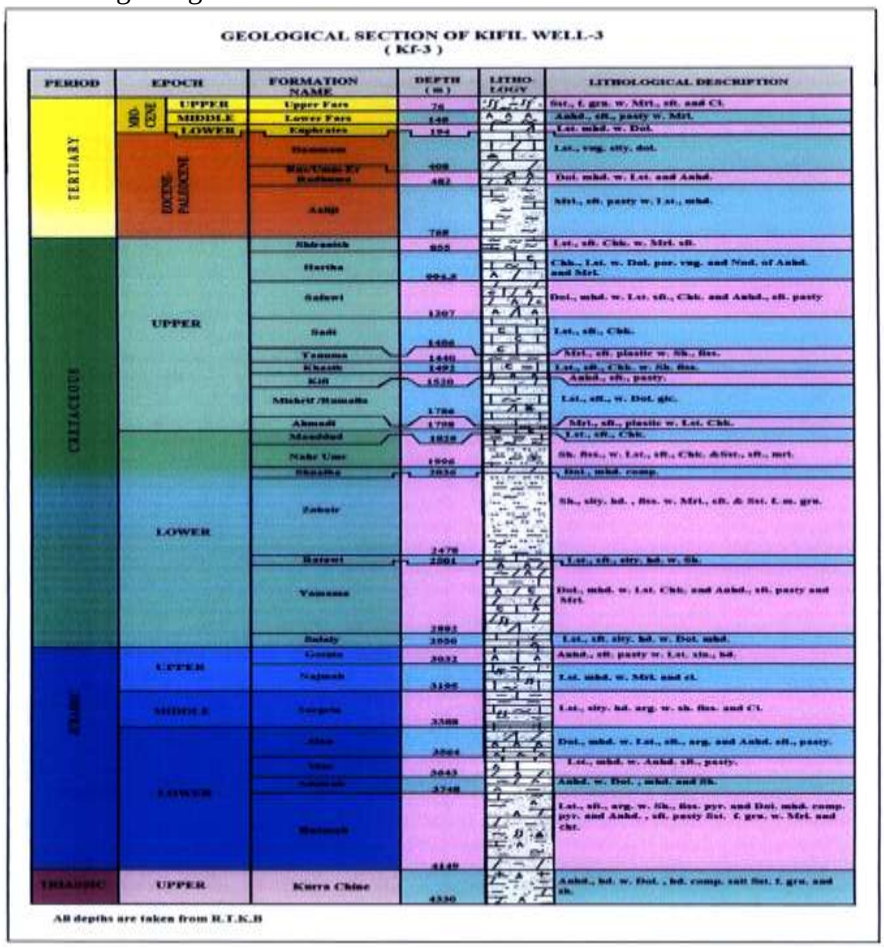

Figure 2- Shows generalized stratigraphic column in study area.

Data and Methodology

The pre- planning report of the Kifl 3D survey

The 3D Kifl survey was carried out by the third Iraqi seismic crew in 1993 and reprocessing was carried out by Anadarko Petroleum Corporation and its partners Dome International and Vitol in 2005. Before 3D survey project execution the pre-planning report of Kifl area was prepared, it includes geophysical study to determine the characteristics of the field before starting the survey. These characteristics and recording requirement includes spread patterns, source points, CDP, bin size, offset, migration aperture and coverage degree. Table 1 Reveals field data requirements in the pre-planning report of the Kifl 3D survey.

Table 1- Show field data requirements in the pre-planning report of the Kifl 3D survey [7]

The general statistics of the 3-D survey project	
Specifications	value
Full migration area	191.5 Km^2
Full fold area	247.5 Km^2
Full shooting area	268.7 Km^2
Source points/Km^2	100
Receiver points/Km^2	100
Bin size	25x25m
Number of receiver lines	96
Total source points	27264
Total receiver points	28560
Total number of swaths	95
Longest swath	19.4 Km
Shortest swath	13.0 Km
The General statistics of the 3-D survey project after the field survey	
Specifications	value
Total number of swath	94
Total Number of VP	27264
Maximum fold	3000%
Total receiver points	28560
Bin size	25x25m
Requirements of the field recording of the Kifl area.	
Specifications	value
Instrument type	MDS 18
Number of channels	480
Recording density(bdi)	6250
Sampling period	2m.sec.
Recording length	5000m.sec
Tape format	SEGD (DEMUX)
Recording filter	(12-125) Hz
Recording gain	36

Reprocessing

The original Kifl seismic data were processed in Baghdad, but because of the computer capabilities was limited it was necessary to process the dataset in smaller pieces, this generating a dataset of fair quality. In order to enhance the data quality of the 3D Kifl survey, The Oil Exploration Company (OEC) decided to reprocess the seismic data once again. A decision was made by the OEC to invite Anadarko Petroleum Corporation and its partners Dome International and Vitol to work with OEC in the reprocessing of the Kifl 3D seismic data in 2005. The main objective for reprocessing the Kifl 3D seismic data was to improve the quality of the data to allow both structural and stratigraphic seismic interpretation. Other specific objectives include improving the resolution at the target level of two way travel time, attenuation of any identifiable coherent and random noise.

Check Shot Survey

Borehole seismic data designed to measure the seismic travel time from the surface to a known depth. P-wave velocity of the formation encountered in a well borehole can be measured directly by lowering a geophone to each formation of interest, sending out a source of energy from the surface of the earth, This method is well designed to measure the travel time from earth's surface to a known depth from this survey, it will have velocity, depth, estimate the time and plot result in time/depth scale. The data can be correlated to surface seismic data by correcting sonic log and generating a

synthetic seismogram to modify seismic interpretations [8]. Figure -3 shows check-shot curve to wells of Kf-1, 2 , 3 and 4.

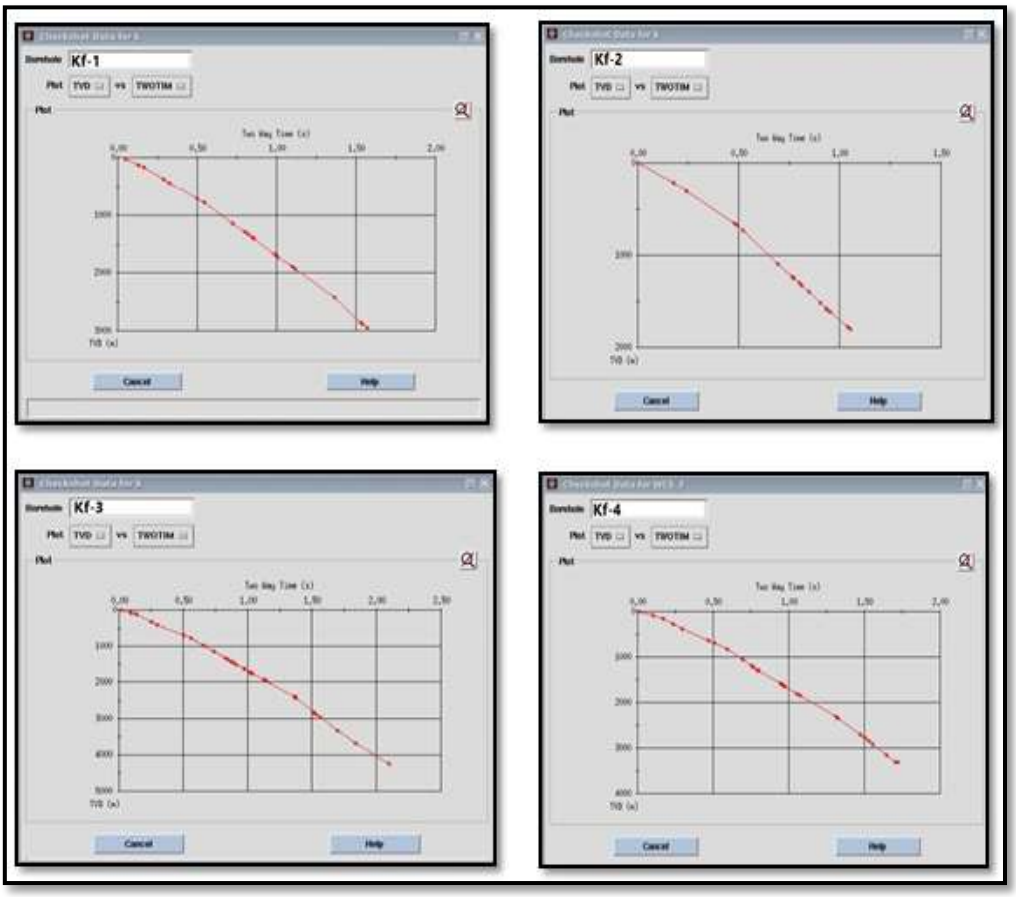

Figure 3- Illustrates the check shot curves for wells of Kf-1, 2, 3 and 4.

Synthetic seismogram generation

The process of interpretation of seismic section requires the identification of reflectors that represent certain formations, This is done by a comparison between the times of reflection Two Way Time (TWT) on the seismic section and between the synthetic seismograms obtained by sonic log and velocities survey in the wells in the study area. Synthetic seismograms were generated for well that is created by convolving a seismic wavelet. Convolution process between the reflectivity and selected wavelet to obtain synthetic seismogram by using a Ricker wavelet, The Ricker wavelet is defined by a single central frequency and has only two side lobes [9] Ricker wavelet which is far from any realistic sources or extract wavelet from the closest seismic inline or crossline method. Synthetic seismogram is a seismic trace created from sonic and density logs and it is used to compare the original seismic data collected near the well location [10].

– Using digital sonic and density logs to generate an acoustic impedance log.
– Using velocity data (e.g check-shot surveys).
– Using acoustic impedance log to derive reflection coefficients, Convolve reflection coefficients with a wavelet that the seismic data (phase, frequency, content).
– Compare synthetic with seismic data [11]. Figure-4 represents the synthetic seismogram.

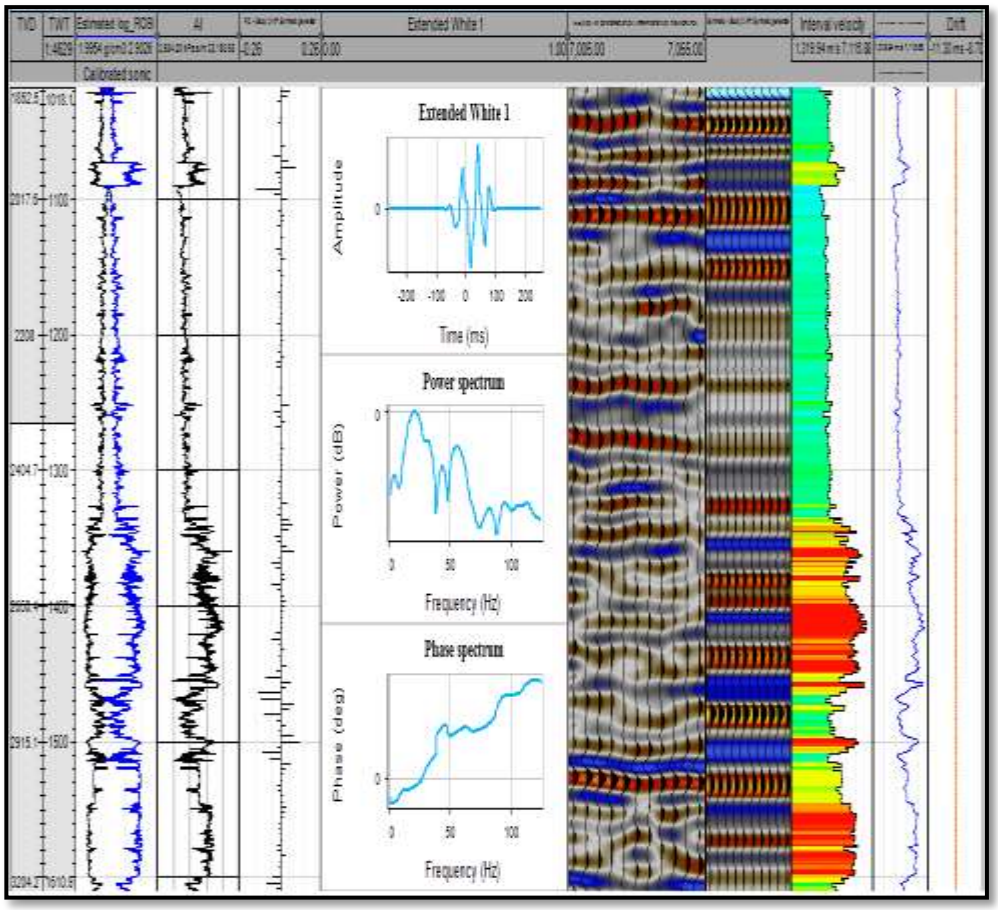

Figure 4- Represent synthetic seismogram of well Kf-1.

Seismic to well tie

Seismic to well ties is the key at any stage of development of a field and is an essential step of the seismic interpretation workflow. 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 synthetics from the computed reflectivity series convolved with a Ricker wavelet of 30 HZ dominant frequency deemed appropriate to match the dominant frequency of reprocessed 3Dseismic data. The Iraqi and American, polarity convention was adopted which states that an increase in acoustic impedance is represented by positive amplitude and is displayed as a black peak Figure -5. The synthetic seismograms illustrates strong reflection coefficients. The picked reflectors appeared as peaks on synthetic trace (positive reflection) but in different intensity. The Shuaiba and Ratawi Formations correspond to a peak while Zubair and Nahr Umr Formations Correspond to a trough. This is very reasonable because the rocks over Zubair are sandstone. The sandstone is characterized by high porosity; therefore, the density of limestone is more than that of sandstone under the natural conditions.

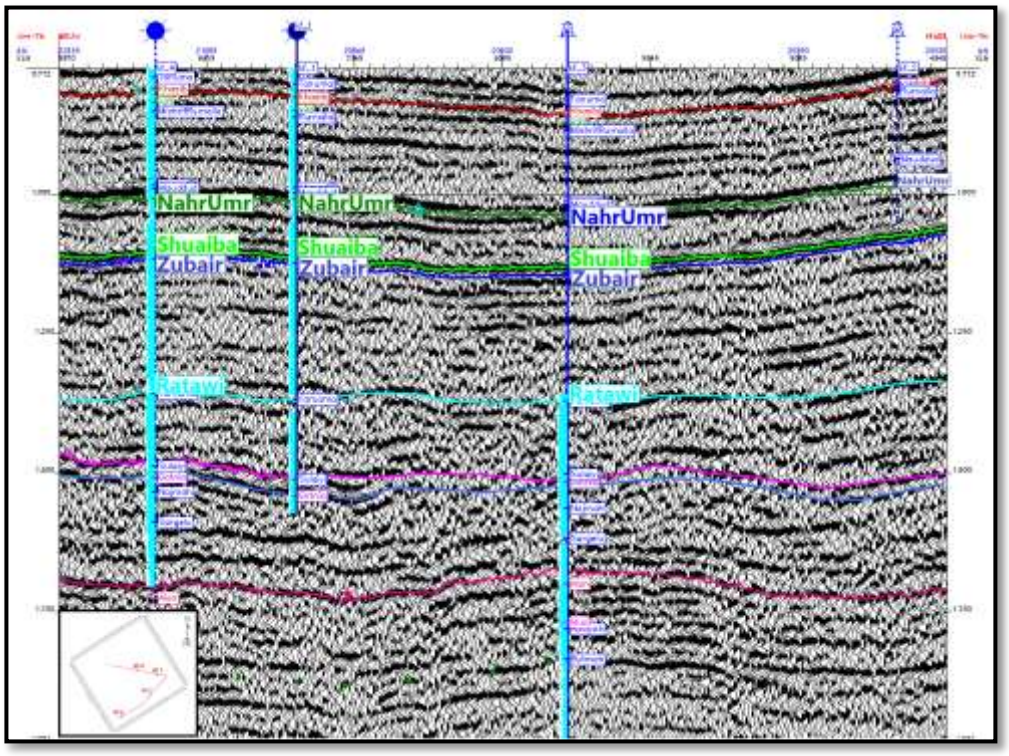

Figure 5- Illustrate the seismic sections tie between wells locations with seismic synthetic trace.

Interpretation of Seismic Data Structural

Structural traps are formed as a result of changes in the structural setting of the subsurface due to processes such as folding and faulting, leading to the formation of anticline traps [12]. [13] Taner, has indicated that seismic attribute sections, especially the instantaneous phase are very important for the distinction of surface reflector continuity, instantaneous phase attributes technique has applied for the seismic sections in 3D volume. The faults were picked in all the area along each inline, cross lines and arbitrary lines Figure-6a, and b. The instantaneous phase section shows that the study area to be affected by a major fault and minor normal faults, its extend from deep levels to influence the formations, two faults system has been observed in the study area; the major normal fault of (NW-SE) trending and minor normal faults of (NE-SW) trending, with a small displacement, these faults system played important role in the distribution of oil in the area. Normal fault form as a result of some tensional force tend to pull the rocks apart. An intrusion may have bent the rock up so the rock breaks, and one part drops down lower than other. Most kind of traps encountered in oil exploration is normal faults.

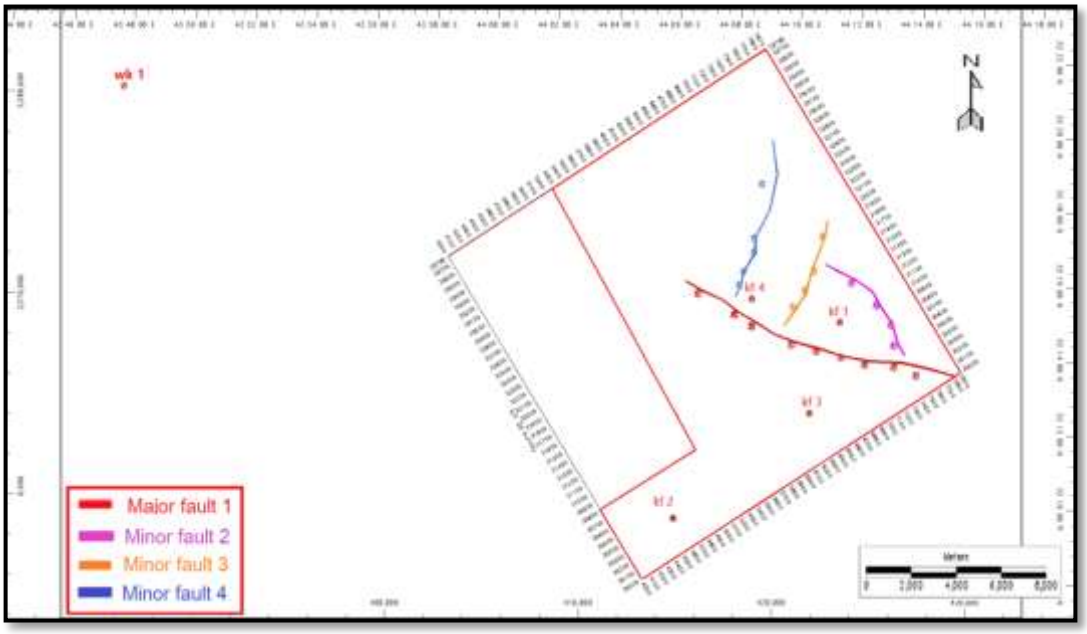

Figure 6- (a) Base map show the probable faults on the study.

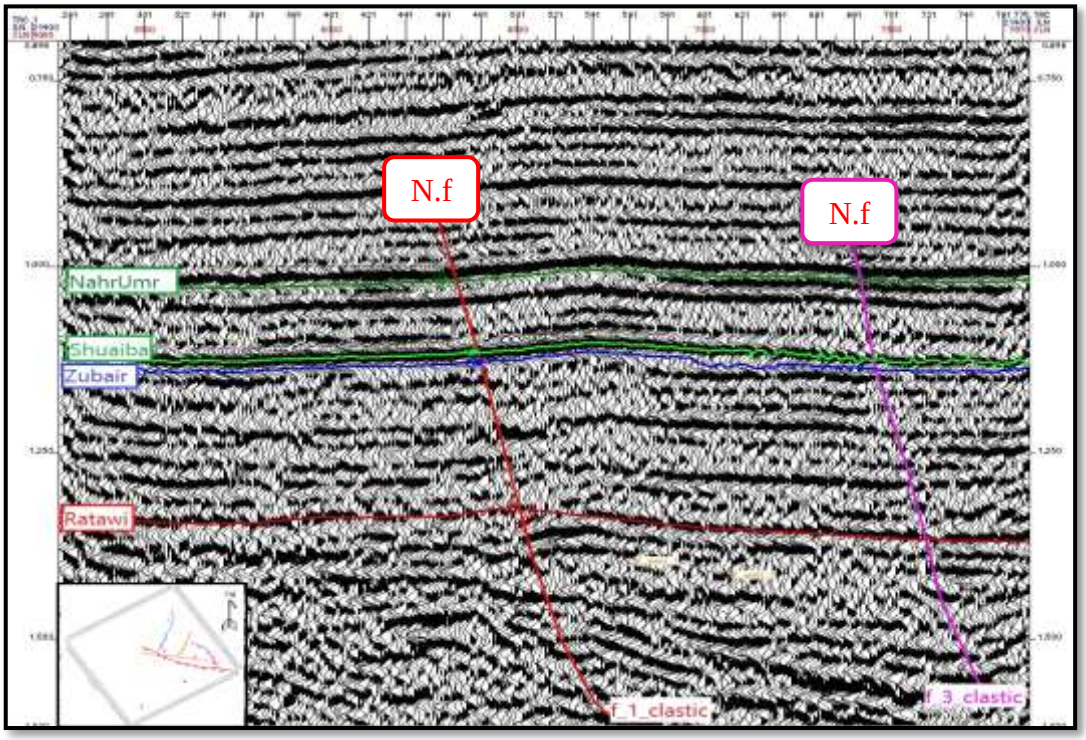

Figure 6- (b) Inline seismic section with instantaneous phase attributes shows the picked faults in the study area.

Structural picture of the picked horizons

TWT maps

The TWT maps have been prepared for the studied reflectors (Shuaiba reflector). The time maps may carry important information on the subsurface geological feature. Figure -7 Show Shuaiba two way time map dominated by NW-SE structural anticline (Asymmetrical anticline), the structure rises sharply to the southwest in the vicinity of Kf-2.The plunged anticline trending to the south east. The general dip tends to the E, the reflector is influenced by a major fault and minor normal faults with small displacement, the major fault of NW-SE trending, this fault separates well Kf-4 and Kf-1 area from Kf-3 and Kf-2, and minor faults of NE-SW trending, these faults separates well Kf-4 area from well Kf-1.

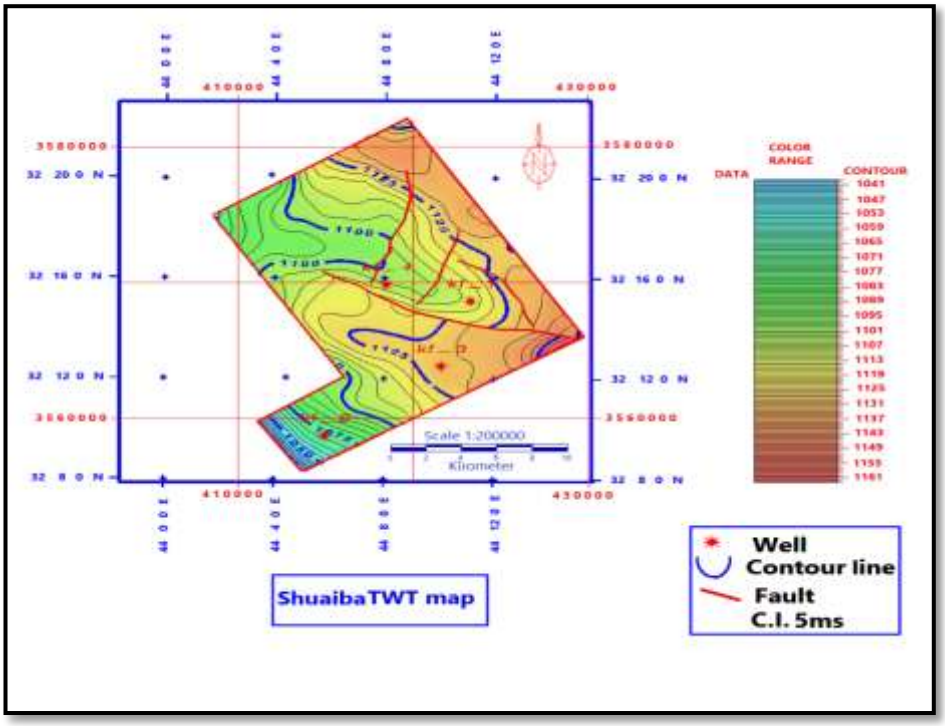

Figure 7-Shows the Shuaiba two way time map

Velocity maps

The average velocity is the suitable velocities which are needed to convert the TWT maps to depth maps .The average velocity was used for the four wells (Kf-1, Kf-2, Kf-3, Kf-4) to conversion from time to depth ,the average velocity map is drawn by using data acquired throw check shot survey of the adjacent wells. The velocity map were prepared by using a contour interval (5m/sec). The average velocity value of Shuaiba reflector increases in the north east trend of Kifl field, while Ratawi reflector increases in the south east trend of Kifl field. Figure-8 shows the velocity maps for the Ratawi Formation.

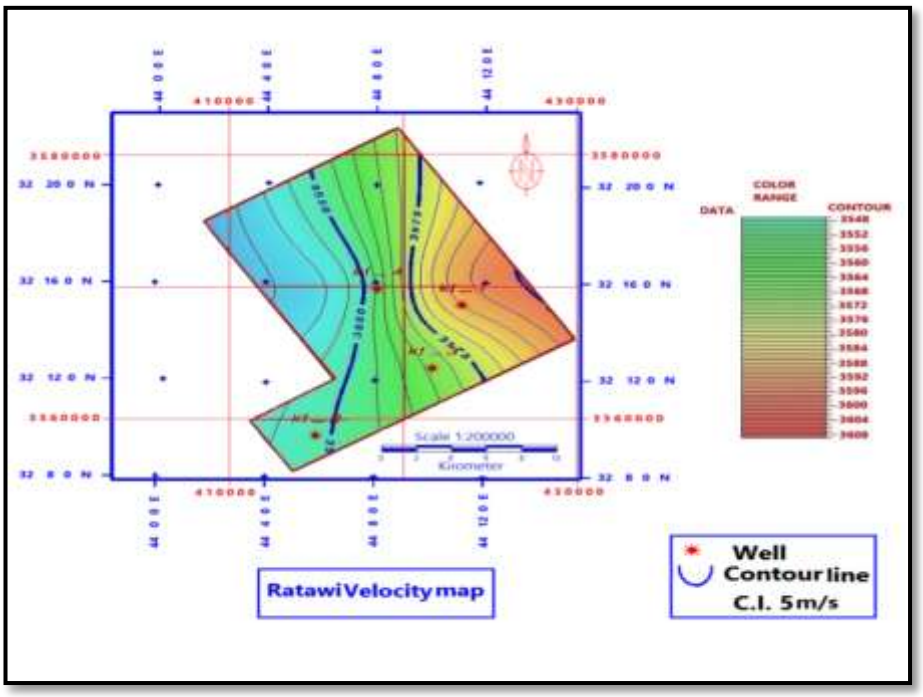

Figure 8- Shows Ratawi velocity map.

Depth maps

Depth maps were prepared for the studied reflectors (Ratawi reflector). Depth maps dominated by structural anticline trending NW-SE, and plunge trending to the southeast. The well Kifl-3 lies in a syncline area while the well Kifl-2 lies within a high and plane area. The minimum depth values are noticed at the west and gradually increase toward the east and northeast. the reflectors are influenced by a major fault and minor normal faults with small displacement, the major fault of NW-SE trending, this fault separates well Kf-4 and Kf-1 area from Kf-3 and Kf-2, and minor faults of NE-SW trending, these fault separates well Kf-4 area from well Kf-1. Figure -9 shows depth map of Ratawi reflector.

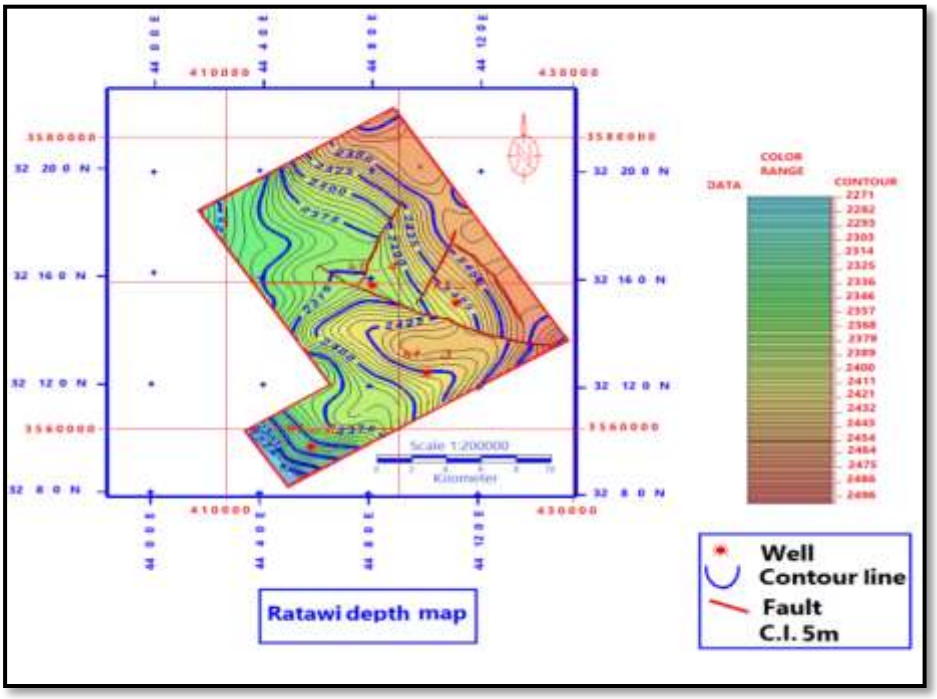

Figure 9- Show top of Ratawi depth map.

Conclusions

1. Four reflectors Nahr Umr, Shuaiba, Zubair and Ratawi Formations are defined by using synthetic seismograms in time domain for wells (Kf-1, Kf-2, Kf-3 and Kf-4).
2. The picked reflectors appeared as peaks on synthetic trace (positive reflection) but in different intensity. The Shuaiba and Ratawi Formations correspond to a peak while Nahr Umr and Zubair correspond to trough. This is very reasonable because the rocks over Zubair are sandstone. The sandstone is characterized by high porosity; therefore, the density of limestone is more than that of sandstone under the natural conditions. For this reason, any interface separating two media, the first contains limestone as (Shuaiba Formation) and the second contains, sandstone as (Zubair Formation), so the reflection coefficient of this interface is negative (trough) and under it a positive (peak)
3. The matching between seismic section and synthetic traces is good.
4. A faults of NW-SE and NE-SW trending was picked. It represents a normal fault that formed due to compression stress and vertical loading of sediments accumulations in the basin, these fault system played an important role in the distribution of oil in the area.
5. The TWT, average velocity, depth maps of the studied area interpret the structural picture of the Kifl field. These maps Shows the Kifl field is structural anticline (asymmetrical anticline) trending NW-SE, with a dip angle about 5 degrees, the general of dip of formations trend to the E.

References

1. Reynolds, John .M**. 1997.** *An Introduction To Applied and environmental Geophysics*. Reynolds Geo-Sciences Ltd, UK, 796 p.
2. Bacon, R. S. and Redshaw T. **2003.** *3-D Seismic Interpretation*, Printed in United Kingdom at the University press, Cambridge, 212p.
3. Brown, Alistair A. **2011.** Interpretation of Three Dimensional Seismic data seventh edition, The American Association of Petroleum Geologists and the Society of Exploration Geophysicists Tulsa, Oklahoma, U.S.A, 646 p.
4. Oil Exploration Company, **1998.** 3D geological study for Kifl Area, (A / 1/ 71), 17 p. (Arabic ref.).
5. Mobil Company, **1985.** Hydrocarbon Potentical, West Baghdad Area, Centeral Iraq, O.E.C. documents 25 p.
6. Oil Exploration Company, **1992.** Kifl 3D survey, pre- planning report, (37 / D / 10), 37 p. (Arabic ref.).
7. Fadhel, S.M. **2010.** 3D seismic reflection study of lower cretaceous rock in Kifl oil field, Iraq, M.Sc. thesis, University of Baghdad, 142 p.
8. Internet; www.glossary.oilfield.sIb.com.
9. Herron, Donald A. **2011.** First Step In Seismic Interpretation, Society of Exploration Geophysics, 193 p.
10. Onajite, E. **2014.** Seismic Data Analysis Techniques in Hydrocarbon Exploration, British Library Cataloguing in Publication Data, ISBN: 978-0-12-420023-4, 232p.
11. Hart, Bruce S. **2004.** Principle of 2D and 3D Seismic Interpretations, McGill University 261 P.
12. Coffen, J.A. **1983.** *Interpreting Seismic data*, Tulsa, Oklanome, 260 P.
13. Taner, M.T., Kohler, F. and Sheriff, R.E**. 1979.** Complex trace analysis, *Geophysics*, **44**(6): 1041-1063.