

# Structural and Stratigraphic 3D Seismic Study of NahrUmr and Zubair Formations in Kifl oil field \_ center of Iraq

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**Abstract**—this research is a reflection seismic study (structural and stratigraphic) of a 268.7 km<sup>2</sup> area located in the central Iraq within the Karbala province (Kifl area). The study area was interpreted by using 3-D seismic data from the Oil Exploration Company. Synthetic traces are prepared by using available data of the four wells (Kf-1), (Kf-2), (Kf-3) and (Kf-4), in order to define and picking the reflector on seismic section, These reflector are: (NahrUmr, Shuaiba, Zubair and Ratawi Formations) which are deposited during the lower Cretaceous age. Faults were picked using instantaneous phase attribute of seismic section 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, this trending conform with Najd fault system in Iraq, and minor normal faults of (NE-SW)trending, with a small displacement are influenceing the studied reflectors. The time slices were studied across 3D seismic volume of the studied reflector, they proved the presence the structural anticline at lower cretaceous reflection level. 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 extending in NW-SE trend and plunges to the southeast, and the general dip towards the east. Using seismic attribute techniques including (instantaneous frequency, RMS amplitude maps and reflection strength section), these attributes showed decreasing in frequency, amplitude and strength values. These reflect rocks of low velocity and indicate the presence of hydrocarbon accumulation area. The study of seismic facies of the picked reflectors distinction parallel seismic configuration. The results show the Zubair and NahrUmr facies are clastic depositional system deposited on delta platform, Zubair represents delta platform facies consisting of shallow-water, high-energy marine (delta sandstone, channel-fill sandstones).Pinch out is picked and interpreted by using cosine instantaneous phase attributes, these phenomena

can be regarded as Pinch out stratigraphical traps. It's the main factor to explain the difference in thickness of the oil column between well Kf-4 and well Kf-1. Mound and Flat spot phenomenon has been observed within Zubair reflector by using the seismic composite attributes (Band pass filter on an instantaneous phase attributes, as mound stratigraphic traps and flat spot which is represent of Direct Hydrocarbon Indicators (DHI) that refers to the presence of hydrocarbons. Where the use of this techniques has helped to identify the (DHI) for hydrocarbon accumulation and have not been previously identified.Finally 3D seismic model for Kifl field show the extension of structural anticline and its plunge and the distribution of hydrocarbons accumulations in the Kifl field.

**Keywords**—Structural anticline, Seismic attributes, Seismic stratigraphy.

## I. INTRODUCTION

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 (Reynolds, 1997). 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, the reflected sound travels back to the surface and recorded by receivers microphones (Bacon and Redshaw, 2003).Seismic reflections come from interfaces where the acoustic properties of the rocks change, and this fact is the basis of understanding of the nature of seismic data (Brown, 2011).The seismic reflection exploration method passed through numerous stages from mid last century to the present time including the field survey, data processing and interpretation (Yilmaz, 1987).The studied area (Kifl oil field) is located in south of Baghdad to the south-west of Hilla city at a distance approximately (35km), and lies

within the tectonically stable Mesopotamian basin between the Zagros fold belt and Arabian shield. 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 Razaza lakes. The aims of study is to Update the structural picture of NahrUmr and Zubair Formations in Kifl field, Re-interpretation seismic stratigraphic phenomena and facies change within NahrUmr and Zubair Formations by using all available data of 3D seismic survey in oil Exploration Company to detect the appropriate location of hydrocarbon accumulation for the two Formations. And Using the seismic attributes, to predict the hydrocarbon accumulations that may present in NahrUmr and Zubair Formations.

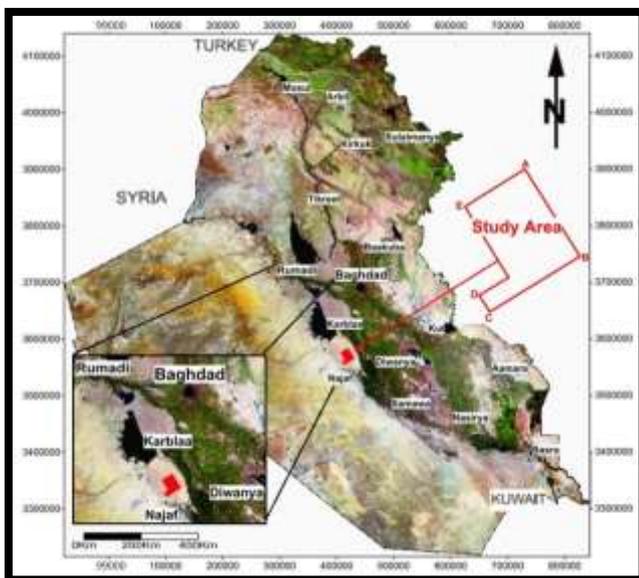


Fig.1: Satellite image of the Study area show location map of the study area(Nasa, 2008).

## II. DATA ACQUISITION

### 2.1 Base Map Preparation

Basically, the base map defined its quality map for geological and geophysical data analysis and interpretation includes the location of wells, seismic survey points, and geographic reference such is latitude and longitude or Universal Transverse Mercator (UTM) Figure (2). A processed seismic data are loaded in interactive workstation of interpretation in SEG-Y format and before, starting special subprograms must be operated to define the required data to loading. This process is called (project creation) to achieve the process of interpretation. this process includes entering the first and last the inline number, the first and the last cross line number, the separated distance between bin sizes along the inline and cross line direction, also includes definition

of the geographic coordinates in UTM coordinate system of the study area.

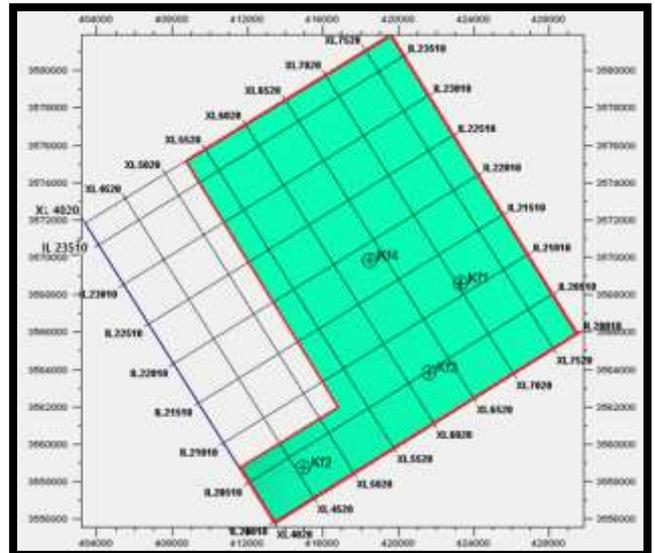


Fig.2: Illustrates a base map of a study area, (3D Kifl survey).

### 2.2 Synthetic seismogram generation

(Onajite, 2014) referred to the 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.

- 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 approximates wavelet in the seismic data (phase, frequency content).
- Compare synthetic with seismic data (Hart, 2004).

In the current study, synthetic seismogram was generated for well Kf-1, Kf-2, Kf-3 and Kf-4 as shown in Figure (3), (4), (5), and (6). The matching between seismic section and synthetic traces is good. 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 NahrUmr 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. 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).

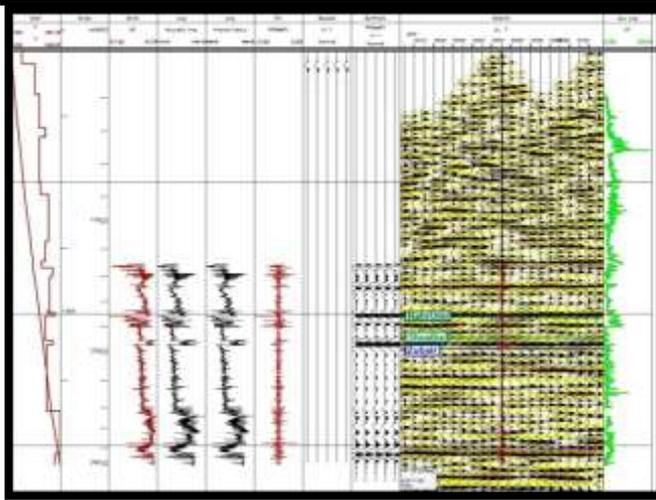


Fig.3:Illustrate the synthetic seismogram of well Kifl 1.

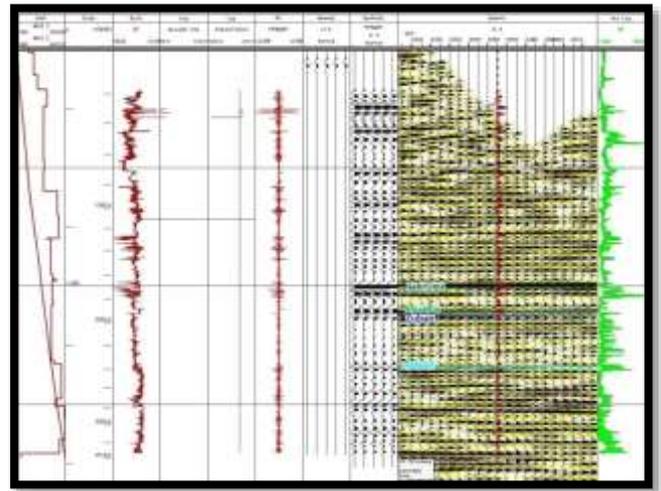


Fig.6:Illustrate the synthetic seismogram of well Kifl4.

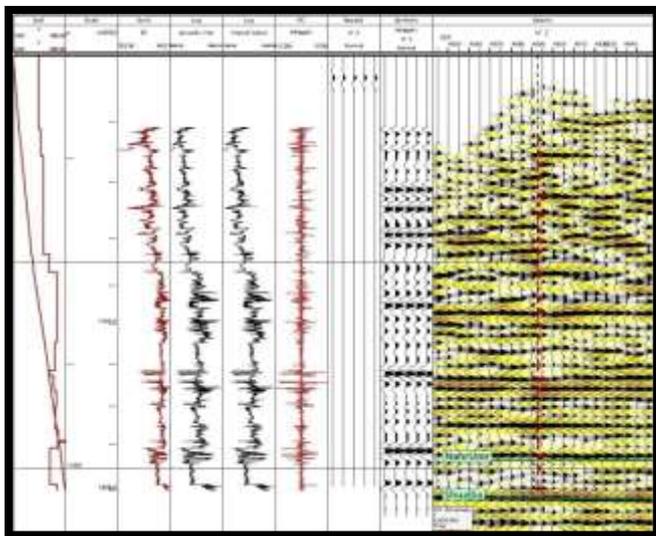


Fig.4:Illustrate the synthetic seismogram of well Kifl 2.

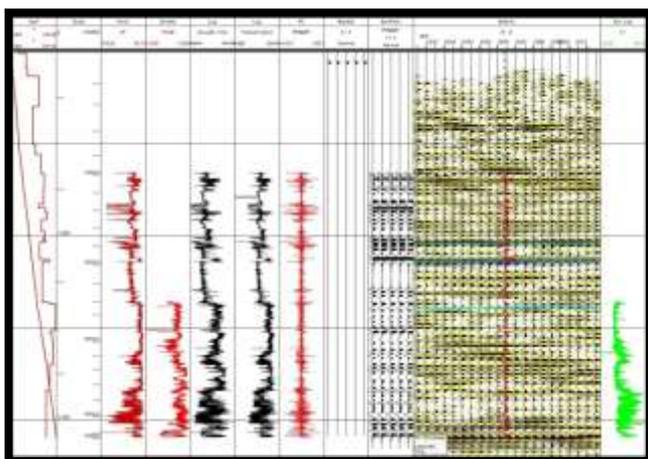


Fig.5:Illustrate the synthetic seismogram of well Kifl3.

### III. INTERPRETATION OF SEISMIC DATA

#### Structural interpretation

(Taner et al., 1979) 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 (7). The instantaneous phase section shows that the study area to be affected by a major fault and minor normal faults, The observed faults is parallel to the collision suture between Arabian and Iranian plates, It extends from deep levels to influence the NahrUmr, Shuaiba, Zubair and Ratawi Formations, Two faults system has been observed in the study area; the major normal fault of (NW-SE) trending, this trending conform with Najd fault system in Iraq, 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.

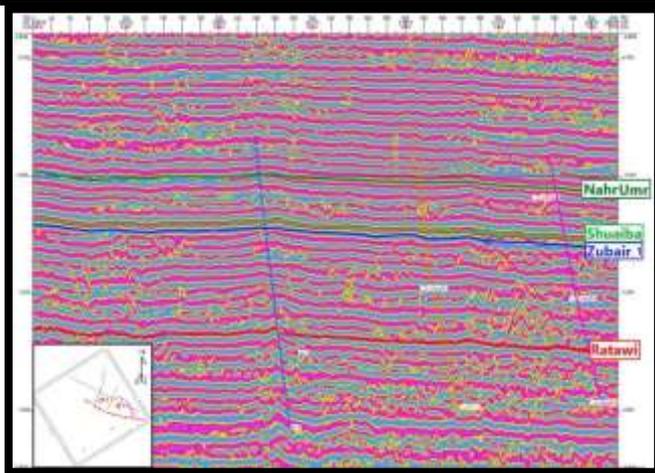


Fig.7: Traverse seismic section with instantaneous phase attributes shows the picked faults in the study area.

#### IV. TIME SLICES

A map view of 3D seismic data having certain arrival time, time slices convenient way to evaluate change in amplitudes of seismic data. The time slices may give important information on subsurface geology features, the primary idea about the subsurface structural anomalies, specially the areas of anticlines and synclines and their extension and the directions, Figure (8) and (9), show time slice of Nahr Umr and Zubair reflectors.

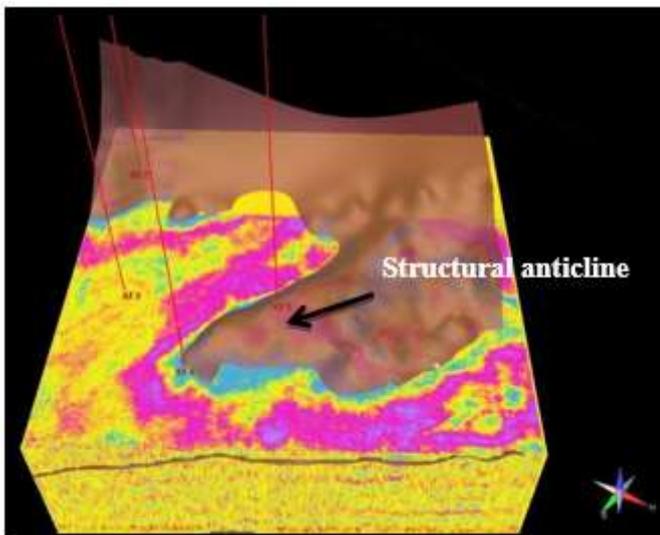


Fig.8: Show time slice of NahrUmr reflector (3D Kifl survey).

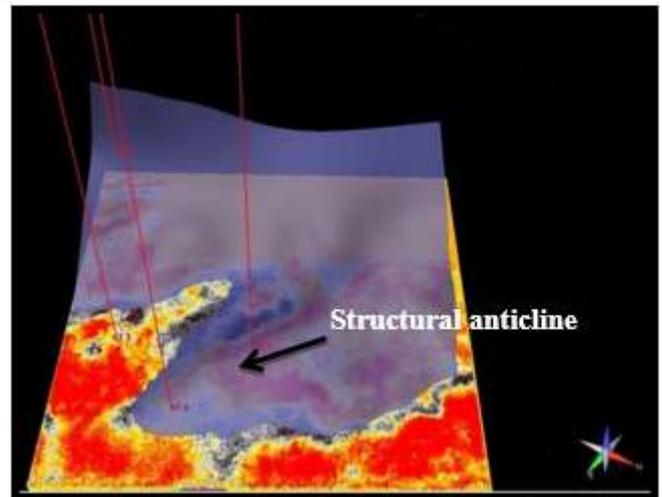


Fig.9: Show time slice of Zubair reflector (3D Kifl survey).

#### V. STRUCTURAL PICTURE OF THE PIKED HORIZONS

##### 5.1 Time Maps

Four TWT maps has been prepared for the studied reflectors (NahrUmr, Shuaiba, Zubair and Ratawi). TWT Maps of the study area dominated by structural anticline trending NW-SE. the plunged anticline trending to the southeast, the two wells (Kf1-Kf-4) located within the plung. The general dip tend to the E, 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 faults separates well Kf-4 area from well Kf-1. Figures (10) shows the TWT map for the NahrUmr Formation.

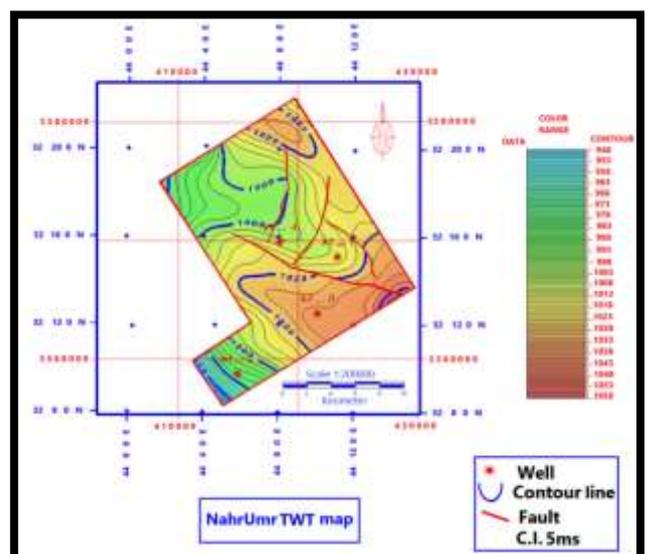


Fig.10: Shows the NahrUmr two way time map (3D Kifl survey).

### 5.2 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 through check shot survey of the adjacent wells. The velocity maps are prepared by using a contour interval (5m/sec). The average velocity value of NahrUmr reflector increases in N trend of Kifl field, Shuaiba reflector increases in the north east trend of Kifl field, Zubair reflector increases in the north east trend of Kifl field, while Ratawi reflector increases in the south east trend of Kifl field. Figures (11) shows the velocity maps for the Zubair Formation.

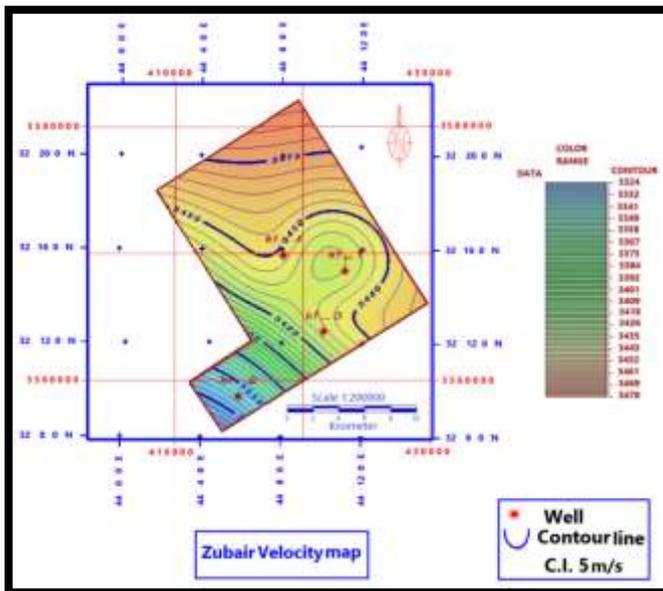


Fig.11: Shows Zubair velocity map (3DKifl survey).

### 5.3 Depth maps

Depth maps were prepared for the studied reflectors (NahrUmr, Shuaiba, Zubair and Ratawi). 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 (12) show depth map of NahrUmr reflector.

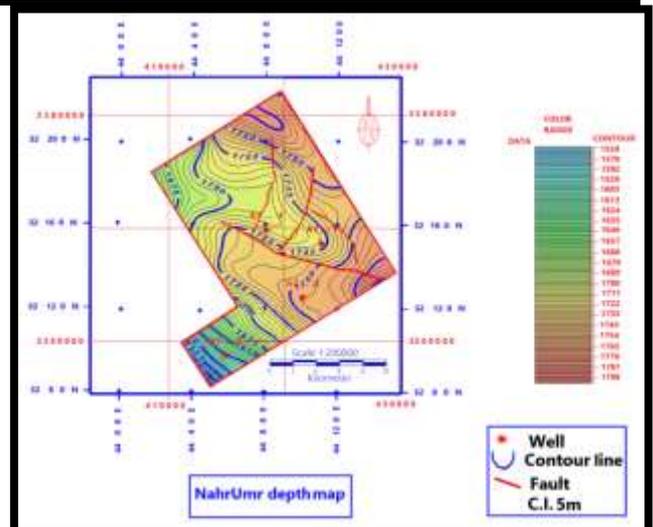


Fig.12: Shows NahrUmr depth map (3DKifl survey).

## VI. Attributes interpretation

Seismic attribute techniques were applied on 3D seismic volume for Kifl oil field, which include, instantaneous frequency, RMS amplitude, and Reflection strength attributes in time domain these types of attributes are important to detect the hydrocarbon accumulation on seismic sections, (Alridha and Muhsin, 2015)

### 6.1 Instantaneous Frequency attributes

(Sheriff, 1980), refers to rate of change of instantaneous phase from one time sample to the next (first vertical derivative of the phase). It is used for visualizing regional depositional patterns. The results of application of attribute is to determine sites changes instantaneous frequency and their relationship to changes in petrophysical qualities, is linked frequencies of low-lying areas to zones communities of hydrocarbon. The 3D seismic volume was processed and converted from seismic signal in time domain to frequency attributes Figure (13), explain the lateral variation of frequency at the reflector, the red and yellow color reflect the area of low frequency this indicates hydrocarbon accumulation areas near the four wells sites, The dark purple color reflects an area of high frequency, which indicates weak probability of hydrocarbon accumulation.

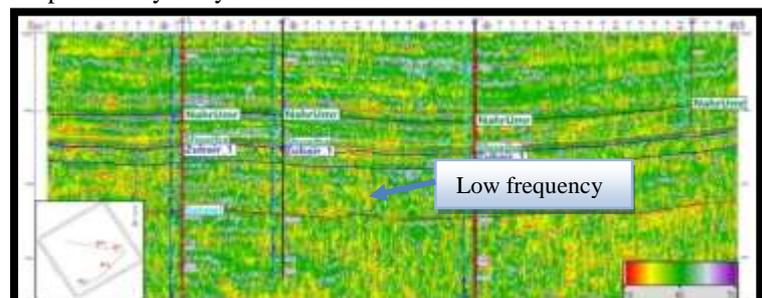


Fig.13: 3D seismic instantaneous frequency attribute of 3D Kifl survey.

### 6.2 RMS amplitude attribute

This attribute is a measure of the reflectivity within a time window or depth window. and may be used to map direct hydrocarbon indicators in a zone (Schlumberger, 2004)The color variation in the maps reflects the relative variation in the reflectors amplitude between traces, Figure (14) represent Nahr Umr RMS amplitude map with contour interval 5db. Figure (15) represent RMS top Zubair amplitude map with contour interval 5db. These maps show three main areas, the first is a blue color area (high amplitude), the second is a white color area (moderate amplitude) and third is pink color area (low amplitude). The white and pink areas of low to moderate amplitude have high probability to be a hydrocarbon reservoir within the Nah Umr and Zubair Formations.

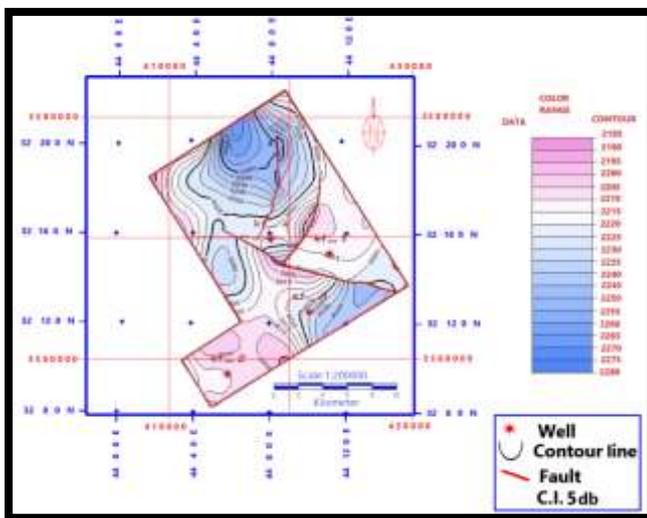


Fig.14:Shows NahrUmr RMS amplitude map (3D Kifl survey).

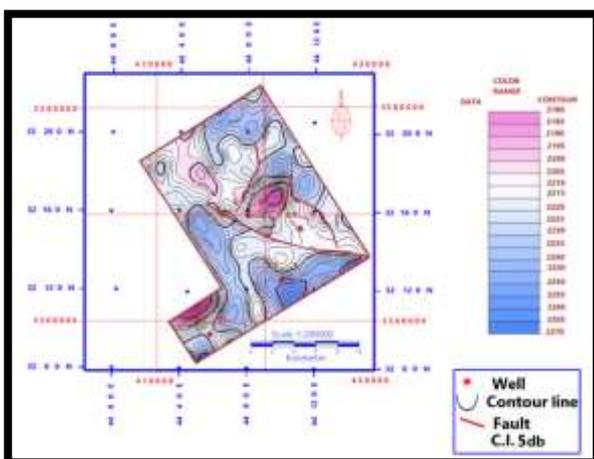


Fig.15:Shows top Zubair RMS amplitude map (3D Kifl survey).

### 6.3 Reflection strength sections

Reflection strength associated with the geological changes as unconformity surfaces or gas content in the

rocks. Figure (16) illustrates reflection strength composite section between Kf-1 and Kf-3 wells, In general, there are zones of high reflection strength, as between Kf-1 and Kf-3 wells of NahrUmr and Shuaiba reflectors which becomes blue color represents high of reflection strength value as according to color scale in the section it likely indicates of gas accumulations area, it represents the surface separating the calcareous rocks of Shuaiba Formation from the sandstone of NahrUmr Formation. The red and green color between Kf-1 and Kf-3 represent low of reflection strength values as according to the color scale in the section, it likely indicates of oil the accumulation.

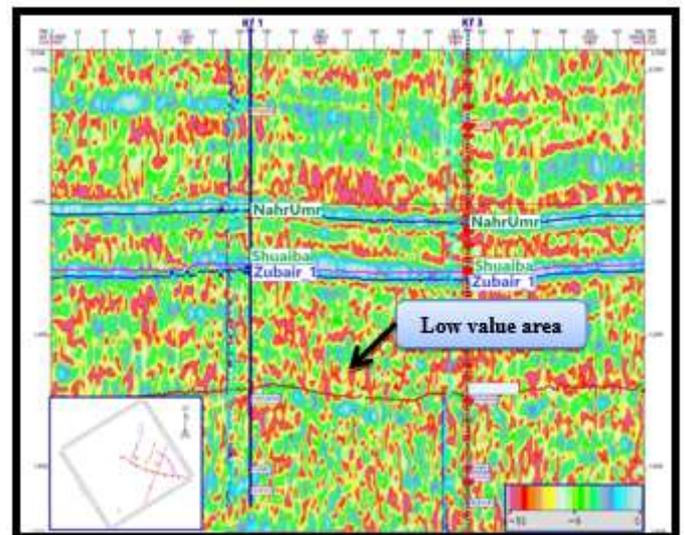


Fig.16: Shows reflection strength section of the studied reflectors between Kf-1 and Kf-3 wells (3D Kifl survey).

### VII. Stratigraphic interpretation

Seismic stratigraphy is a geologic approach to interpret regional stratigraphy from seismic section. It is a powerful technique, especially suitable for less explored or virgin basins with no or sparse well data. The seismic stratigraphy method is based on analysis of reflection patterns of stratal surfaces (Nanda, 2016).

### VIII. SEISMIC REFLECTION CONFIGURATION

In the studied interval of Kifl (NahrUmr- Ratawi), two main types of seismic reflection configuration are observed.

NahrUmr, Shuaiba, Zubair, and Ratawi reflectors display parallel configuration.

The NahrUmr, Shuaiba, Zubair and Ratawi reflectors characterize high to moderate amplitude and continuity. Reflection configurations of Shuaiba and Zubair indicate wide, relatively uniform lateral extent in sedimentary basin. It can be inferred that Shuaibafacies are deposits on a broad relatively stable shelf, while Zubairfacies are

deposited on delta platform. The shelf facies consist of neritic shale and limestone strata; sandstone is rare and generally transgressive. While Zubair represents delta platform facies consisting of shallow water, high-energy marine (delta sandstone, channel-fill sandstones) Figure (17), the detection of channels is an important part of seismic interpretation for oil and gas exploration.

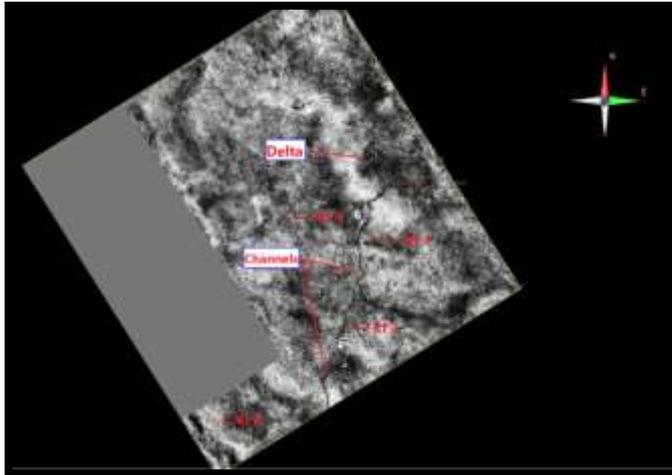


Fig.17: Illustrate time slices shows Zubair channels and delta (3D Kifl survey).

Figure (18) Show a type of Stratigraphic traps has been observed between wells Kf-1 and Kf-4. Termination by thinning or trapping out (Pinch out) of reservoir against a nonporous sealing rock creates a favorable geometry to traps hydrocarbon if the adjacent sealing rock is a source rock such is shale. These phenomena can be regarded as Pich out stratigraphical traps. Seismic attribute has applied to clarify it (Cosin instantaneous phase). Theseismic section show that the thickness of the oil unit hasbeen decreased toward well Kifl 1, and it's the main factor to explain the difference in thickness of the oil column between the two wells.

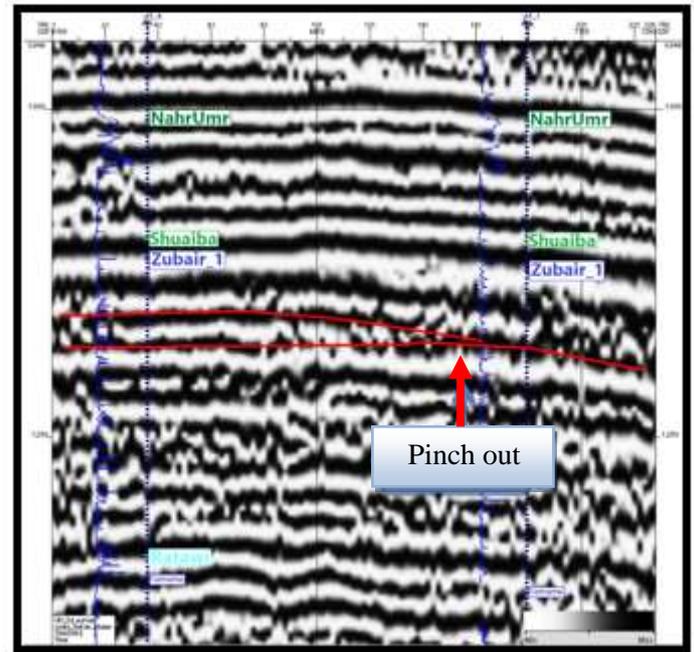


Fig. 18: Illustrate Zubair pinchout at (3D Kifl survey).

#### IX. DIRECT HYDROCARBON INDICATORS

The determination of DHI (Direct Hydrocarbon Indicator) which were difficult to identify it on the normal seismic sections, but using the seismic composite attributes (Band pass filter on an instantaneous phase attributes) has applied in order to clarify it. Where the use of this technique has helped to identify the (DHI) for hydrocarbon accumulation and have not been previously identified, this type of attributes has not been previously used.

- 1- Mound phenomenon has been observed in Inline 2185, these phenomena can be regarded as mound stratigraphical traps, underlying by flat spot which represents direct hydrocarbon indicator, Sands associated with channels often make good reservoirs for hydrocarbons. For this reason, the detection of channels is an important part of seismic interpretation for oil and gas exploration as shown in Figure (19).
- 2- Figure (20) show flat spot and channel in inline 21705.

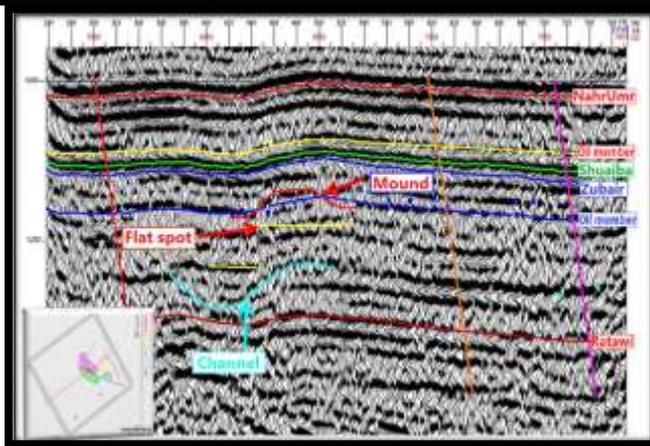


Fig.19: Composite attribute section of the Mound , flat spot & channel in Inline 21805.

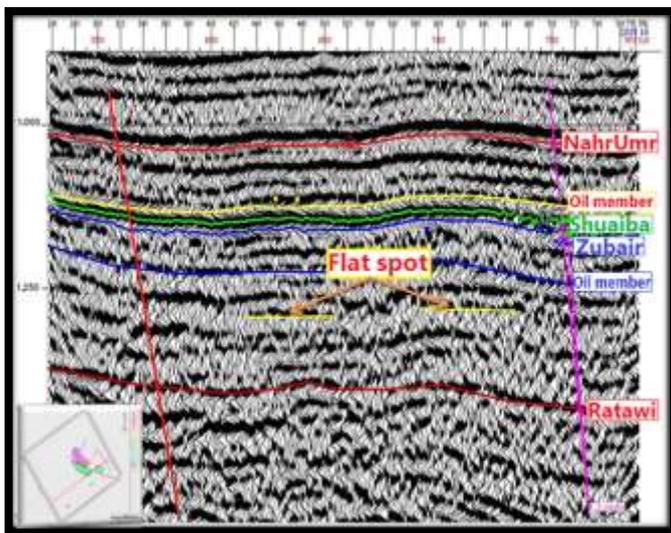


Fig.20: Composite attributes section of the flat spot in Inline 2115-21005.

## X. GEOPHYSICAL MODEL

Geophysical models of the Kifl field were constructed based on the structural and stratigraphic interpretation of the 3D Kifl seismic data. The distribution of the oil in the area is not clear, several models have been developed with depended on the hydrocarbon indicators shows the distribution of oil in the area, The model capture essential structural features within the lower Cretaceous reservoirs, in order to do initial strategy for the future seismic work of Kifl field. TWT grids of the studied reflectors and 3D seismic volume of Kifl field were used as input in visualization program that are available in Geoframe software to construct the structural seismic model for Kifl field. Two faults system has been observed in the study area; the major normal fault of (NW-SE) trending and minor normal fault of (NE-SW) trending. Figure (21) seismic structural model show the extension of structural anticline and its plunge and the distribution of hydrocarbons accumulations in the Kifl field.

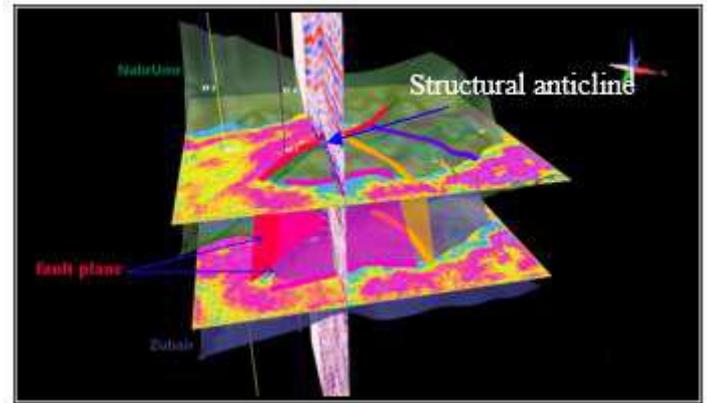


Fig.21: Show geophysical structural seismic model for Nar Umr and Zubai Formations with TWT map of them (3DKifl survey).

## XI. CONCLUSIONS

- 1- A faults of NW-SE and NE-SW trending was picked. It extends from deep levels to influence the NahrUmr, Shuaiba Zubair and Ratawi Formations. It represents a normal fault has formed due to compression stress and vertical loading of sediments accumulations in the basin, these faults system played important role in the distribution of oil in the area.
- 2- The TWT, average velocity, depth maps of the studied area interpret the structural picture of the Kifl field. These maps Show the Kifl field is a structural anticline of trending NW-SE, the general of dip of formations tend to the E,
- 3- The average velocity maps show increasing of velocity value to the E and NE direction for (NahrUmr, Shuaiba, Zubair Formations), and to the SE for top of Ratawi Formation.
- 4- The depth maps for NahrUmr, Shuaiba, Zubair and Ratawi Formation were constructed which leads to illustrate the structural configuration of Kifl area. Depth maps reveal that the minimum depth values are noticed at the west and gradually increase toward the east and northeast.
- 5- Seismic attributes techniques were applied on Kifl oil field 3D seismic volume, which include, instantaneous frequency, cosine instantaneous phase, RMS amplitude, and reflection strength , these attributes show low values near four wells site areas, this indicates hydrocarbon accumulation
- 6- Seismic facies were determined NahrUmr, Shuaiba, Zubair, and Ratawi reflectors has parallel configuration, Zubair and NahrUmr facies are clastic depositional system deposited on delta platform Zubair represents delta platform facies consisting of shallow- water, high-energy marine

(delta sandstone, channel-fill sandstones), Sands associated with channels often make good reservoirs for hydrocarbons. For this reason, the detection of channels is an important part of seismic interpretation for oil and gas exploration

- 7- There are stratigraphic phenomena in Kifl field, seismic attribute (Cosin instantaneous phase). has applied to clarify it these phenomena can be regarded as Pinch out stratigraphical traps. The seismic section show that the thickness of the oil unit has been decreased toward the well Kifl1, and it's the main factor to explain the difference of the oil column between the two wells.
- 8- The seismic composite attributes (Band pass filter on an instantaneous phase attributes) has applied in order to clarify the (DHI). seismic reflection Mound and flat spot phenomenon has been identified, These phenomena can be regarded as mound stratigraphical traps, flat spot which represents direct hydrocarbon indicator. These can be either gas/oil, gas/water and oil/water contacts
- 9- Finally 3D seismic model for Kifl field show the extension of structural anticline and its plunge and the distribution of hydrocarbons accumulations in the Kifl field.

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