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Structural Interpretations for Zubair Formation in Kumait oil field, Using 3D Seismic Reflection Data, Southern-East Iraq.

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Abstract

This study deals with the interpretation of structural 3D seismic reflection of the Kumait oil field in southern Iraq within the administrative boundaries of the Maysan Governorate. Synthetic seismograms are prepared by using available data of the Kt-1 oil field by using Petrel software to define and pick the reflector on the seismic section of the Zubair Formation, Which represents the Cretaceous Age. The study shows that the Kumait structure is an anticline fold. It is thought to be a structure trap caused by the collision of the Arabian and Iranian plates and trending in the same direction as driving factors in the area, which are from the northwest to the southeast, and the overall trend of strata is north and northeast. Seismic structure interpretation results show the top of the Zubair Formation and several structure closures. The stratification Phenomenon of the study area was clear evidence of the existence of closures which are probable to be hydrocarbon traps.

Keywords: 3D Seismic Section, Kumait Oil Field, Zubair Formation, Structure interpretation, Stratification Phenomenon

التفسيرات التركيبية لتكوين الزبير في حقل الكميت النفطي، باستخدام بيانات الانعكاس الزلزالي ثلاثي الأبعاد، جنوب–شرق العراق.

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قسم علم االارض، كلية العلوم، جامعة بغداد، بغداد، العراق

الخلاصة

يمثل هذا البحث تفسيرات لدراسة زلزالية انعكاسية تركيبية لحقل كميت النفطي جنوب العراق, ضمن الحدود الادارية لمحافظة ميسان. تم اعداد الاثر الزلزالي المصنع بأستخدام البيانات المتاحة من البئر (كميت –1) بأستخدام برنامج البترول لغرض تعريف والتقاط العاكس من المقطع الزلزالي لتكوين الزبير الذي يمثل العصر الطباشيري. أظهرت النتائج ان حقل الكميت النفطي عبارة عن طية محدبة تعتبر مصيدة تركيبية ناتجة من تصادم الصفيحة العربية مع الصفيحة الايرانية وان مضربها بنفس اتجاه تأثير القوة الحركية في المنطقة من الشمال– الغربي الى الجنوب– الشرقي وان الانحدار العام للطبقات هو الشمال والشمال الشرقي. حددت نتائج التفسير التركيبي الزلزالي قمة تكوين الزبير وبينت النتائج عدد من الانغلاقات. ظاهرة التطبق في منطقة الدراسة كانت دليل واضح على وجود الانغلاقات التي من المحتمل ان تكون مصائد هايدروكاربونية.

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1. Introduction

Seismic reflection plays a key function in providing a clearer, better, more detailed picture of the subsurface geological features. The seismic section, two-way time map, and velocity map are used to construct a structural seismic interpretation and a stratigraphic seismic interpretation [1]. The final stage in the exploration of seismic projects is seismic interpretation, and there are two stages before it (the acquisition of data and data processing) [2]. A previous survey to study the Kumait oil field during a two-dimensional survey of the Dujaila area in 1976-1979 was conducted, and the interpretation of the survey's results was the recommendation to conduct a second detailed study, which was conducted in 1980.

The research was a preliminary study of the reflective maps of the formations of Shiranish, Hartha, Sadi, Tanuma, Khasib, Mishrif, Rumaila, Ahmadi, Mauddud, Nahr Umr, and Shuaiba. In 2008, the oil exploration company reinterpreted the old survey of the area and came to similar results but recommended a three-dimensional (3D) seismic survey to get a better picture of the discovered reservoirs. Moreover, it better determines the levels of hydrocarbons present in different reservoirs [3]. This study aims to construct three-dimensional structural maps to locate hydrocarbons and examine the stratigraphic phenomena that are likely to exist in the study area.

2. Location and geological setting of the study area

As part of the official border of the governorate of Maysan, the Kumait oil field represents the study area, which is located in southern Iraq's eastern regions(Figure 1). The Kumait oil field is located within the Universal Transverse Mercator (U.T.M) coordinates, as shown in Table 1.

Table 1: Study area coordinates

ID	Easting (m)	Northing (m)
A	664162	**3555840**
B	650511	**3544715**
C	671267	**3531222**
D	681724	**3547326**
E	675778	**3551024**

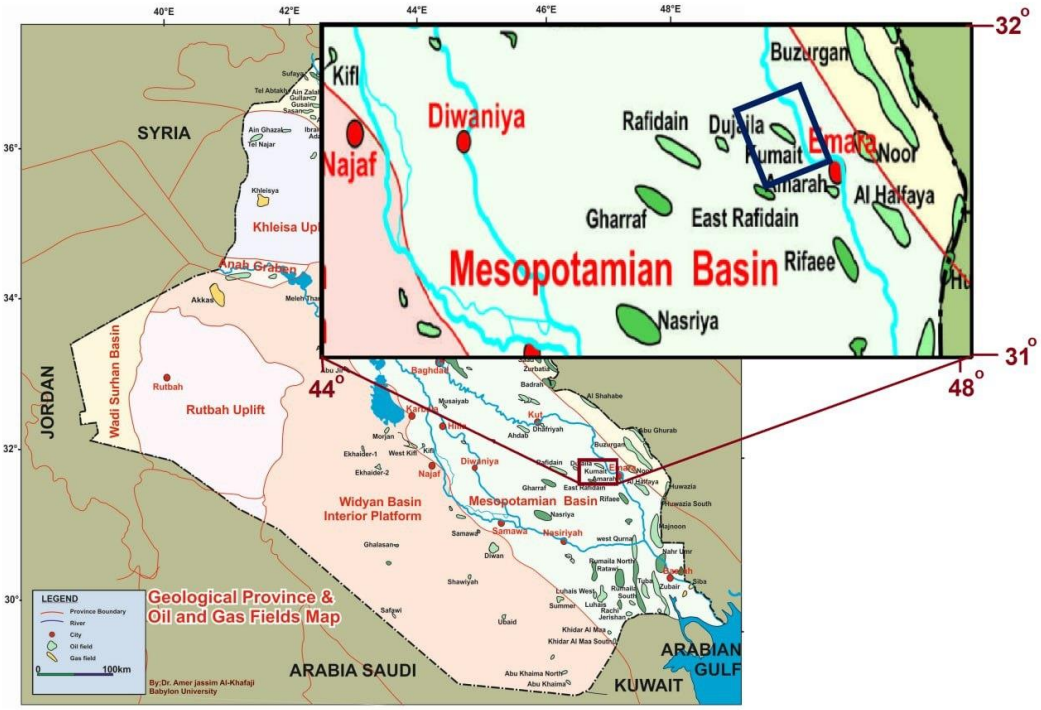

Figure 1: Iraq map shows the study area with surrounding oil fields.

2.1 Structural of the study area

The study area is located in the Mesopotamian basin, close to the northeastern slope of the Arabian-African platform, which is bounded to the west by the Arabian Shield and to the east by the Zagros Mountains. Because of the forces caused by the collision of the Iranian and Arabian plates, the Mesopotamian tectonic subzone's formations are mainly trending NW-SE. The research region contains several tiny fold closures, including the Kumait, Dujalia, Abu Amoud, and East Abu Amoud fields [4].

2.2 Subsurface Geology

The Zubair Formation is the most important formation of the Lower Cretaceous sequence in Iraq [5]. In the study area, the Zubair Formation is the most important reservoir of sandstone in Iraq and the most extensive formation in a Barremian. The formation consists of fluvial-deltaic and porous and permeable marine sandstone. The thickness of the formation in southern Iraq is about 200–500 meters. A change of facies defines the northeastern boundary of the Zubair sandstone fairway from the delta front or finest sandstones into shelf mudstones [6]. An example of delta platform facies is the Zubair Formation, which consists of plain shale, channel-fill sandstones, high-energy marine (delta-front) sandstones, shallow water, and broad coal or lignite beds. In the Zubair Formation, the latter may have served as the source rock for the Kerogene and later oil [7]. The upper member of the Zubair formation is distinguished into the sand and shale units based on the neutron, density, and gamma-ray logs [8]. This formation is displayed in the well Kt-1: 4020.5m-4221m (Figure 2).

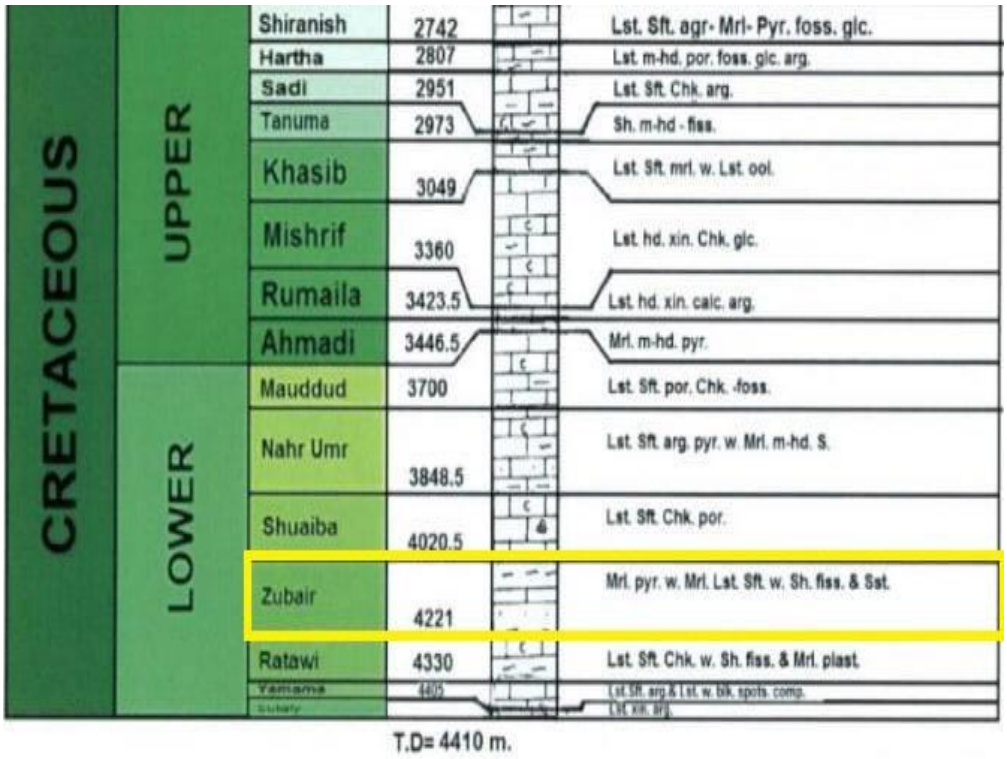

Figure 2: Geological column in Kt-1 well [9].

3. Materials and methods

3.1 Database

Two wells have been drilled in the study area, representing a 3D survey. These two wells are Kumait-1 and Kumait-2. Before achieving the 3D seismic survey project, the pre-planning report for the Kumait oil field was prepared. A 3D, symmetrical split spread with vibrators source model Nomad 65 was executed by the Oil Exploration Company (O.E.C.) in 2018. The survey in the Kumait oil field covered an area of 629 km^2.

3.2 Processing

The seismic data was processed at the Oil Exploration Company's Processing Center. The main objective is to improve the quality of recorded seismic reflection data. Fundamentally, this development is necessary to support the seismic interpretation of the stratigraphic and structural features. The improvement in reflection continuity and seismic attribute computation are both results of the noise reduction process. The primary procedures of processing are deconvolution, stacking, and migration.

The two processing phases are pre-and post-stack processing [10].

3.3 Procedure of interpretation

The structural interpretation of the Zubair Formation consists of the following:

1-Inserting available well information data of Kt-1 involving (well tops-check shots-sonic logs-density logs).
2-Loading 3D seismic data.
3-Generating synthetic seismogram by a seismic well tie.
4-Connecting seismic wells to the synthetic seismogram (Kt-1 well).
5-Selecting the reflector of the Zubair Formation.
6-Building TWT map, average velocity, and depth map for the studied reflector.
7-Identifying stratigraphic features of the Zubair formation.

3.4 Base map preparation

The research area's base map was made once the data were loaded into the Petrel program. Entering the initial inline number, the first crossline number, the last inline number, the last crossline number, and the spacing between the bin size along the inline direction and the crossline direction presented are all steps in this process (Figure 3).

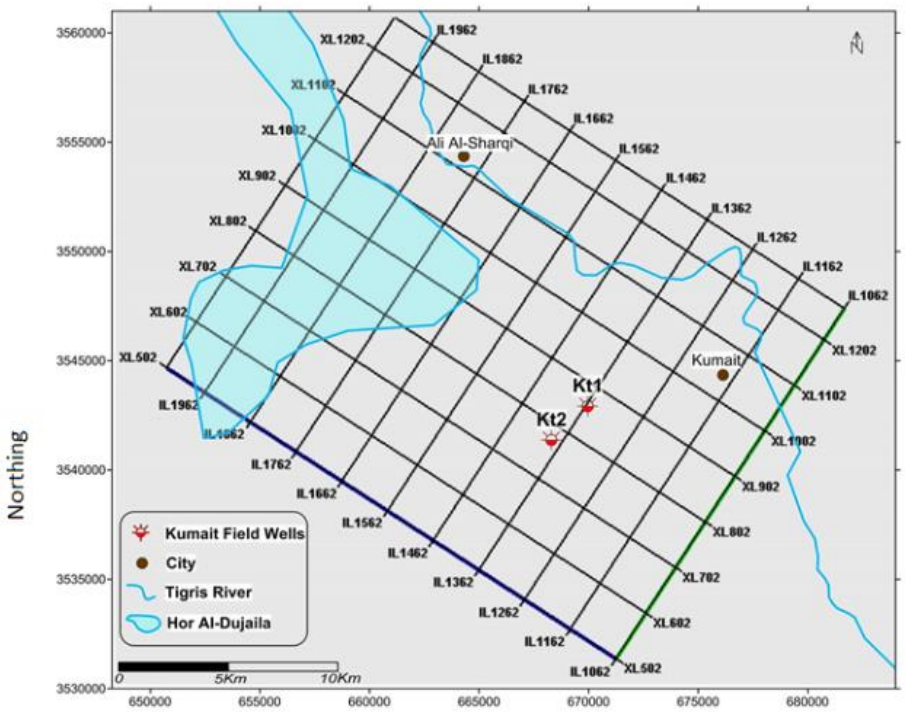

Figure 3: Base map of Kumait oil field [11].

3.5 Synthetic seismogram generation

The interpretation requires comparisons between the logs, core tests, well velocity surveys, thin section data, and the seismic section's TWT reflection. The synthetic seismogram provides a practical way of selecting the reflectors in the seismic section that includes the distinct boundaries between the various lithological horizons.

The primary steps for creating a synthetic seismogram were described by [12]. These are:

1-determining the acoustic impedance Eq. (1)

$$z = v.d \tag{1}$$

Where:

v=seismic velocity.

d=density is obtained from the log of density.

2-Two series of time intervals I and (i+1), having acoustic impedance values of (P_i) and (P_i+1) and (V_i+1), respectively, are used to compute the reflection coefficients of the vertical incident wave on the reflector.

According to [12], It may compute the reflection coefficients as shown in Eq. (2)

$$Rci = (Pi+1)(Vi+1) - Pi\,Vi \,/\, (Pi+1)(Vi+1) + Pi\,Vi \tag{2}$$

Where:

(P_{i+1}, P_i), the density at the interval (i), (i+1).

(V_{i+1}, V_i), the velocity at the interval (i), (i+1).

3-On the synthetic seismogram, a convolution procedure is done to acquire the reflection coefficients and an experimentally determined wavelet. Since it is the most straightforward method for figuring out the geological velocity (average velocity) of geological layers, the sonic

log information is contrasted with the well velocity survey. The synthetic Petrel software tools were used to create the synthetic seismogram traces for the Kumait oil field.

The seismic sections travelling through the well sites are shown in (Figure 4), together with artificial reflector traces. Seismic traces and synthetic traces closely match one another. The selected reflector (Zubair) has a negative reflection coefficient (trough) on the synthetic traces.

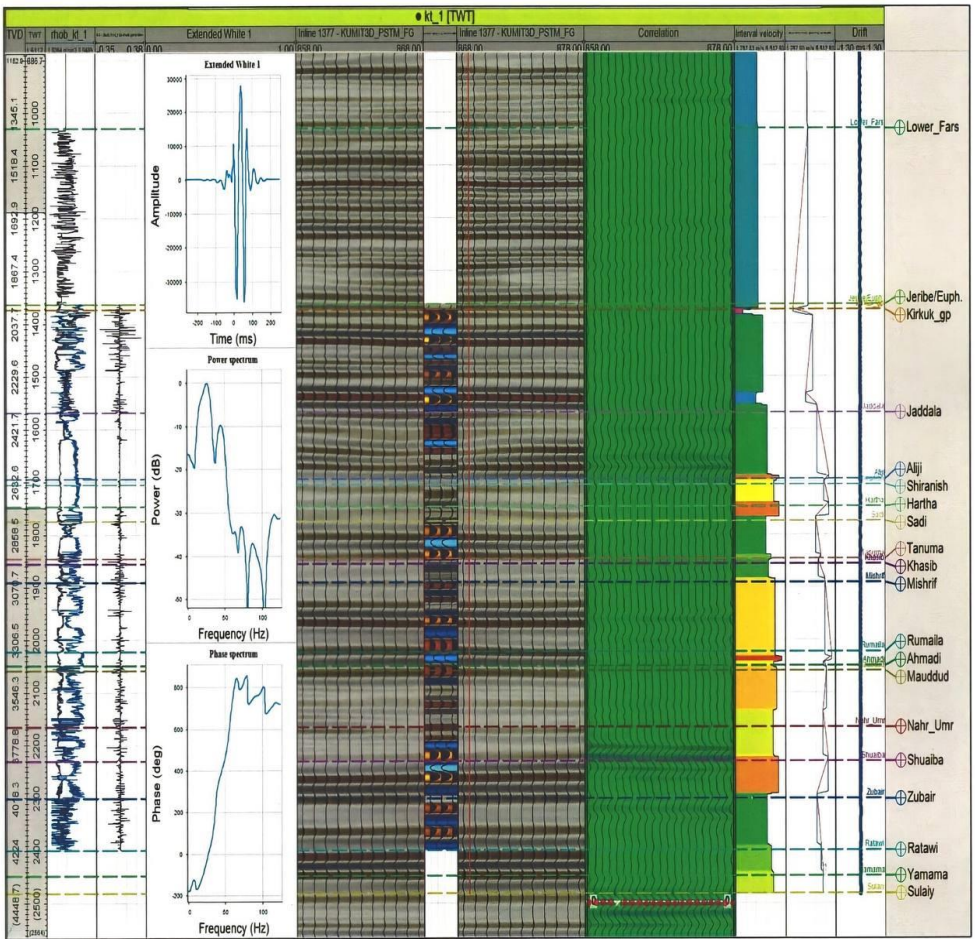

Figure 4: Synthetic generation of Kumait 1 oil field.

3.6 Structural Seismic Pictures of the Picked Horizons

Following the study of synthetic seismograms in the time domain for reflectors (Kt-1), the region was chosen to prepare time maps using reflectors. These time maps were transformed into maps of structural features in the depth domain utilizing the information velocity from these reflectors. All maps use the sea level as a basic reference point. Below is an explanation of the reflector used in this work (Figure 5). The Zubair reflector, represented by sandstone interbedded with shale, is a trough because its density is less than the cover layers (limestone).

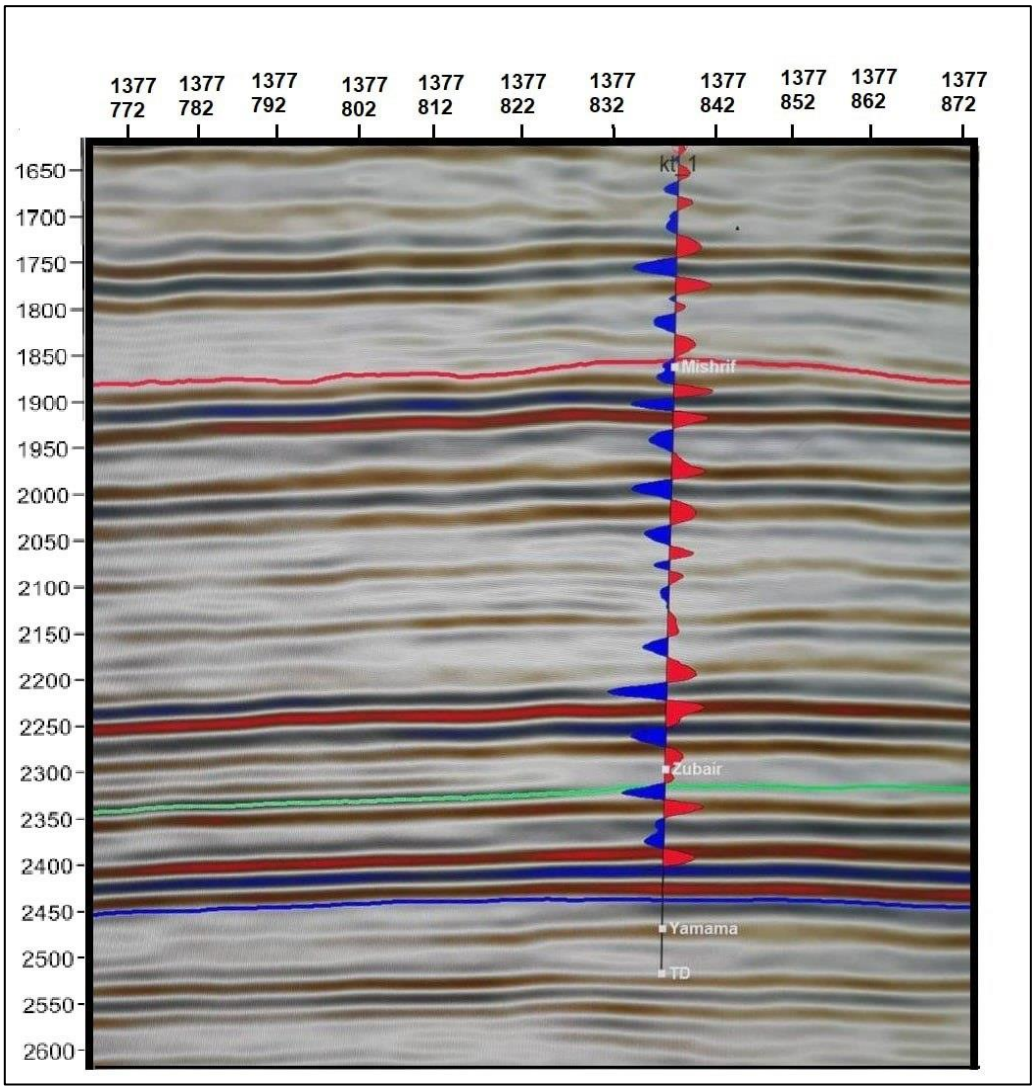

Figure 5: Showing Zubair Formation top in seismic line 1377.

4. Results and Discussion

4.1 Time maps:

For the investigated reflector Zubair, TWT maps have been created. The variance in TWT indicates the variation in depth of these reflector parts.

The maps of that time may have provided essential information on the underlying geological features [13]. The Zubair TWT map (Figure 6) shows a structural anticline (symmetrical anticline) trending NW-SE. The higher contour value can be observed in the northeast direction of the area at 2460 ms and decreases in the southwest direction at 2280 ms. In the middle of the study area, irregular-shaped closure structures dominated by NE-SW trending are found. The NE closures are already drilled by Kt-1, while Kt-2 is drilled outside the structure, and the other domes are not drilled but show a good probability area.

The TWT map of the Zubair Formation also shows a major transversal fault system dominated by NW-SE due to Mesozoic salt movement due to the Zagros orogeny [14]. The contour interval is 10 ms.

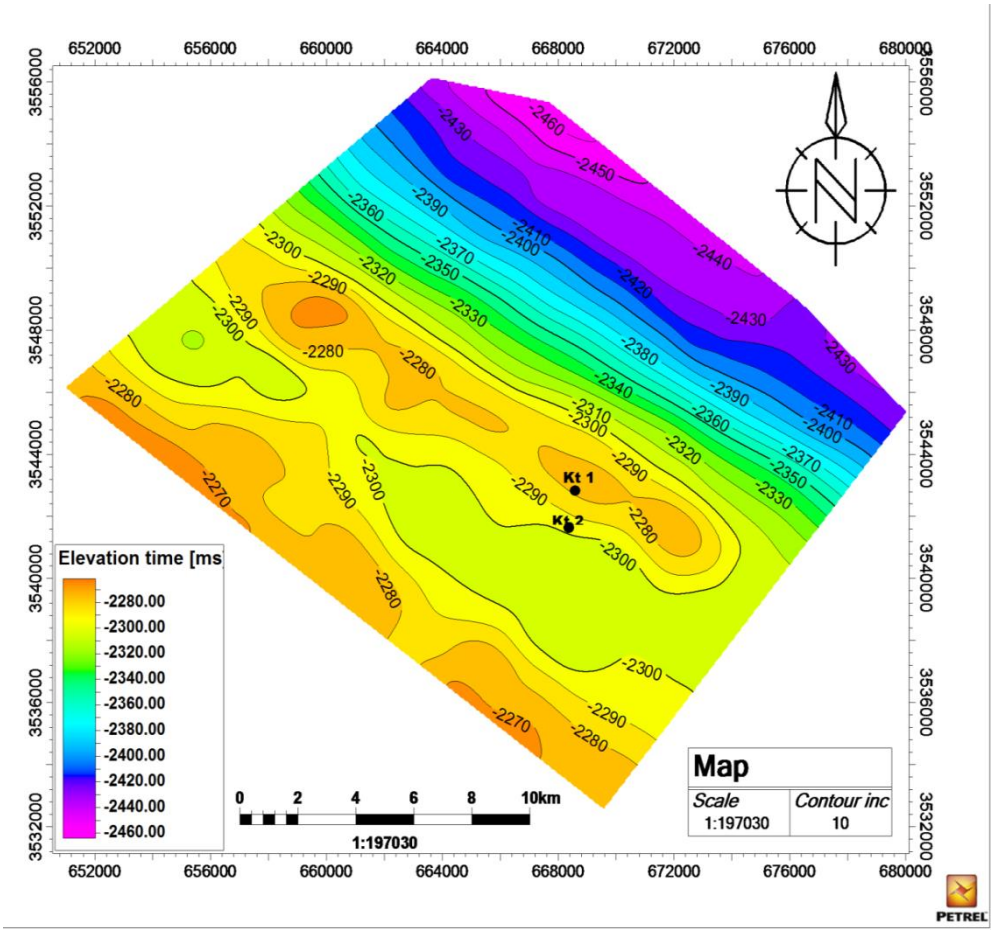

Figure 6: Represents a TWT map of the Zubair Formation.

4.2 Velocity maps:

An essential factor for converting a time map to a depth map is determining the velocity distribution over the study area. The average velocities of Kt-1 were used to draw the map. The velocity map of Zubair (Figure 7) shows the following:

-The velocity value increases toward the NE direction and decreases toward the SW direction.

-The velocity magnitude varies from (3540-3630) m/sec.

-The contour interval is 50 m/s.

-The velocity increases under Kt-1 and decreases to the southeast by 3500 m/s because the velocity increases with depth.

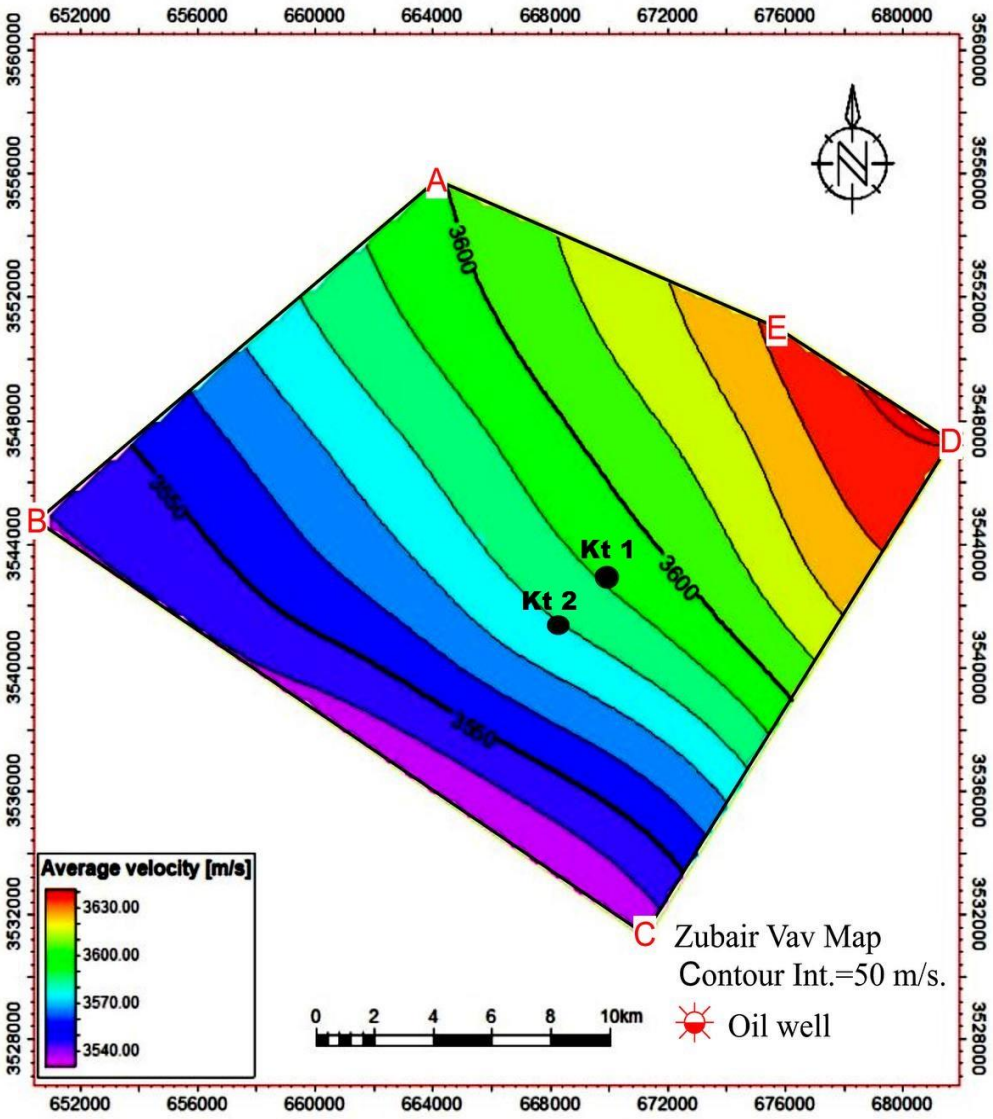

Figure 7: Represent a velocity map of the Zubair Formation.

4.3 Depth maps:

They were created based on the structural interpretation of the picked reflectors to illustrate various structural features [15]. A technique known as depth conversion clarifies the structure and eliminates the ambiguity of time's inherent structure.

The depth map displayed below is constructed by combining a specific reflector's time map with its average velocity map.

Figure 8 shows that the structural anticline has a general trend of NW-SE. The minimum depth value of 4050 m was observed in the southwest and progressively increased in the middle, reaching 4100 m in Kt-1, representing the structure's crest, and toward the east and northeast to reach 4380 m, where a contour interval of 10m. Structure closure was observed in the NW-SE direction.

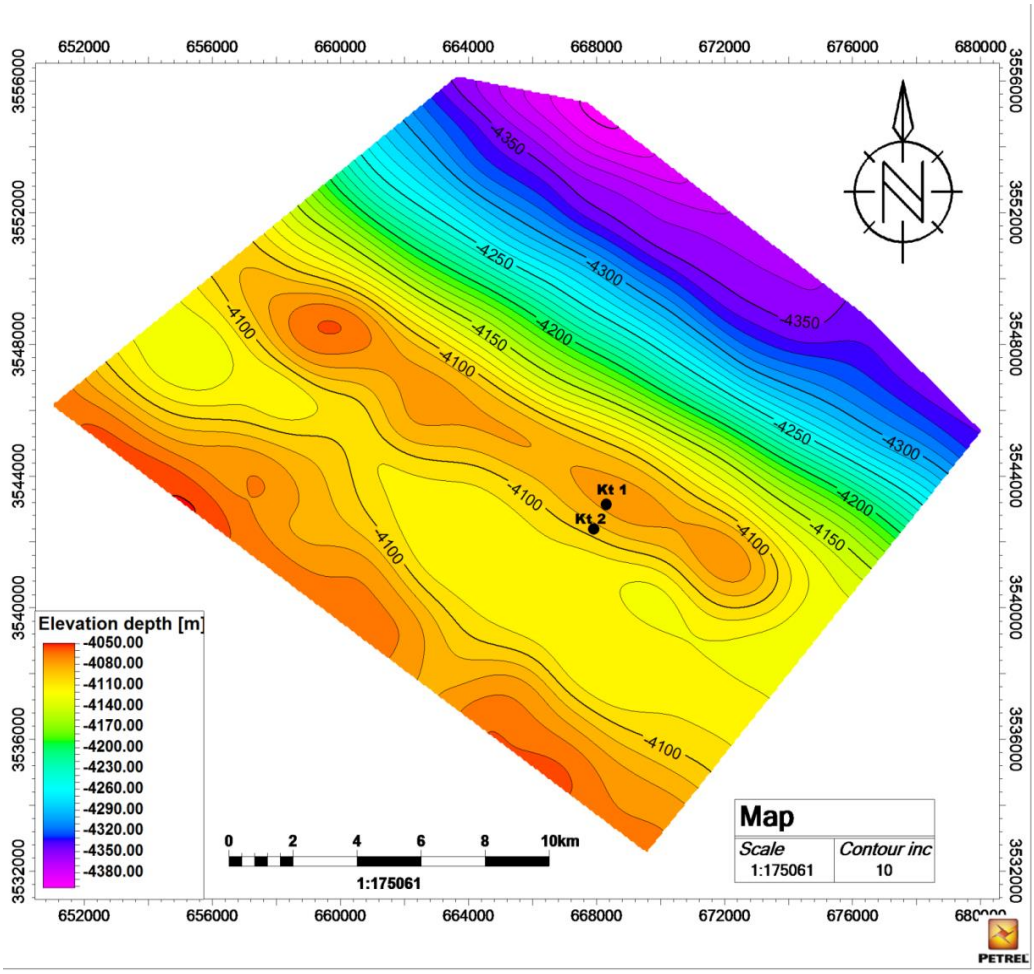

Figure 8: Represent a depth map of the Zubair Formation.

4.4 Stratification Phenomenon

The seismic facies of the Zubair Formation may be seen varying both vertically and laterally [16]. In 645, the Seismic line shows evidence of closures that appear in the TWT map and depth map called boundary bending (Figure 9).

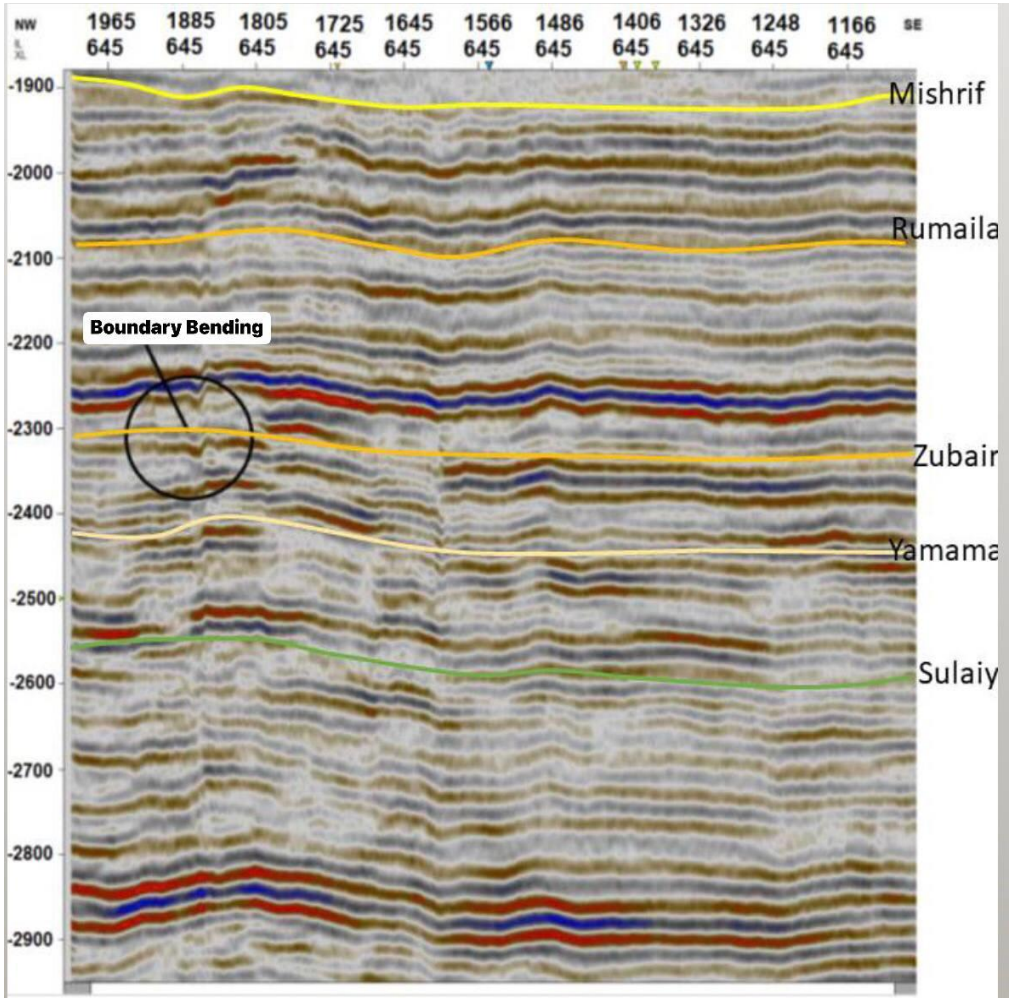

Figure 9: Al-Zubair stratification phenomenon.

5. Conclusions

On a synthetic trace (negative reflection), the selected reflector appears as a trough, and, in the natural conditions, the Zubair reflector, which is composed of sandstone and shale interbedded, is a trough as the density is lower than the cover layers (selects the top of Zubair at 2345 msec). The two-way time, average velocity, and depth maps of the studied area interpret the structural picture of the Kumait oil field. These maps show that Kumait oil field is a structural anticline (asymmetrical anticline) trending NW-SE and the general trend of strata is N and NE. By relying on the structural interpretation of the Zubair reflector, some closures in the middle part of the study area are acknowledged, which is evidence of the existence of hydrocarbon accumulations.

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