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3D Seismic Structural Study of Zubair Formation in Najaf-Karbala Area-Central Iraq

Ahmed S. Abdul Majeed*, Kamal K. Ali
Department of Geology, College of Science, University of Baghdad, Baghdad, Iraq

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Abstract

The current study included interpretations of the three-dimensional seismic survey data of the Najaf-Karbala region, which was recently implemented by the Fifth Amphibious Seismic crew of the Oil Exploration Company for the period from 30/1/2016 to 13/10/2017. The total area planned to be covered by the three-dimensional survey program was about (3340 km ²). The Zubair reflector was picked, interpreted, and tracked within the region. The faults affecting this reflector were captured. The reflector's temporal, velocity, and depth maps showed the presence of structural closure features in the southeast of the region and extensions to the structural noses to the northwest of the study area. The structural maps showed a general tendency towards the east and the presence of faults in the area extending towards the northwest-southeast.

Keywords: Najaf-Karbala area, 3D seismic structural study, Zubair formation, Seismic interpretation, Geophysics

دراسة تركيبية زلزالية ثلاثية الابعاد لتكوين الزبير في منطقة النجف–كربلاء –وسط العراق

احمد سعيد عبدالمجيد* , كمال كريم علي
قسم علم الارض,كلية العلوم,جامعة بغداد,بغداد,العراق

الخلاصة

تضمنت الدراسة الحالية تفسيرات لبيانات المسح الزلزالي ثلاثي الابعاد لمنطقة النجف – كربلاء والذي تم تنفيذه مؤخرا من قبل طاقم المسح الزلزالي البرمائي الخامس الاستكشافات النفطية (OEC) للفترة من (2016/1/30 حتى تاريخ 2017/10/13). إجمالي المساحة التي يغطيها برنامج المسح الثلاثي الأبعاد كانت حوالي (3340 كم 2) ، وتم التقاط وتفسير وتعقب عاكس الزبير ضمن منطقة الدراسة ، والتقطت الفوالق التي تؤثر على هذا العاكس في المنطقة ، وتم تحضير خرائط الزمنية والسرعية والعمقية للعاكس ، والتي أظهرت وجود ملامح انغلاق تركيبي في جنوب شرق المنطقة ، بالإضافة إلى وجود امتدادات للأنوف التركيبية في الشمال الغربي من منطقة الدراسة ، وأظهرت الصورة الإنشائية وجود ميل عام باتجاه الشرق وكذلك وجود صدوع رئيسية في المنطقة الممتدة باتجاه الشمال الغربي – الجنوب الشرقي.

*Email: ahmed.said1208m@sc.uobaghdad.edu.iq

1. Introduction

The reflection method has shown to be the most effective seismic approach for finding subsurface geologic conditions conducive to oil and gas formation [1]. The importance of seismic methods provides more specific details than other geophysical approaches (high accuracy, high resolution, and significant penetration). The seismic method is widely used in hydrocarbon exploration [2]. In most cases, seismic surveys include three main steps, data acquisition, processing, and seismic interpretation. First, the seismic wave is generated and then reflected, and processing steps are applied to form a stacked seismic section suitable for interpretation [3]. The seismic interpretation techniques used two main interpretation tools; the travel-time tool (for Structural interpretation) and the waveform tool for stratigraphic interpretation [4].

Because of the importance of the economy, the Zubair Formation is the most significant formation of the Lower Cretaceous sequence in Iraq [5]. The formation is assumed to represent a prograding delta from the Arabian Shield [6-7]. Ali and Kadhim [8] have achieved a study using the seismic reflection method to investigate the subsurface geology of the Zubair Formation in Al-Akhadeir area northwest of the study area and concluded that the Zubair Formation represents clastic facies with a delta front environment that is represented by two transgressed stand system tracts (TST) [9].

The Zubair Formation consists of a succession of shale, sandstone, and siltstone, ranging from 350 m to 500 m thick [10]. The formation represents the coastal sedimentation sequences and partly the deltaic environments resulting from the erosion of the Arabian Shield and the stable platform [11]. This research shows the structural picture of the formation in the region and indicates the possibility of oil development by giving a geological subsurface picture.

The study area is within the governorates' administrative borders of Karbala, Najaf and Babylon (Table 1). The most significant part of the area includes all the districts and eastern areas in the governorate of Karbala. Lake Al-Razaza borders it from the northwest, and the southern part of the study area extends to cover the north of the Najaf governorate. The area included part of the areas adjacent to the western borders of the province of Babylon (Figure 1).

According to the division of Boday (1980), the area falls within the Al-Salman Al-Jazirah Zone (the stable shelf), except for the eastern and northeastern parts of the area located within the Mesopotamia basin [12]. The stable shelf is characterized by its sediments that were not affected by the Alpine orogeny movements but were affected by descending tectonic movements (Subsiding) and others (Uplifting), and the other parts are located within the basin of Mesopotamia (Figure 2).

Table 1: The coordinates of the study area.

Point	UTM System	
	Eastern	northern
A	432468	3549316
B	389444	3556868
C	389136	3628085
D	434729	3627289

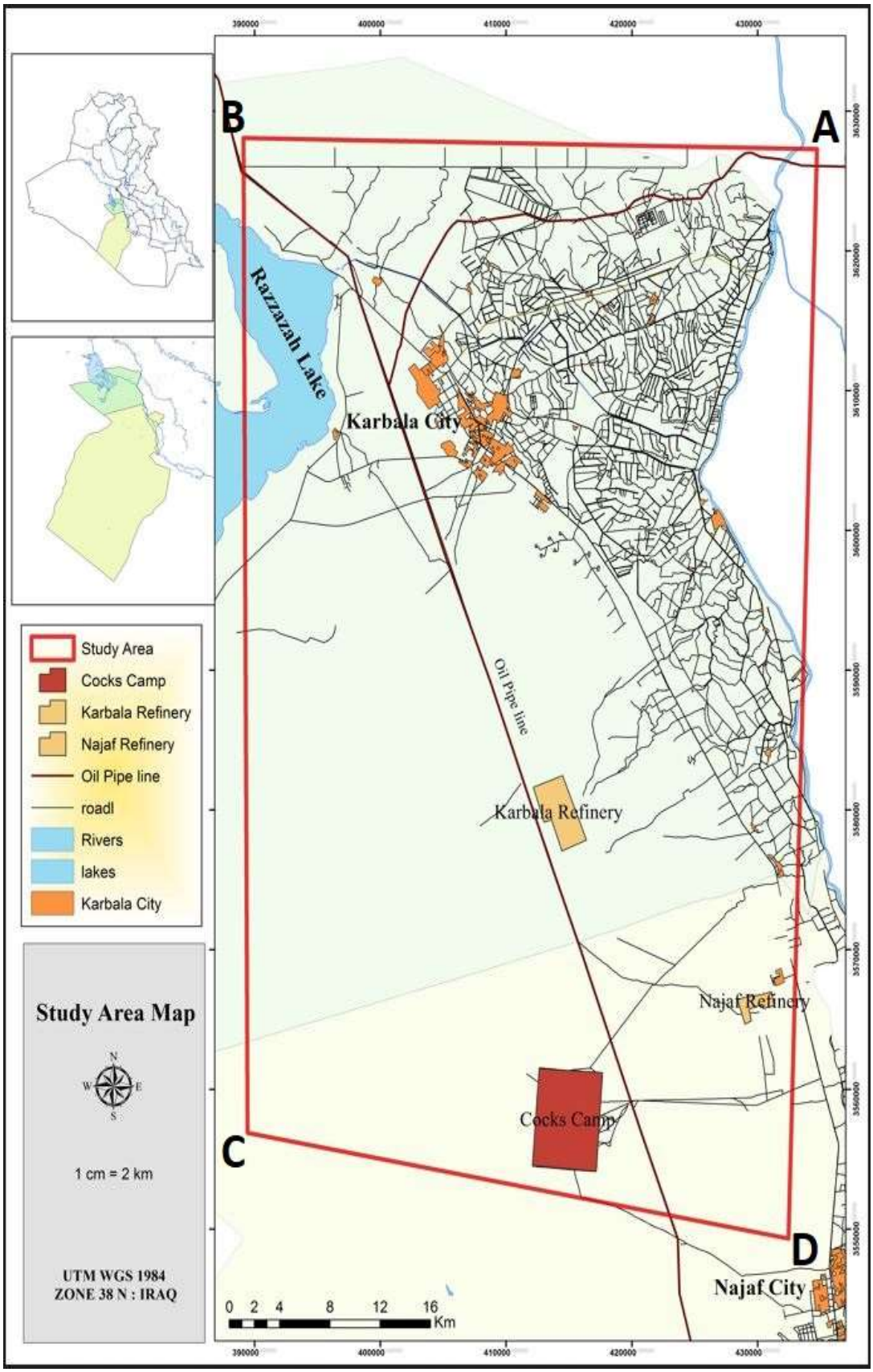

Figure 1: Location map of the study area.

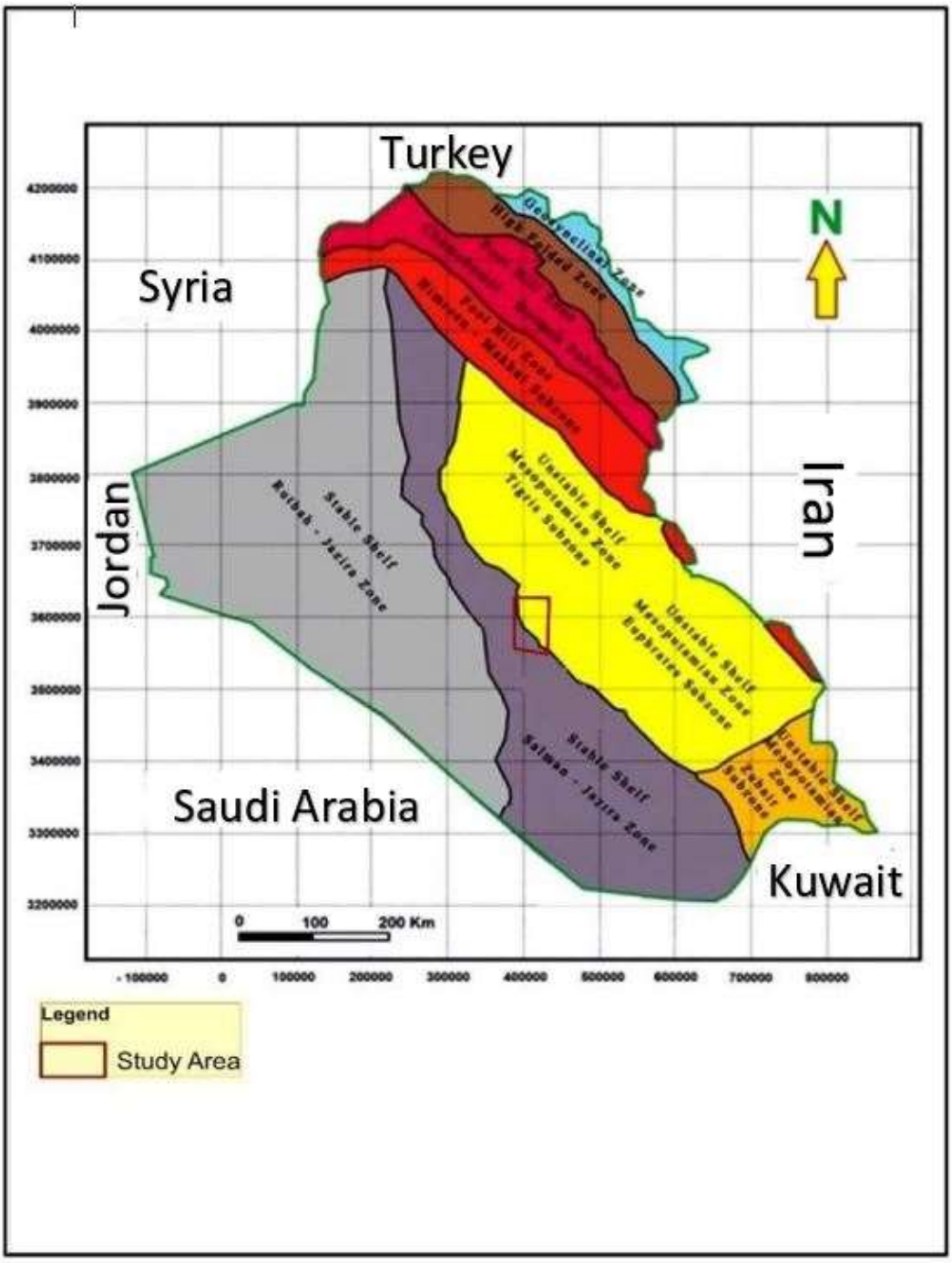

Figure 2:The structural map of Iraq shows the study area [13].

2. The data used in the study:

1- The seismic cube of the Najaf Karbala three-dimensional area (PSTM) was loaded into the seismic interpretation program (Petrel-2018) [14].

2- The well-data and records (top formations, check shots, and well log) were used (Figure 3).

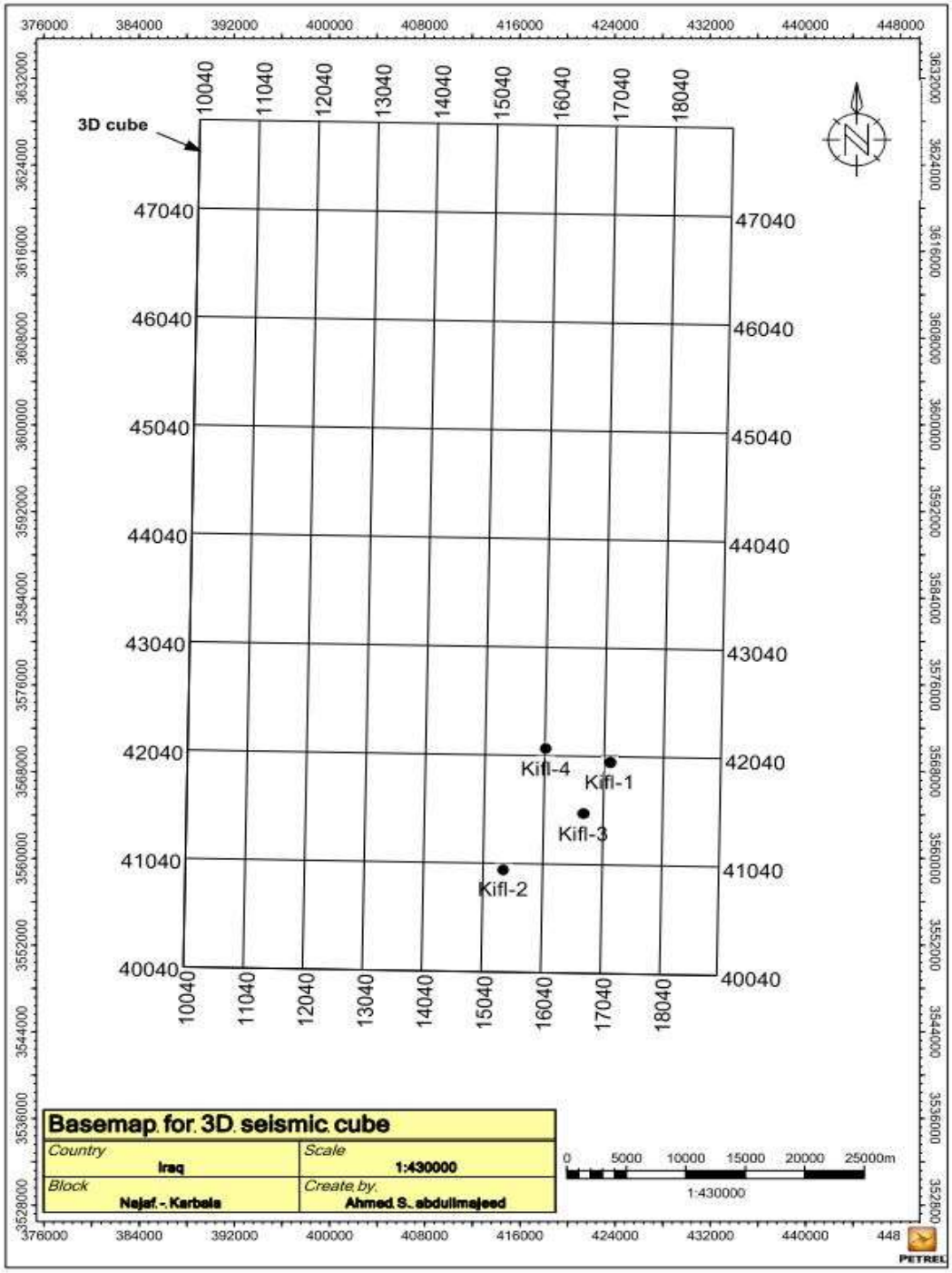

Figure 3: A basic map showing the surface boundaries of the three-dimensional seismic survey program in the Najaf-Karbala region.

3.The Interpretation Procedure

The translation of seismic data information into geological terminology is known as geological interpretation. Seismic data interpretation was carried out on an interactive workstation, a high-powered computer with specialized programs. Interactive software is used in conjunction with the interpreter to speed up and improve the accuracy of the interpretation process. The following are the primary steps in the interpretation process employed in this study: (Figure 4)

1- Inserting (KF-1, KF-2, KF-3 and KF-4) well information, including (well top, check-shot, sonic log, and density log).

2- Loading the 3D seismic cube for the area.
3- Draw a polygon to mark the area for which seismic data is available.
4- Well to Seismic tie (generated synthetic seismogram).
5- Identifying the study's interesting reflector Zubair.
6- Construction surface map for the above-selected reflectors in two-way time (TWT).
7- To get the average velocity maps, build a velocity model for the studied reflections. This map was used to transform time-domain TWT maps into depth domains to build depth maps for the selected reflectors.
8- The seismic attribute has been applied to interpret and analyze seismic sections, especially in interpreting faults.

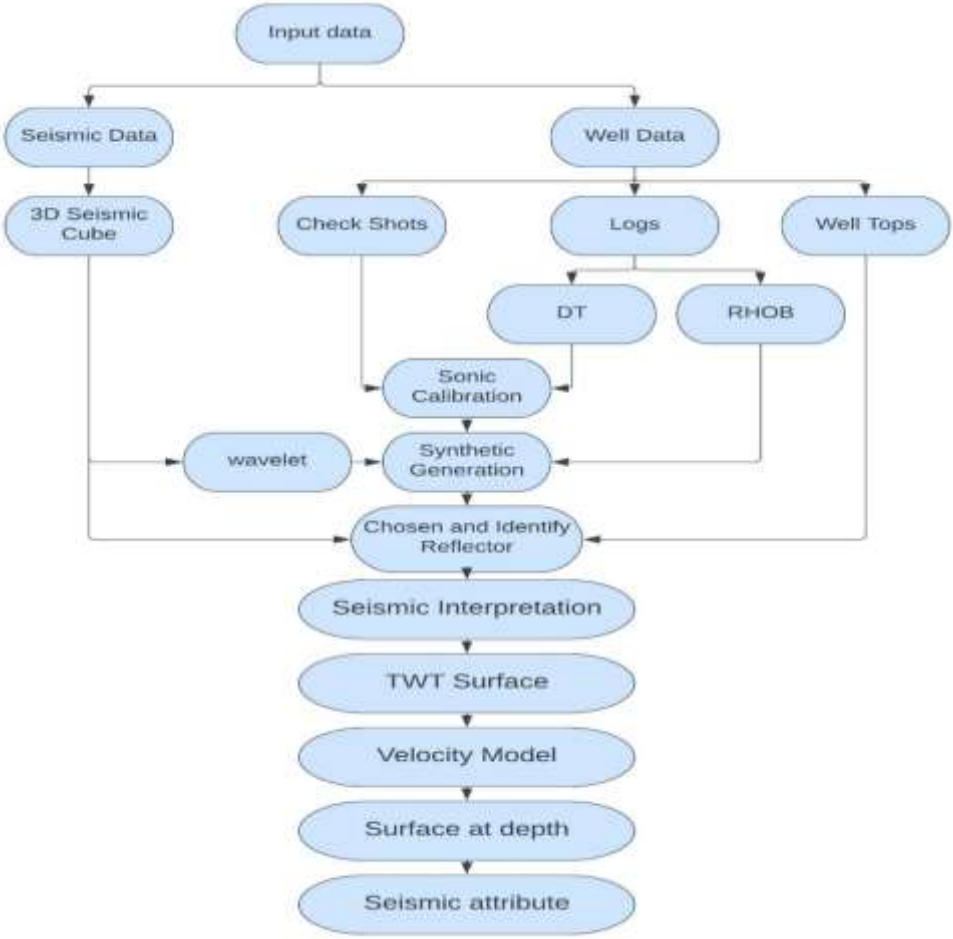

Figure 4: Flow chart of seismic interpretation procedure**.**

4.Structural interpretation of the picked horizons and faults

The Zubair reflector, which has good to very good quality and continuity, was installed and traced, and the interpretation was performed automatically and manually for the reflector. The number of interpreted seismic sections reached 1,792 west and east, and the reflector showed a huge match with the seismic lines embedded when they were matched and calibrated (Figure 5). The faults in the geological section were explained and traced using the seismic attributes, especially the (variance attribute) which is a very effective tool for delineation faults on both horizon slices and vertical seismic profiles. Variance attribute proved to help to image channels and faults [15] used to display the major fault zones, fractures, unconformities and the major sequence boundaries (Figure 6) directly. The

Variance attribute indicated the presence of the faults also, it was confirmed during the traceability of the fault drawn on the geological section.

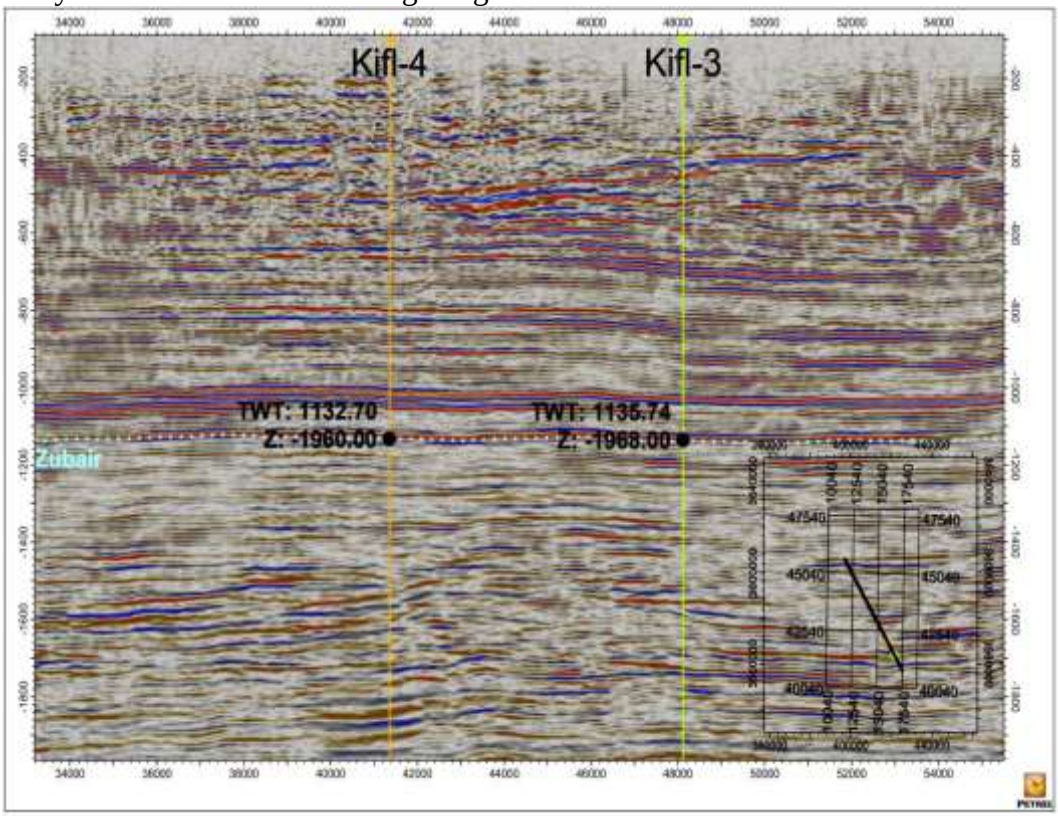

Figure 5: The seismic section shows the traceability of the interpreted reflectors at the sites of Kifl-3 and Kifl-4 wells.

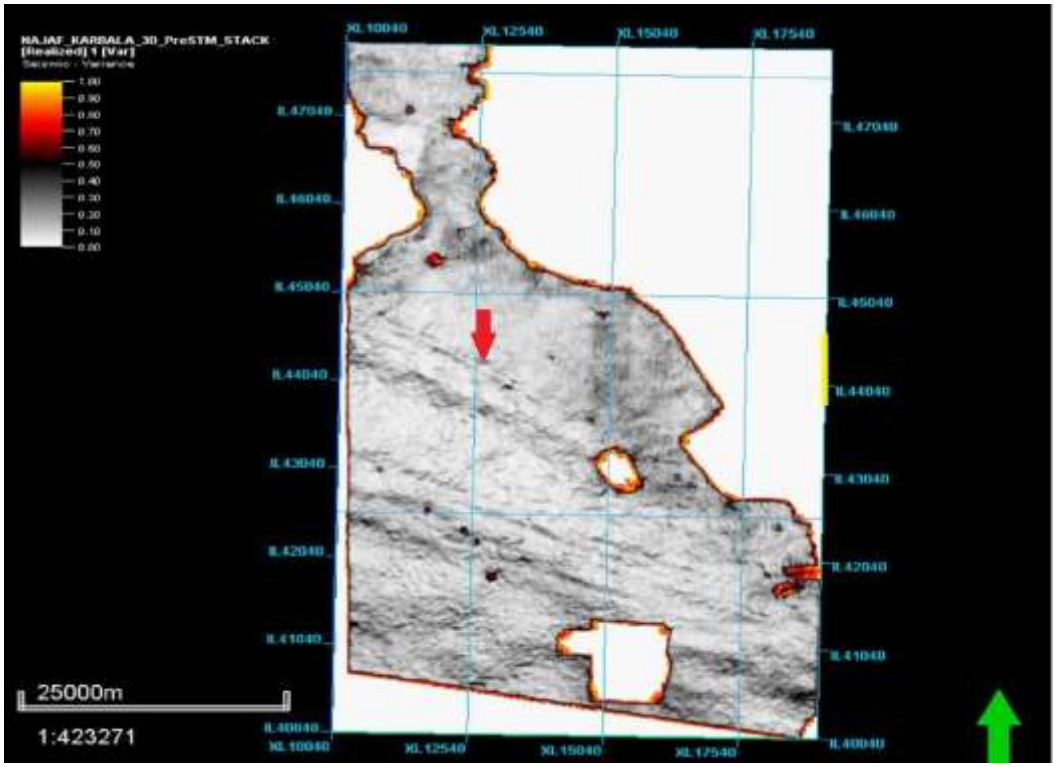

Figure 6: Use the Variance attribute on the study area; a red arrow highlights an example of the variance attribute-showing fault. The darkest regions, which make vertical strips, might suggest fracture zones

5.Two-Way Time (TWT) map of top Zubair reflector

The studied reflector's structural maps are drawn in the time domain after the reflector and faults of the seismic data have been captured and tracked. The time map showed a general trend for the studied reflector towards the east and northeast, where the values of time levels increase in those directions and decrease towards the west and southwest. The structural time map showed that the Kifl-1, Kifl-2, Kifl-3 and Kifl-4 wells are located on a structural nose axis extending north-south, representing the Al-Kifl structure field is located to the east and southeast of the study area (Figure 7).

The map also showed that the study area is affected by faults (solid black lines on the map) of the normal type with a small displacement that increases with depth. These faults extend towards the northwest-southeast and at a relatively small angle. It is noted that the contour levels converge in the structural map from one level to another in the time domain. It reflects an increase in the slope of the reflectors with an increase in the formation depth (Figure 8).

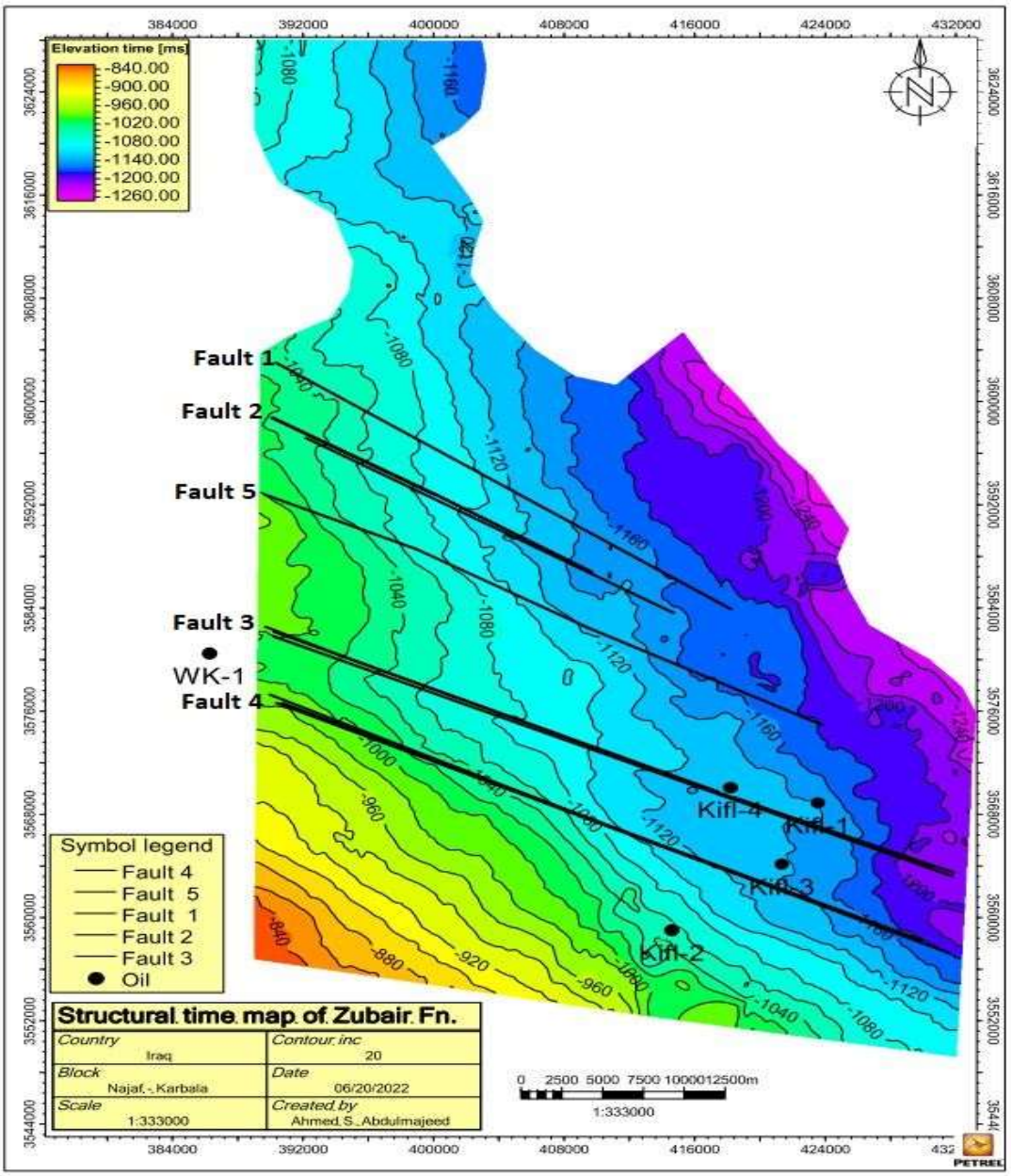

Figure 7: The Two-way Time (TWT) map of Zubair Formation in the area.

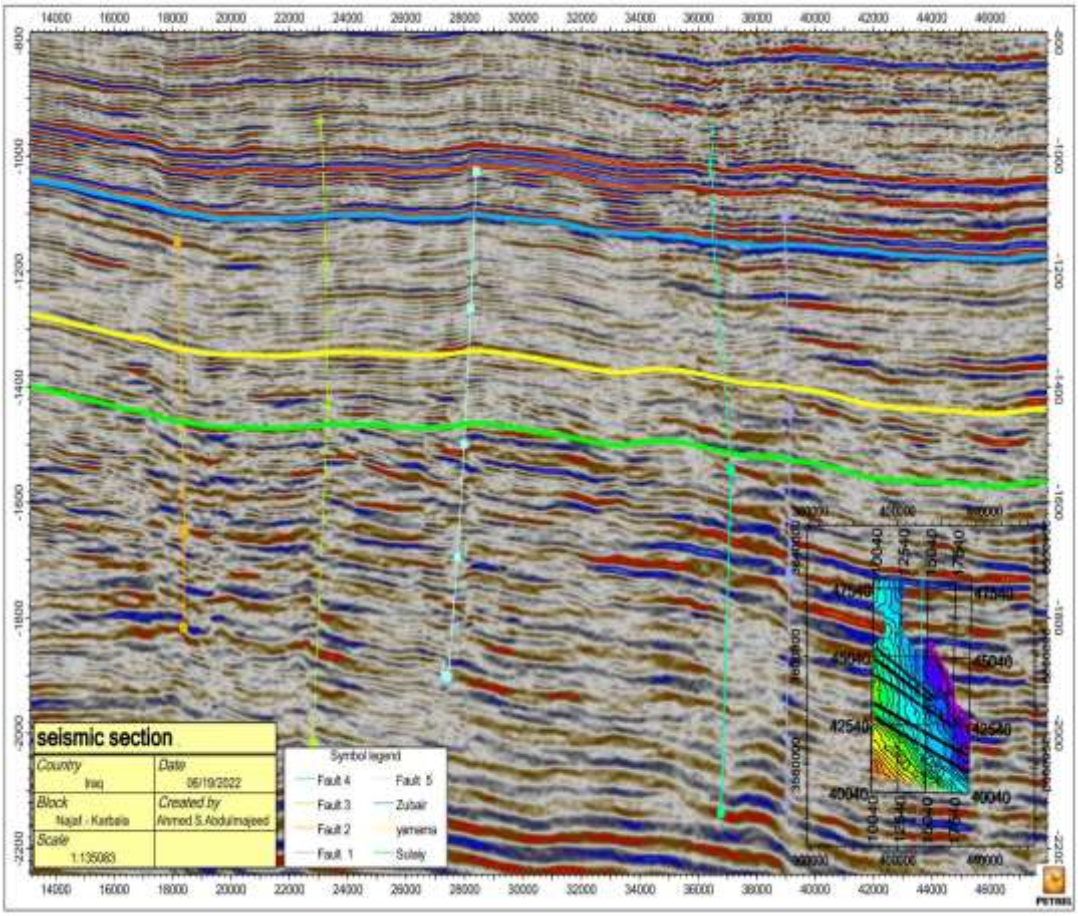

Figure 8: Seismic section shows the fault in the area (14540 xline).

6. Velocity map

The velocity model of the study area was constructed based on the values of the average velocity of the Al-Kifl field wells located within the study area, which is a three-dimensional cube suitable for converting the structural maps from the time domain to the depth domain.
The average velocity map at the level of the Zubair reflector showed that the average seismic velocity values within the study area ranged between (3380-3500) m/sec and that the velocity values increased in the west and southwest directions and decreased in the east and northeast directions of the study area (Figure 9).

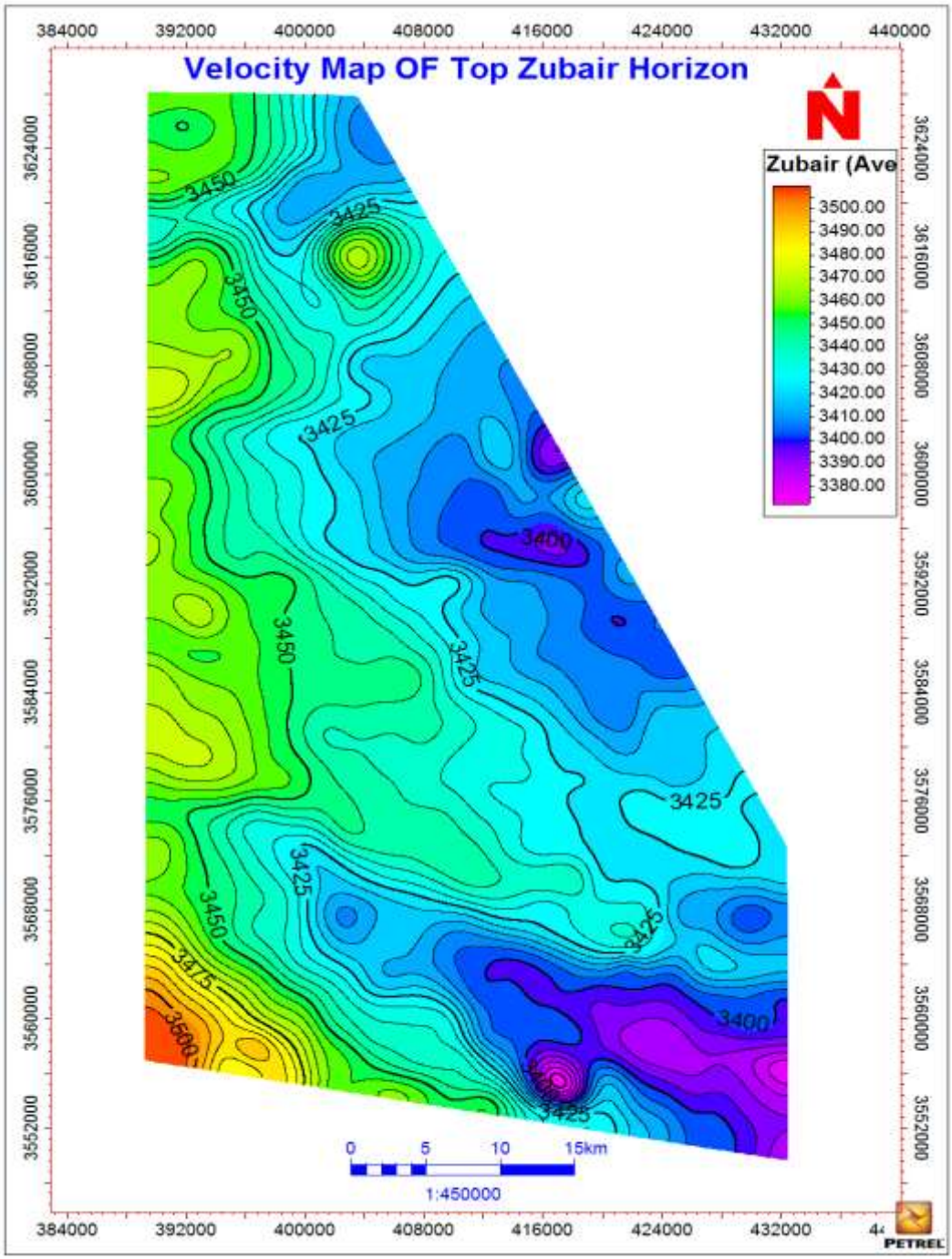

Figure 9: The velocity map for Zubair formation

7. Depth map

After converting the structural map from the time domain to the depth domain using the velocity model, a level period of 10 meters for the color scale was used, and the sea surface was adopted as a unified reference level for this map, which is the same as the reference for three-dimensional seismic data, time and velocity maps.

One of the most important principles of the reflection method is that the structural image of depth maps is similar to the image reflected by time maps but with different dimensions and several closures.

All the depth maps showed a general tendency of the layers towards the east and northeast, where the values of the depth levels increase in these two directions and decrease in the southwest direction. The map also showed an indicator of a structural closure located in the eastern part of the region, likely forming a structural anticline (Figure 10).

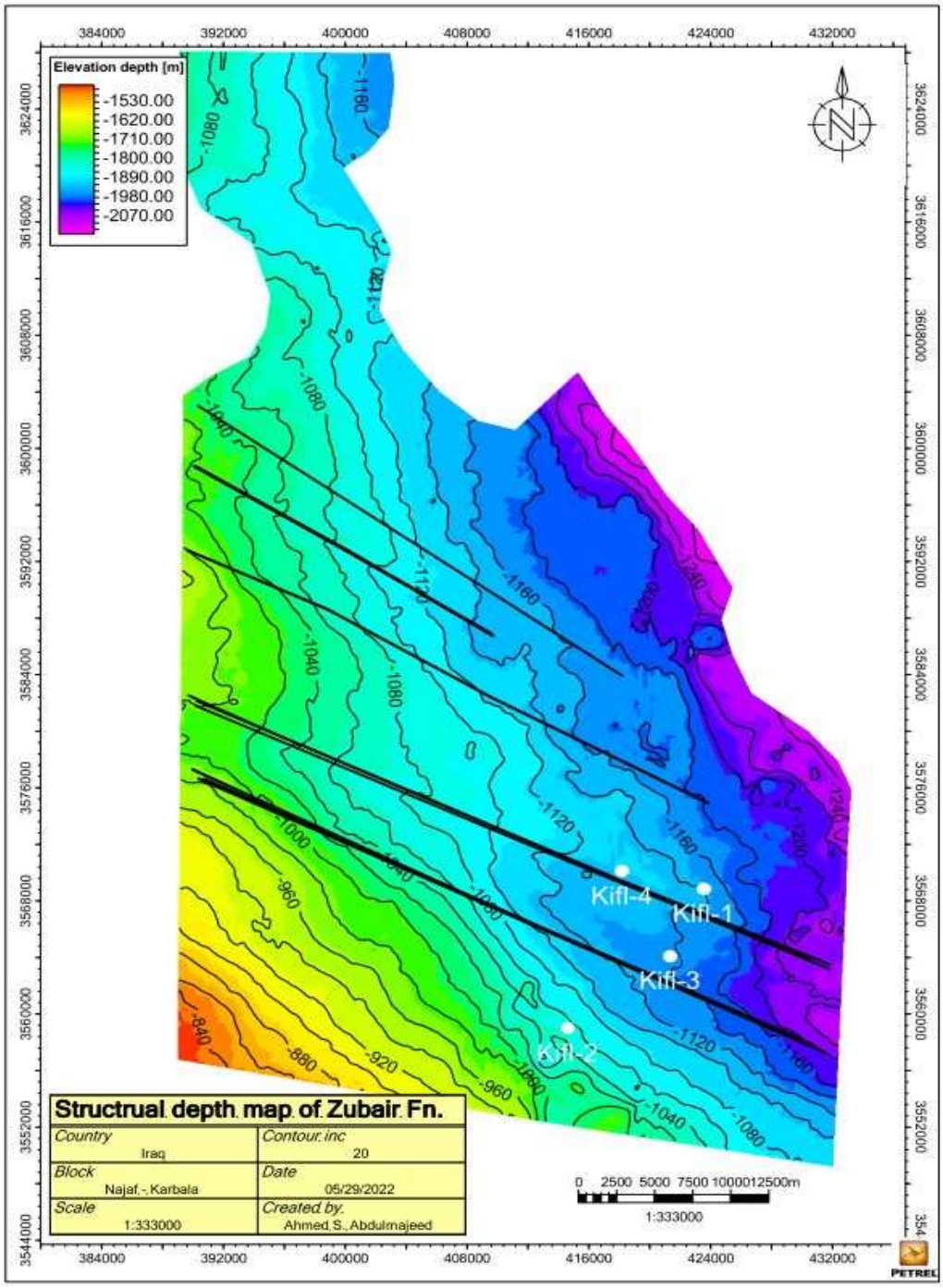

Figure 10: The depth map of Zubair Fn.

8. Conclusion

1- Time, velocity, and depth maps of the Zubair reflector were created, and the structural features were shown on them

2- The temporal and depth maps showed the presence of an indicator of a structural closure in the southeastern part within the reflector represented by the Al-Kifl field and the presence of extensions of structural noses in the northwestern part of the study area.

3- The main faults were picked in the region. It represents normal faults as they extend from the northwest to the southeast and have a small displacement, increasing with increasing depth.

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