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2D Seismic Stratigraphic Analysis of Harthaand Kifl Formations in Balad Area– Center of Iraq

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Abstract

An interpretive study of the two-dimensional seismic data of the Balad area was carried out. The study area is important due to its location within the oil field zone and still without exploration wells. A synthetic seismogram with good matching with the seismic section was done, to ensure the identification of reflectors and reflectivity type: peak or trough following each one through the whole area. Top Al-Hartha and Al-Kifil formation reflectors were picked using the composite line to link the seismic sections with each other after enhancing the tie between seismic lines. Time and depth maps were made using velocity maps created from the velocity model. The seismic interpretation showed the existence of certain stratigraphic features in the studied reflector. Some distribution grabens in the study area are continuous in more two-dimensional seismic lines. By calculating the difference in depth values between the Al-Hartha and Al-Kifl formations, an isopach map of the Al-Haritha Formation was obtained. The minimum thickness of the Hartha formation is approximately 250 m in the center, While the highest thickness of the formation was 650 m in the southwest of the study area. These activity elements provide a reasonable explanation for the distribution of hydrocarbons in the area of study.

Keywords: *Seismic stratigraphy, Hydrocarbon indicators, Al-Kifl Formation, Seismic reflection.*

1. Introduction

Stratigraphical interpretations of seismic data require clarification of the seismic sections and give them the geological marker of the component of the earth's content within the known geological basis and principles, including good information and the expected geological changes in the area. Seismic Stratigraphy is divided into seismic-sequence (facies) analysis and reflection-character analysis. It determines the nature of sedimentary rocks and their fluid content from the analysis of seismic data.

In seismic-sequence analysis, the first step is to separate seismic-sequence units, which are also called seismic-facies units (Lessenger, 1988). From seismic sections processing and identifying the sedimentation situations in the region and the available petrophysical studies, we can pick up the seismic reflectors as well as the characteristics of rocks and fluids in general (Haq et al., 1987). For the first time, an interpretation was attempted in terms of seismic stratigraphy (not yet formalized at the time) by examining the lateral and vertical variations of the reflections and units consisting of several reflections in a homogeneous sequence (Ravenne, 2002). The geophysical studies history regarding hydrocarbon accumulations began in the last century when the seismic reflection method was used to detect the accumulations of hydrocarbons (Berg, 1982).

The seismic method can be looked the most important geophysical technique in cost and number of geophysicists obligated. The spread of This method compared with other geophysical methods is due to many factors such as the accuracy results, great resolution, high penetration, and considered as an over wide used in petroleum exploration (Hart, 2004).

Several authors have studied seismic attributes derived from seismic data that can be used in seismic-stratigraphic interpretation [Taner et al. 1979; Marfurt, 2005; Ali and Kadhim, 2019; Nassir et al. 2021; Ali et al. 2021].

Numerous studies have been focusing on the Cretaceous succession in Iraq because it is the largest productive reservoir which contains about 80% of Iraq's oil reserves. One of the most important carbonate reservoirs in the southeast of Iraq is the Zubair Formation which contains oil in structures of more nearest oilfields (Khorshid and Kadhim, 2015)

Albeyati et al., 2021interpreted the 3D seismic reflection data for the Kifl oil field to detect the Zubair Formation and how the oil is trapped in it. Fadhil (2010) analyzed the 3D seismic reflection data for the Kifl oil field to delineate the seismic stratigraphy of the Lower Cretaceous Formations. In the study area and the regions to its east, a seismic reflection survey was conducted by the Iraqi Petroleum Exploration Company several times during the years 1979-1984.

Abdul-Rahman, 1997 studied some of the seismic sections of the southern Hamrin region, preparing depth maps for each of the Fatha, Injana, and Al-Juraibiformations.In 1990, a reinterpretation of previous seismic data was carried out, and the Balad structure at the intra-Hartha reflector is an anticline (faulted traps) located southeast of the study area where the Ba-2, 5, 6, and 7 wells were drilled. Also, two small closures

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(faulted traps) located northwest of an Anticline, separated by two saddles where Ba-3well was drilled in the second saddles. The presence of the main graben consists of small structural faulted traps on both sides of the graben, where the Ba-1, 4, and 8 wells were drilled (figure 1-13). All these structural features extend in the NW-SE trend.

The current study aims to build the seismic depositional models of the Hartha and Kifl Formations in the Balad area. Reflection patterns and reflection amplitudes are interpreted to determine bed thicknesses and depositional environment.

2. Materials and methods

2.1. Description of site and stratigraphy

Based on the geological map of Iraq issued by the General Organization for Geological Survey and Mining in 1990, the study area is flat land with some simple elevations ranging from (48-58 m)and increases in height towards the northeast. This area is characterized by agriculture, many orchards, irrigation projects, marshes, and swamps, as well as the presence of residential areas, and civil and military facilities. Recent and Pleistocene sediments represented by alluvial deposits and river terraces covered all the studied areas as shown in Figure (1). The rocks of these formations generally consist of muddy muddy deposits with sand and gravel (Abdul-Rhaman, 1997). Balad field is one of the Iraqi oil fields where 9 oil wells were drilled according to two-dimensional seismic surveys. Figure (2) shows the generalized stratigraphic column of the Balad oil field and adjacent area (JAPEX Company, 2006). In general, the formations of Pliocene to late Jurassic are characterized by increased thickness towards the east of the region and the Mesopotamia foredeep, while the thickness of older formations (late Jurassic to the early Triassic) is decreasing towards the northwest part of the region.

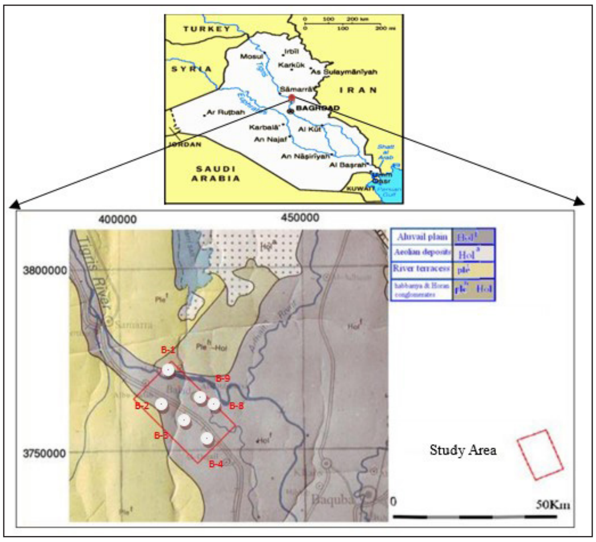

Figure 1. Surface geology map of the study area and surroundings, after (the State Establishment of Geological Survey and mining)

Structurally Balad field is divided into two sectors: • The first sector is located within the major graben area, which includes the wells Ba-1, 3, 4, and 8. • The second sector is located outside the major graben area (east shoulder, which includes the wells Ba-2, 5, 6, 7 and 9.

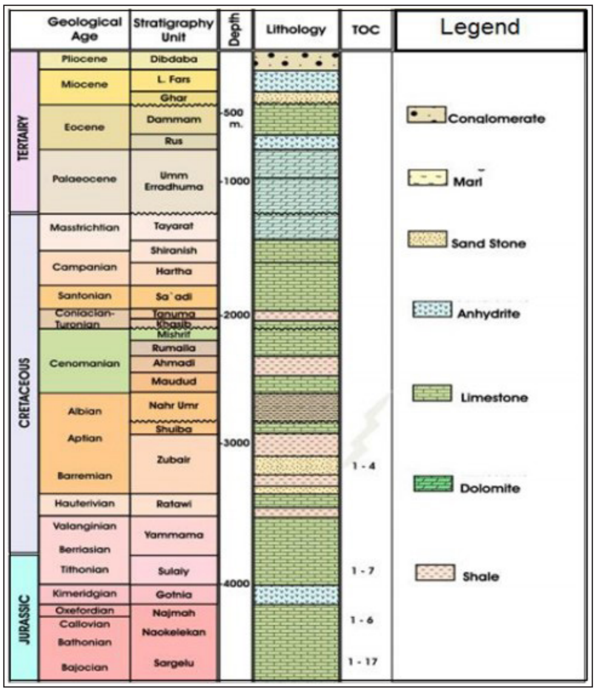

Figure 2. Generalized stratigraphic column in Balad and adjacent area, after (JAPEX Company, 2006).

2.2. Processing of seismic data

The selection of field techniques before implementing the seismic reflection surveys leads to improved field recordings, in other words, to improve the signal-to-noise ratio. These options which are decided by the geophysicist contribute to determining the number of controls including the length of the seismic trace, the fold of coverage, the distance between the traces, and others. It is worth noting that the study area is within the survey areas of Baquba– Samarra (BS) and west of Tikrit–Makhoul (WTM). The main objective of processing seismic information is to convert the recorded seismic information into a picture that greatly facilitates the process of geological interpretation. A large number of researchers have addressed the processing steps [Telford, et al. 1970; Dobrin, 1976; McQuillin, et al. 1984; Yilmaz,1987; Al-Sadi, 2017].

Several processing steps were applied to the seismic sections studied in the present paper, these steps are True Amplitude Recovery (TAR), Common Depth Point gathering (CDP Gather), Data Editing, Time-Variant De-convolution (TVD), Time-Variant Scaling (TVS), Static Correction, Velocity Analyses, Normal-Move-Out (NMO) Correction, Mute, CDP Stack and Time-Variant-Filtering (TVF). Additional processing was done for each seismic section namely, Residual Static Correction, Coherence, Migration in tilted areas, Wavelet Process, and 3D-Processing.

3. Results and Discussions

3.1.Two-Way-Time (2To) maps

Quantity two reflectors were picked in this study which represent the Upper Cretaceous age and they are:

- the First reflector represents the top Hartha Formation.
- the Second reflector represents the top Kifl Formation.

Hartha was picked to understand the type of faults and their effect on Balad field construction to get the final structural and geological models image of traps in the Balad field. The continuity of the picked reflector can be described as top of Hartha reflector has moderate continuity and Kifl reflector has good continuity. Seismic sections show the concordance of reflectors to be good, especially at the Tertiary Formations. While at the Upper Cretaceous Formations, the seismic sections with geophysical and geological models show that there is a variation of reflector thicknesses, especially in the graben areas, this is due to the presence of the structuralandstratigraphicfeatures.

The TWT maps can be described as a major graben area (faulted syncline) over the area and have variable widths (4-4.5km) in the southern part and the east and west shoulders of the major graben. The major graben and its shoulders are separated to the north and south parts by a Strike-Slip fault-dominated E-W trend. Thus, the study area is divided into the following regions: • The north and south graben areas (faulted Synclines) dominated with NW – SE trend. This area contains small secondary normal faults formed by elongated narrow traps at the right side of the major graben area.

The east shoulder of the major graben is divided into two parts (south and north). The south part is a faulted nose confined by the south major graben fault, which represents the Balad field trap. The north part is a horst area confined by north major graben and other local graben faults. The time maps show that the Balad field trap and the horst have one axis dominated by NW – SE trend and shifted by the strike-slip fault. The west shoulder of the major graben represents an open nose dominated by the NW – SE trend and located in the northwest part of the area. Figures (3 and 4) represent the TWT maps with contour intervals (10ms) for the studied reflectors.

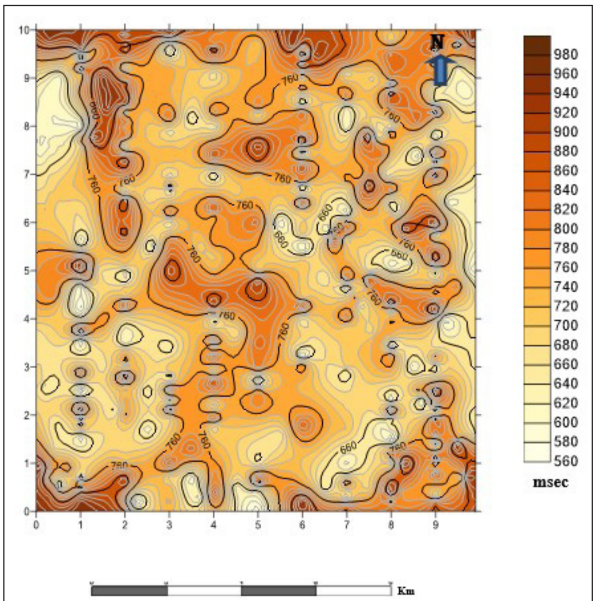

Figure 3. Two way time map of top Hartha Formation.

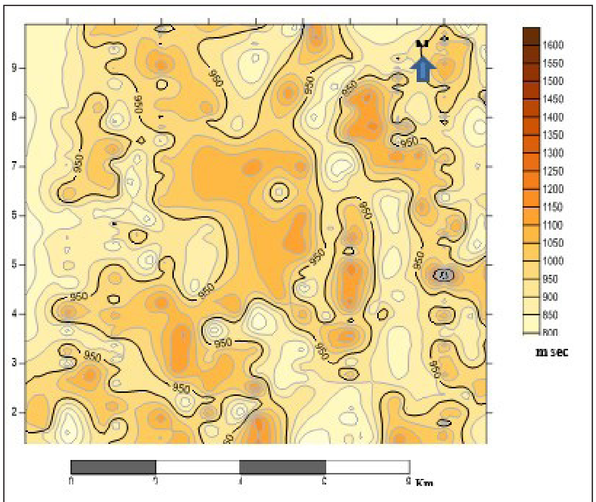

Figure 4. Two-way time map of the top Kifl Formation.

3.2. Velocity maps

The average velocity is the suitable velocity that is used to convert the TWT maps to depth maps. It is considered the more accurate velocity type used in seismic methods and can be computed directly from a good velocity survey (check shot) (McQuilline, et, al 1984). In the study area, there are 6 wells (Ba-1, 2, 3, 4, 8, and 9) with average velocity values from check shot logs which are used, but (Bd-5, 6, and 7) wells don't have check shot logs, therefore, the TWT time values at well locations and depth values from good markers are used to obtain average velocity values of the studied reflectors; but it's not enough velocity values to cover all the study area. Thus, the stack velocity values provided by the processing department and printed on 2D seismic paper sections were used.

First, the average velocity maps are drawn from the good data for all studied reflectors. Stack velocity values were computed along with the studied reflectors from the velocity boxes. The average values of the velocity of each neighbor's group of stack velocities values were taken. Thus, the stack velocity maps were drawn and smoothed to all studied reflectors, because the stack velocity has values more than the average velocity values, the differences in velocity values between them were calculated and removed from the stack velocities map to get the final velocity maps for studied reflectors in the studied area.

This method offers a good distribution of velocity points in the study area. The velocity maps of studied reflectors show the following: •The top Hartha velocity values increase in the south and there is local closure in the middle of the area representing an increase in velocity values. The magnitude of velocity values ranges in the top Hartha velocity map from (2680 to 2920 m/sec) (figure5). • The top kifl velocity values increase in the south and there is local closure in the middle of the area representing an increase in velocity values. The range velocity values range in Kifl velocity map from (2800-3040 m/sec) (figure 6).

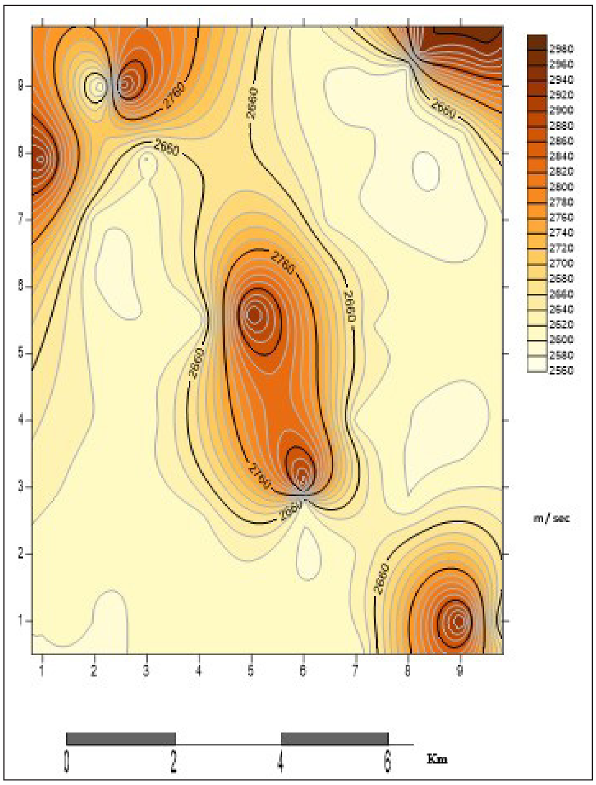

Figure 5. Average velocity map of top Hartha Formation.

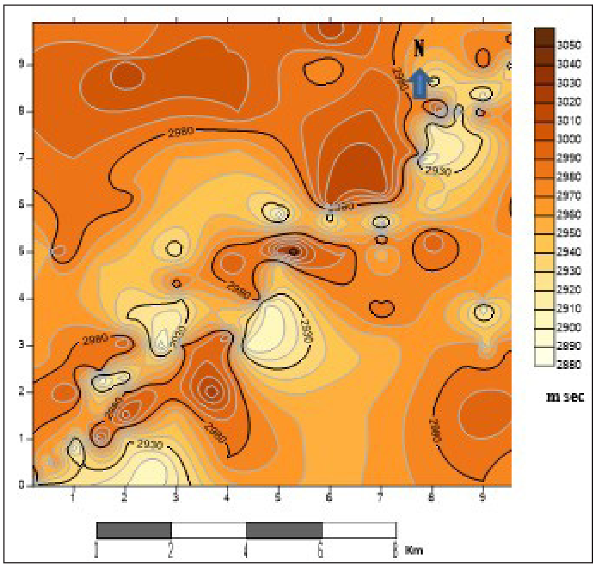

Figure 6. Average velocity map of top Kifl Formation.

3.3. Depth maps

In seismic methods, the depth map is established by using the time map of a given reflector with its velocity map, as follows:

Depth at any point = (velocity × time) at this point.

In the seismic reflection method, a map of the top of a geologic formation reflects the geologic image below the surface. Thus, the depth maps also show the same picture of the studied formations, but the difference lies in the closures dimensions, number of contour intervals between these maps, faults displacements, and difference in the number of minor faults located in major graben areas. The structural picture can be described as a major graben area (faulted syncline) along the study area with the east and west shoulders of major graben.

The major graben has variable dimensions (4-4.5km) in width, large displacements of about 400m, large throw of about 300m, and heave of about 265m in the left side of the south graben at the top Kifl Formation. Figures (7), and (8) represent the depth maps with contour intervals (10m) for studied formations.

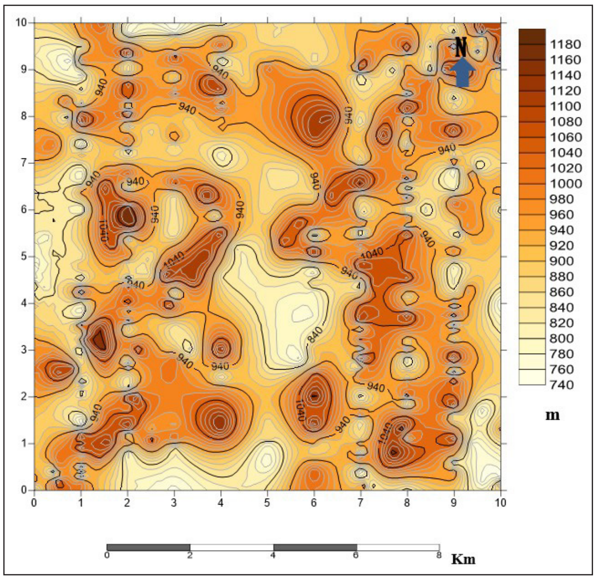

Figure 7. Depth map of top Hartha Formation.

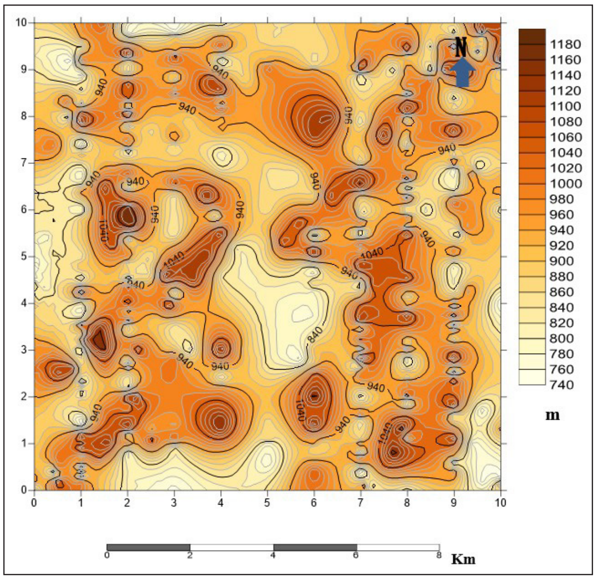

Figure 8. Depth map of top kifl Formation.

3.4.Isopach map

By calculating the difference in depth values between the Al-Haritha and Al-Kifl formations, an isopach map of the Al-Haritha Formation was obtained (Fig. 8).

The minimum thickness of the Hartha formation is approximately 250 m in the center, While the highest thickness was 650 m in the southwest of the study area. The average thickness value of the formation is approximately 450 m for most of the study area.

When a comparison is made between the depth map of the Hartha Formation and the isopach map of the formation, it becomes clear that the depression in the depth map is accepted by the lowest thickness values. the depth of the formation in the center of the map has the lowest values of about 250 m, while the depth values for the same area range from 990 m to 1040 m. Since this formation represents a reservoir, we expect that the presence of oil in the northern, southern, and western sections will be more quantitative compared to the central and eastern settlements of the study area. This is based on the heterogeneity of formation thickness values between the different parts of the area. This is based on the heterogeneity of formation thickness values between different parts of the region. On this basis, the southwestern part can be considered more abundant for oil, as the formation thickness reaches more than 650 m.

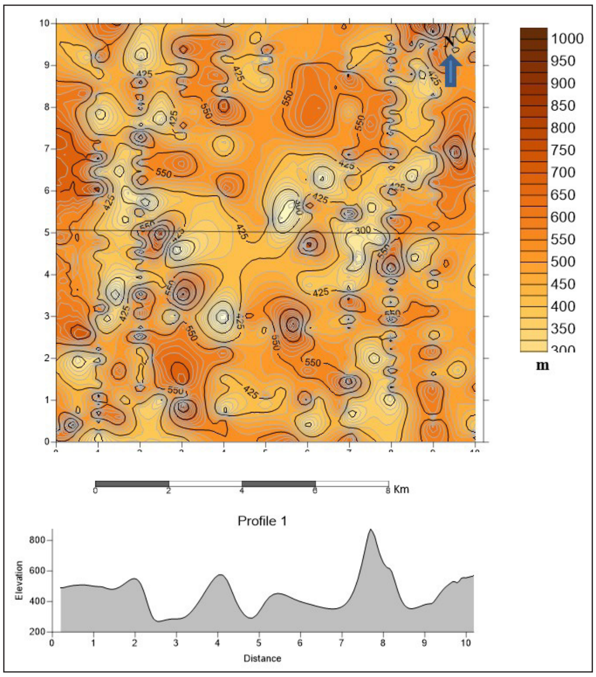

Figure 9. Isopach map of Hartha Formation.

4. Conclusions

The time and depth maps show many nose structures located at NW and SW the studied reflectors bearing E-W, NE-SW, SE-NW with a general slope towards the southeast. These monoclonal structures are a result of the compressional tectonic phase in the Middle Cretaceous-Tertiary time. This is because of the convergence between Arabian Plate (AP) and adjacent plates; however; subduction of AP beneath the Eurasian plate event has occurred. Velocity maps show an irregular increase in depth due to the inhomogeneity of the sedimentary layers as a result of different facies and depositional environments.

The study area was affected by three faults, and only one of them, which is a normal fault with a small offset reached the studied reflectors. Its trend (NW-SE) was shown to be parallel to the collision stretching between the Arab and Iranian plates, which formed due to tension stresses maybe belongs to either the Najd fault system (Precambrian faults) or Abo-jir fault which is located to the west of the studied area .This is because of the convergence between Arabian Plate (AP) and adjacent plates; however, subduction of AP beneath the Eurasian plate event has occurred. Velocity maps show an irregular increase in depth due to the inhomogeneity of the sedimentary layers as a result of different facies and depositional environments.

As further future work the following recommendations are important:

Re-interpretation of the northwest and southwest part of the studied area, and outside the studied area by using available 3D seismic data. Structurally, the area is considered a promising hydrocarbon area; therefore, re-interpretation gives more details about apparent structural phenomena which are maybe closed outside the studied area to the northwest and define faults systems more precisely.

3D interpretation of seismic data to obtain high-resolution power for recognition of a stratigraphic feature on the time sections and attributes section.

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