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Structural and Stratigraphic Interpretations for Mishrif Formation in Kumait Oil Field, Using Seismic Reflection Data, Southern-Eastern Iraq.

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Abstract

The Kumait oil field is located in the Maysan Governorate southeastern Iraq, which was studied and interpreted by using 2D and 3D seismic data provided by the Oil Exploration Company using Petrel software. The study concerned the Mishrif Formation belongs to the Cretaceous Age. The reflector was detected based on synthetic seismograms and well logs for Kt-1 well. Structural maps (two-way time, velocity, and depth) were derived from seismic reflection interpretations to show several structural features, such as four isolated irregular enclosures representing the Kumait structure plunging NW-SE and demonstrating that the Kumait oil field is influenced by the Najd fault system trending NW-SE. The stratigraphic interpretation used the variance attribute to delineate the edge of the fault, which extended from the Mishrif Formation with a depth of 3090m and used the Direct Hydrocarbon Indicators (DHI) to identify the stratigraphic features in the research region and the extraction of seismic attributes. The applied seismic attributes, such as the instantaneous phase, show dim spots, flat spots, and mounds and is followed by down-lap; the instantaneous frequency, which offers low-frequency areas indicating a high probability of hydrocarbon accumulation; and the RMS amplitude, which shows high amplitude in the seismic data that conforms to the structure and confirms the presence of hydrocarbon.

Keywords: Kumait oil field, Synthetic Seismogram, Structural interpretation, Stratigraphic interpretation, Fault system, Seismic attributes.

التفسيرات التركيبية والطبقية لتكوين المشرف في حقل كميت النفطي، باستخدام بيانات الانعكاس الزلزالي، جنوب-شرقي العراق.

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الخلاصة

يقع حقل نفط الكميت في محافظة ميسان جنوبي شرقي العراق ، جرت دراسته وتفسيره باستخدام البيانات الزلزالية ثنائية وثلاثية الأبعاد مجهزة من شركة التنقيب عن النفط باستخدام برنامج Petrel. تهتم الدراسة بتكوين المشرف الذي ينتمي إلى العصر الطباشيري. اكتشف العاكس بناءً على مخططات الزلازل الاصطناعية وسجلات الآبار لبئر Kt-1. اشتقت الخرائط التركيبية (الوقت ذو الاتجاهين ، السرعة ، والعمق) من تفسيرات الانعكاس الزلزالي لإظهار العديد من الميزات التركيبية ، مثل أربعة انغلاقات غير منتظمة معزولة تمثل تركيب كميت

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الغاطس باتجاه شمال غرب–جنوب شرق وتوضح أن حقل نفط الكميت يتأثر بـ نظام صدع نجد في اتجاه شمال غرب–جنوب شرق. استخدمت التفسيرات الطبقية سمة التباين لتحديد حافة الصدع الممتد من تكوين المشرف بعمق 3090م ، كذلك استخدمت مؤشرات الهيدروكربون المباشرة (DHI) للتعرف على الظواهر الطبقية في منطقة البحث ، واستخراج السمات الزلزالية. جرى تطبيق السمات الزلزالية مثل الطور اللحظي ، الذي يظهر بقع قاتمة ، بقع مسطحة ، تلال ، ويتبعها اللفة السفلية ؛ التردد اللحظي ، الذي يُظهر مناطق التردد المنخفض التي تشير إلى احتمال كبير لتراكم الهيدروكربونات ؛ والسعة RMS ، التي تُظهر سعة عالية في البيانات الزلزالية التي تتوافق مع الهيكل وتؤكد وجود الهيدروكربون.

1- Introduction

Seismic methods are the most widely used, where seismic reflection is used to examine and detect hydrocarbon accumulations in underground sediments [1]. The structural and stratigraphy seismic traps were determined using the seismic sections, time map, velocity map, and depth map [2]. The Kumait field was discovered in 1979 due to the Iraqi National Oil Company's interpretation of seismic data from the Dujaila region. The interpretation of the survey results led to the recommendation to conduct a second detailed study conducted in 1980. The study was a preliminary investigation of the reflective formation maps such as Shiranish, Hartha, Sadi, Tanuma, Khasib, Mishrif, Rumaila, Ahmadi, Mauddud, Nahr Umr, and Shuaiba. The Oil Exploration Company reinterpreted an earlier area survey in 2008 and reached similar conclusions, recommending a three-dimensional (3D) seismic survey and identifying the hydrocarbon sites in the field [3]. The [4] [5] studied and interpreted the 3D seismic data of the Mishrif and Shuaiba formations in the Kumait oil field and the 3D seismic cube for the Nahr Umr Formation in the Kumait oil field, respectively, recommends including 2D seismic data in the new interpretation study, especially in the places which not covered by the 3D survey, as it may reveal good information about these covered areas. DHI can be measured using amplitude, frequency, attenuation, and time or combinations of all these [6]. The interpretation of seismic data and attribute analysis can help evaluate faults and fault sites based on the continuity and discontinuity of the traces in seismic sections. Seismic attribute analysis is used to generate meaningful subsurface images [7]. The variance attribute analysis has significantly helped fault identification in comparison to other attributes [8].

This study aims to construct three-dimensional structural maps to detect subsurface structural features, apply the variance attribute technique to identify the fault and apply the DHI for stratigraphic features identification using seismic attribute techniques.

2. Location of the Study Area

The study area is the Kumait oil field, located in southeastern Iraq, as it forms a portion of the governorate of Maysan, as shown in (Figure 1). The Kumait oil field is situated in the Universal Transverse Mercator (UTM) 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

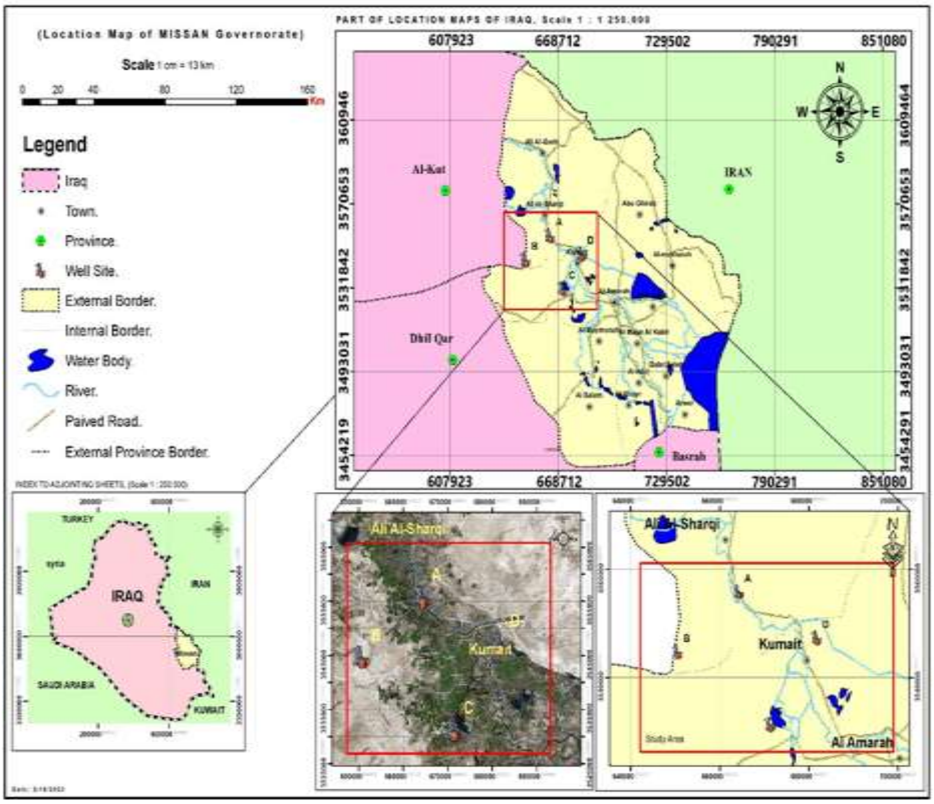

Figure 1: Iraq map shows the Kumait oil field.

2.1. Subsurface Geological Framework

The Mishrif Formation is considered the most important carbonate reservoir in Iraq, accounting for up to 30% of Iraqi oil reserves [7]. This formation is displayed in the well Kumait-1 (Kt-1): 3049 m–3360 m, as shown in (Figure 2), and the well Kumait-2 (Kt-2): 3063 m–3373 m, as shown in (Figure 3). The Mishrif Formation is divided into the first reservoir unit (MA): In the well Kt-1, this unit is located within the depth range of (3075m - 3078m), and the second reservoir unit MB: In the well Kt-1, this unit is situated in the depth range of (3086m - 3104m), [3].

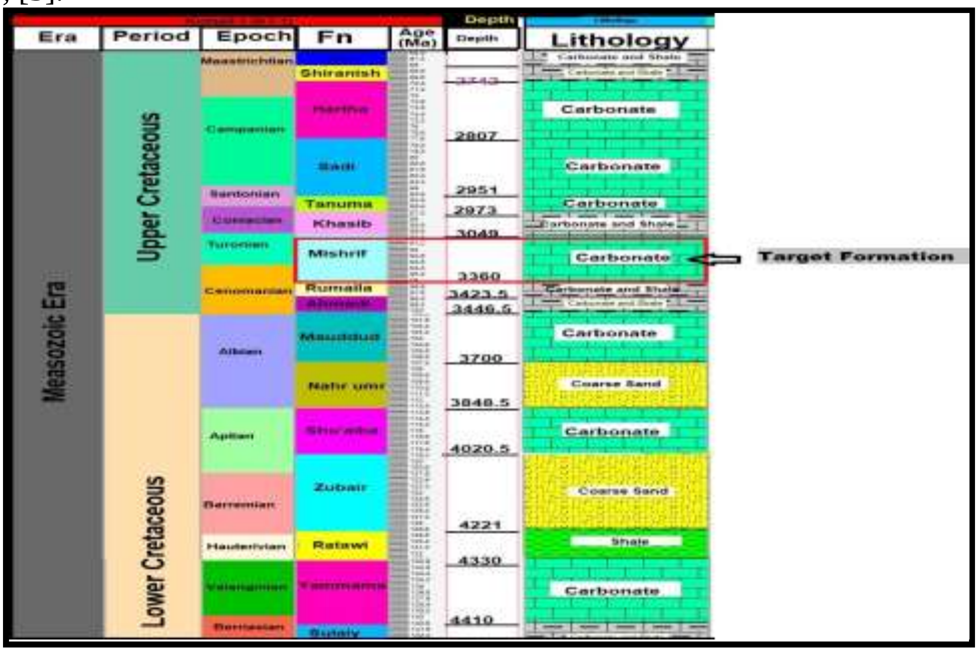

Figure 2: Geological column of the Kt-1 oil field shows the target formation [3].

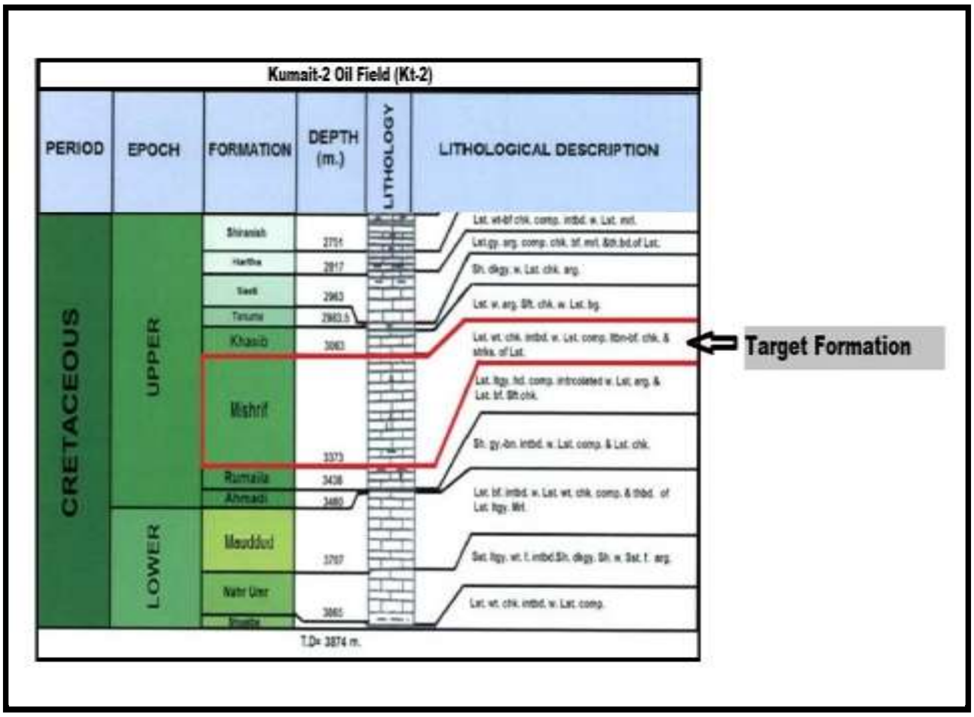

Figure 3: Geological column of the Kt-2 oil field shows the target formation [3].

2.2 Tectonic Setting

Kumait oil field is located within a Zone near the side of the Arabian-African platform to the north-east and is included in the Euphrates subzone in an area that lacks primary structural forms, and structural forms in this part of Iraq have a unilateral tendency [9][10]. The Kumait oil field in the Euphrates subzone doesn't contain primary structural forms, and structural forms in this part of Iraq shape unilateral tendency [11]. The NW-SE Najd Fault System is very significant in Iraq as it forms boundaries between the Precambrian terrines and the tectonic zone [12].

3. Materials and Methods

3.1 Database

It represents 3D surveys and data from two wells drilled in the study area, Kt-1 and Kt-2, conducted by the Iraqi Oil Exploration Company. The surveys were completed in two stages: the first from 9/1/2013 to 3/1/2014 and the second from 7/1/2015 to 12/1/2015. The proportion of land area covered was approximately 629 Km^2, with only 60% of the total area covered.

3.2 Procedure of Interpretation

The structural interpretation of the Mishrif Formation consists of inserting Kt-1 well information data that is currently available (well tops, check shots, sonic logs, and density logs) and loading seven 2D seismic lines and 3D seismic data, but the 2D lines were used in preparing the synthetic seismogram because the results were more clear in defining the Mishrif reflector. The Mishrif reflector was picked in the current study. The TWT map, average velocity, and depth map for the reflector under study were created. An analysis of seismic attributes was performed to examine several features that are assumed to be key predictors of hydrocarbon accumulation. The base map in 2D and 3D for the study area was created, as shown in (Figures 4 A and 4 B).

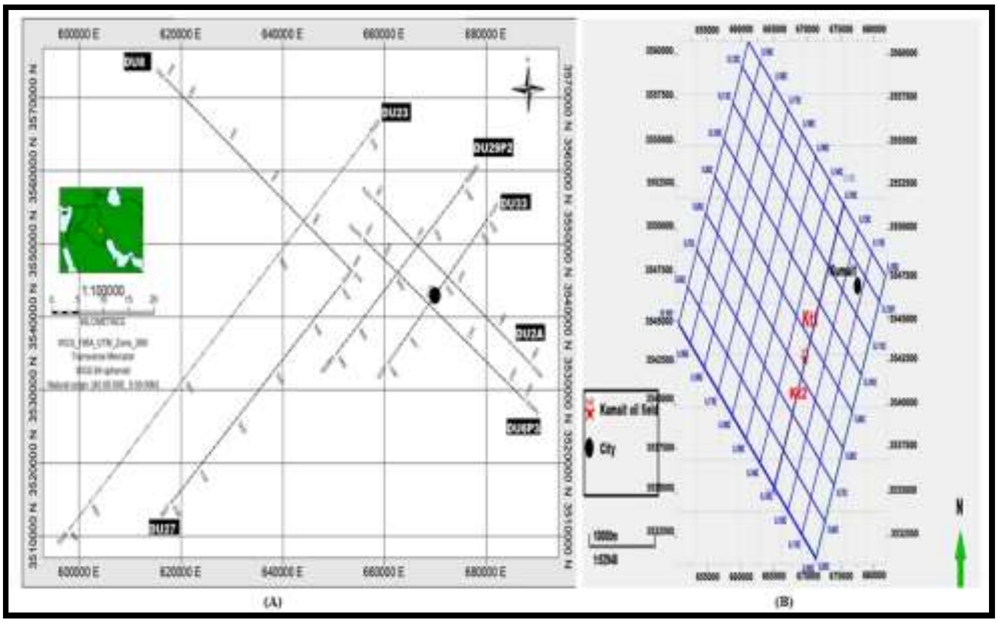

Figure 4: (A) Base map of some 2D seismic survey of Kumait oil field (B) Base map of 3D survey of Kumait oil field.

3.3 Synthetic Seismogram Generation

Utilizing the Petrel program, the Kumait oil field synthetic seismogram traces were created (synthetic programs). The synthetic seismogram offers a practical method for defining the reflectors in the seismic section considering the separated boundaries between the various lithology's horizons. The primary steps for creating a synthetic seismogram (Figure 5) were described by [13]. The synthetic seismogram is a convolution procedure to acquire the reflection coefficients and an experimentally determined wavelet. The well velocity survey, which is the direct way to determine the geological velocity (average velocity) of geological layers, is compared with the sonic log data. The match between seismic and synthetic traces is particularly good. The Mishrif reflectors represent a trough with a weak and sporadic peak because the bottom of the Khasib Formation is primarily made up of shale, which has a lower density than the limestone in the Mishrif Formation. The mound phenomenon also causes this appearance at the top of the Mishrif Formation.

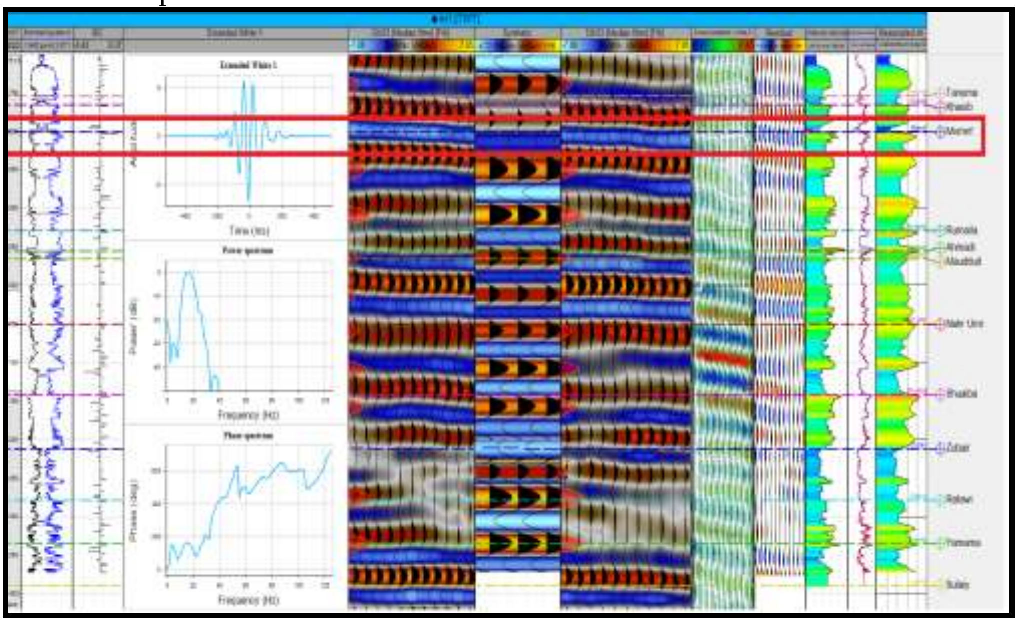

Figure 5: Synthetic seismogram generation of Kt-1 oil field.

4. Interpretation and Discussion

4.1 Two-Time Map of top Mishrif

The TWT maps have been prepared for the Mishrif reflector. The variation in TWT reflects the variation in depth of these reflector parts. TWT of Mishrif ranging between (-1870 ms to -2070 ms) with four isolated irregular enclosures represents Kumait structure plunging NW- SE. Three enclosures have been investigated by two drilled wells (Kt-1, Kt-2) with dimensions of (2237m × 4698m, −1890 msec) for the mid enclosure, (2493m × 1647m, −1890 msec) for the E enclosure and (3472 × 6558 m, −1905 msec) for the S enclosure. The fourth enclosure was far west with maximum dimensions (6052.31m × 2790.55m, -1896 ms). The area's northeastern direction has a higher value of the contour, which declines in the southwesterly direction with a value of -1870 ms. The map depicts fault effects; the effect of this fault on contour lines were indicated by the white arrows as shown in (Figure 7), with the system set dominated by the NW-SE direction.

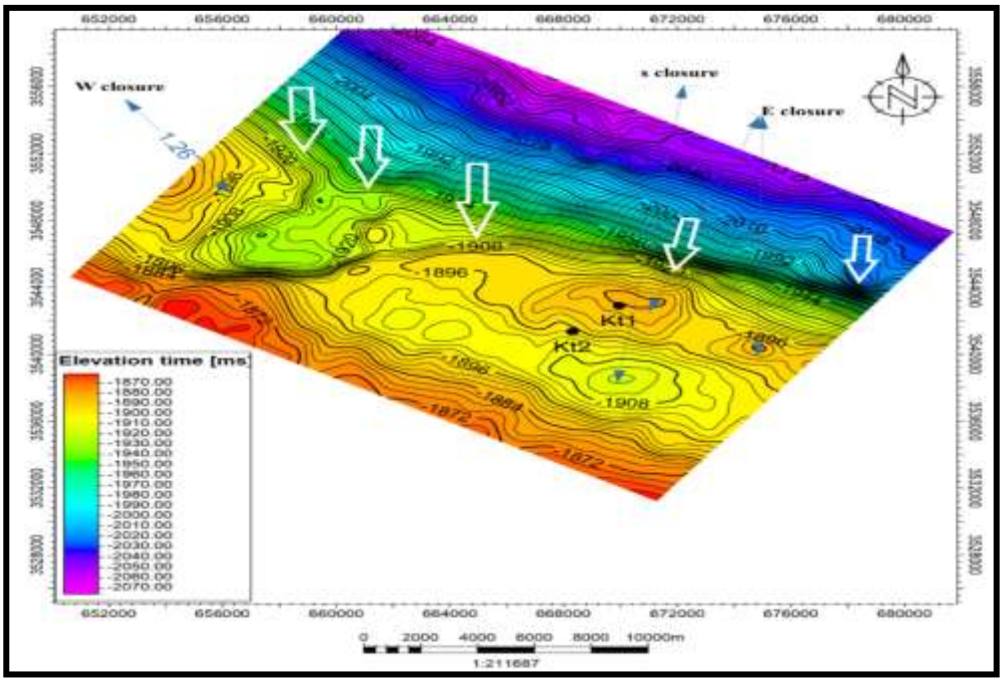

Figure 6: Shows TWT map of the top Mishrif Formation.

4.2 Velocity Map

The average velocity map for the Mishrif Formation, as shown in (Figure 8), shows that the lower average velocity value starts with (3090 m/s) in the SE part of the study area. Also, the average velocity values increase toward the northeast part reaching (3330 m/s), while the average velocity in the west (3200 m/s) decreases. The magnitude of the velocity ranges from(3500–3900m/s).

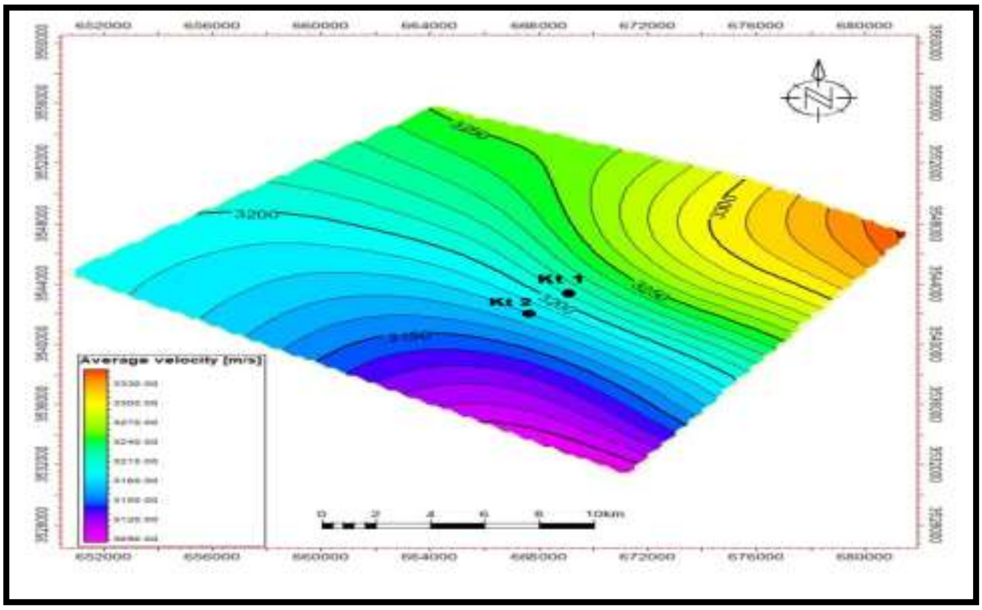

Figure 7: Shows velocity map of Mishrif Formation.

4.3 Depth Map

The depth map of a given reflector is produced using seismic methods by combining its time map and average velocity map as in Eq. (1)

$$Depth\ at\ any\ point\ = \left(velocity\ \times \frac{TWT}{2}\right) at\ this\ point. \qquad (1)$$

Depth map was drawn depending on the structural interpretation of the picked reflector. The depth map of the Mishrif Formation, as shown in (Figure 9), shows that the general dip is towards the NE. The minimum depth value (2925 m) is noticed at the SE and SW and gradually increases toward the NE part of the area to reach (3475 m) towards the basin. The depth map showed the same structure picture as the TWT map of the Mishrif Formation. The map showed a gradual reduction toward the southeast direction around Kt-1 and Kt-2 wells reaching out (3000m). The general depth values range between (2925m - 3475m).

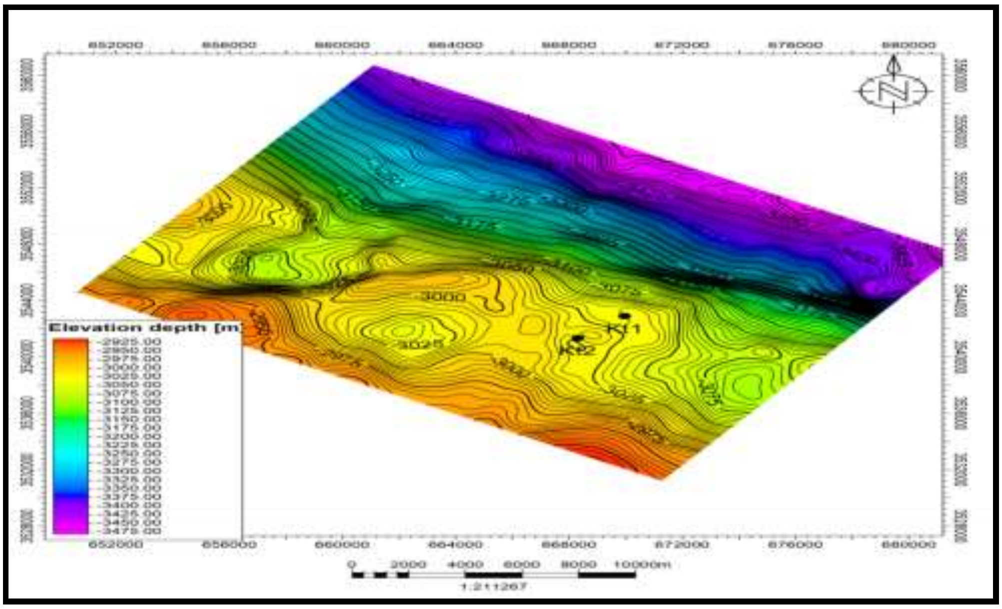

Figure 8: Shows depth map of the top Mishrif Formation.

4.4 Variance Attribute and Fault Identification

The variance is an appropriate and efficient edge faults detection attribute. A depth slice (3114.97 m) with clear fault extends on the Mishrif surface with NW-SE direction as indicated in (Figure 10).

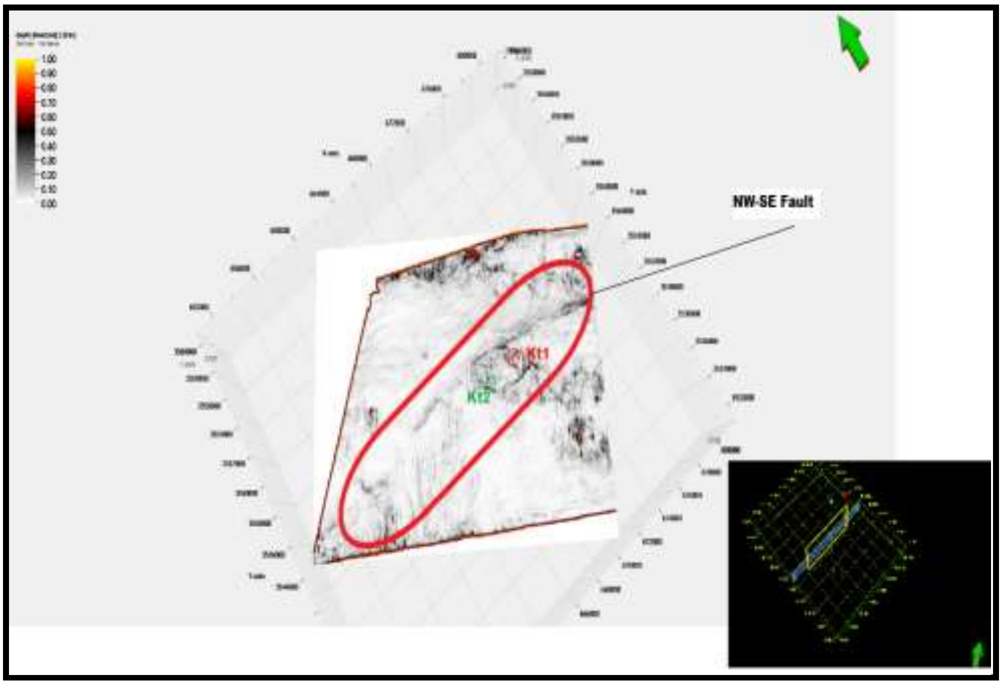

Figure 9: Variance depth slice (3114.97 m) on Mishrif Formation.

4.5 Seismic Attributes

The seismic attributes are practical tools for interpreting non-evident conventional 3D seismic data [14]. The seismic stratigraphic interpretation of the area approves some stratigraphic features in the studied formation [15]. Because variations in seismic attributes can result from changes in stratigraphic rock and fluid characteristics, seismic attributes is used to predict and examine geologic information, which reflects the geometry, dynamics, kinematics, and statistics of seismic information. The three seismic attributes with horizon-based attribute categories are instantaneous phase, instantaneous frequency, and instantaneous amplitude attributes. The amplitude of seismic data is utilized for lithological interpretation and prediction of the reservoir. It is affected by physical properties, fluid changes, lithological changes, stratigraphic sequence changes, unconformity, and the strata-tuning effect [16]. The instantaneous phase is a seismic attribute representing the phase angle at any point along a trace [17]. The fast frequency represents the mean amplitude of the wavelet. Furthermore, the instantaneous frequency is a helpful tool for seismic stratigraphy analysis [18].

A- Instantaneous Phase Sections

A hydrocarbon contacts seismic response where it appears flat (flat spot) within the Mishrif Formation at 3450 m. The Dim (dim spot) areas are caused by highly cemented sands with a significantly higher acoustic impedance than the underlying shale. Gas and oil, oil and water, or gas and water can come into contact. The mound phenomenon can be found in IL1403 and XL 1121 within the Mishrif sequence (Figure 11).

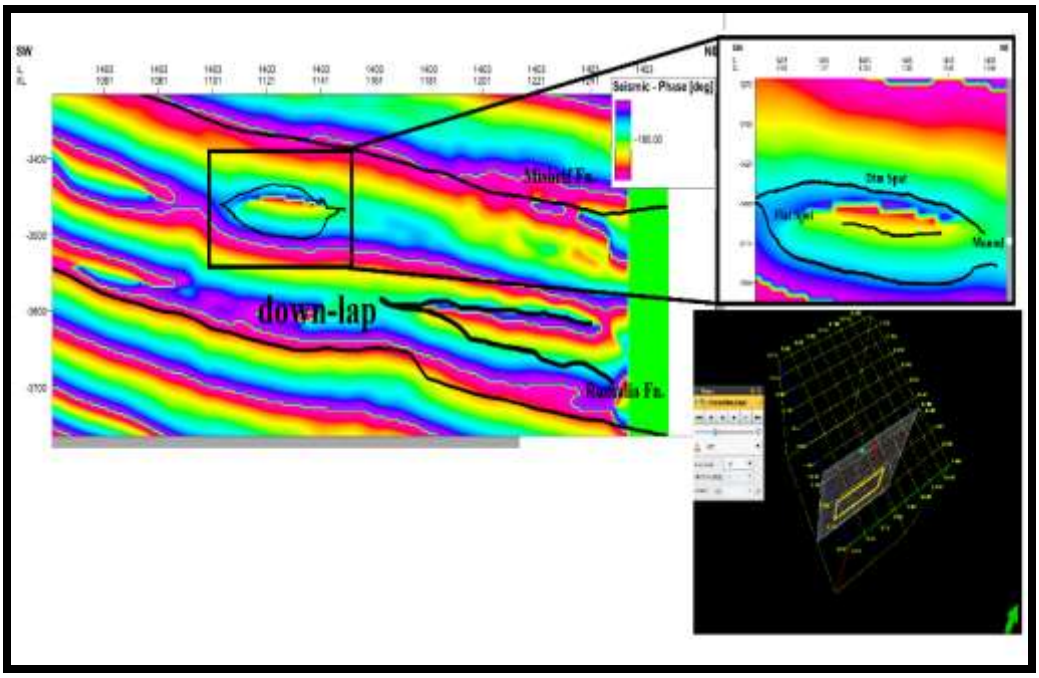

Figure 10: Instantaneous phase attribute section in Kumait oil field within Mishrif Formation.

B- Instantaneous Frequency Sections

Because fractures can appear as lower frequency zones, hydrocarbon indicators can detect lateral changes in lithology by low-frequency anomalies and fracture zone indicators. An increased lateral instantaneous frequency can indicate bed thinning or pinch-outs [19]. The lateral variation of frequency at Kt-1 and Kt-2 is depicted in (Figure 12) The legend appears to indicate that the dark colors reflect an area of low frequency, which indicates hydrocarbon accumulation areas. The red color represents a high-frequency area, showing a low probability of hydrocarbon accumulation at 3113m.

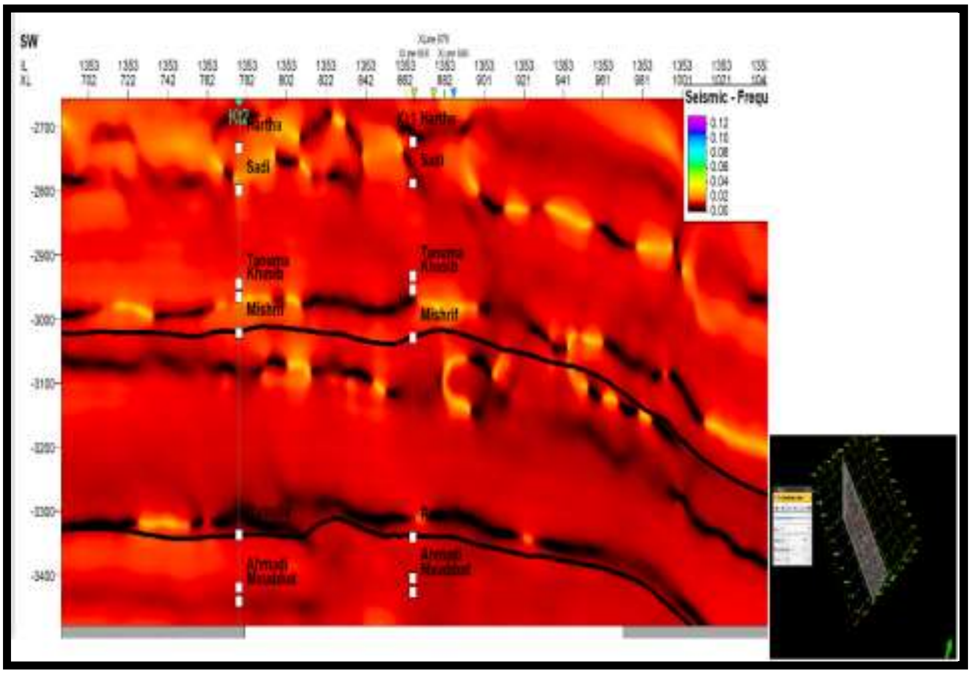

Figure 11: Instantaneous frequency attribute section in Kumait oil field within Mishrif Formation.

C- RMS Amplitude Attribute

The high amplitude in Figure 13 in the seismic data confirms the structures and confirms the presence of hydrocarbon. The high RMS amplitude values circled in the map correspond to high porosity. These segments with high RMS amplitudes could be high-quality hydrocarbon reservoirs.

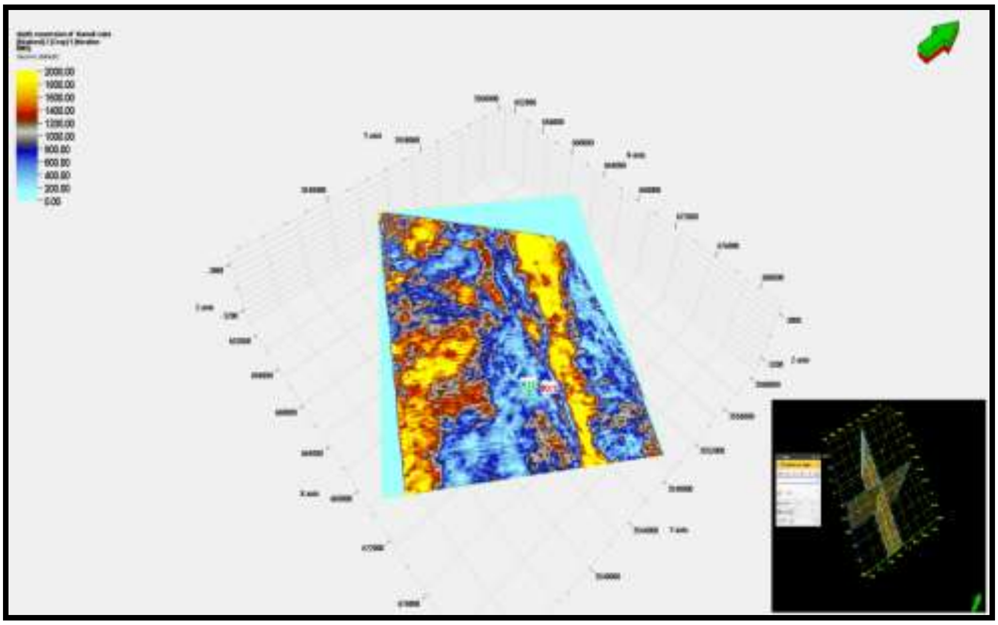

Figure 12: RMS amplitude attribute within Mishrif Formation at depth slice 3114m.

5. Conclusions

The selected reflector appears as a trough with a weak and sporadic peak on a synthetic trace (positive and negative reflection) due to changes in rock densities and the mound phenomenon in the first reservoir MA unit. A fault that was identified from a variance attribute in the Mishrif Formation with NW-SE direction that corresponds to the major direction of the Najd fault system crossing the area, and structural maps show four irregular enclosures (structural anticlines trending NW-SE and the general trend of strata is N and NE) that were impacted by the fault system. Also, when applying seismic attributes, phenomena such as mounds, dim spots, and down-lap were found, which are evidence of the existence of hydrocarbon accumulations.

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