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Hydrocarbon Possibilities and Structural Setting in Ad'Daimah Oil Field, Southern Iraq.

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Abstract

Ad'Daimah Field is a structural trap with a proven gas condensate reservoir in limestone. The Yamama Formation is the faulted anticline that makes up the field. Thirteen seismic lines were used for this study, with one well (Da-1). Velocity maps derived from the velocity model were used to construct time and depth maps. Certain stratigraphic features were present in the examined reflector, according to seismic interpretation in the region. In the research area, certain distribution mounds and continuous sand lenses in more than two-dimensional seismic lines were seen. These activity components offer a logical justification for the distribution of hydrocarbons in the study region. The major normal fault of (NW-SE) trending and minor normal faults of (NE-SW) trending, both with a bit of displacement, has been seen in the research region. These fault systems influence the examined reflectors (Yamama, Sulaiy). Time, velocity, and depth maps are created according to the selected reflectors' structural interpretation. The structural interpretation of these reflectors reveals an asymmetrical anticline that extends in an E-W trend, plunges to the southeast with a dip angle of about 5 degrees, and generally dips direction toward NE-SW.

Keywords: Ad'Daimah oil field, DHI, hydrocarbon accumulation, structural picture. nose enclosure.

الاحتمالية الهايدروكاربونية وتقيم الوضع التركيبي لحقل ديمة النفطي جنوب العراق.

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الخلاصة

حقل الديمة عبارة عن مصيدة تركيبة مع خزان مكثف للغاز مثبت في الحجر الجيري. يعتبر تكوين اليمامة الخزان الرئيسي في الحقل والحاوي على عدة فوالق . تم استخدام ثلاثة عشر خطاً زلزالياً لإجراء هذه الدراسة ببئر واحد (Da-1). تم استخدام خرائط السرعة المشتقة من نموذج السرعة لإنشاء الخرائط الزمنية والعمقية .استخدمت تقنيات الملامح الزلزالية مثل التردد الاني (Frequency Instantaneous) فقد لوحظ وجود تطابق بين مناطق الترددات الواطئة ومناطق التجمعات الهايدروكاربونية،وكذلك استخدم (phase instantaneous) وهو مهم في تحديد حدود التتابع وطبيعة الترسيب ونوع التلاشي onlap و downlap وذلك لتحديد التجمعات االهايدروكاربونية في المقاطع الزالزالية ، وأوضحت ملامح السعة (attributes

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(instantaneous phase نقصان في السعة spot flat. تم تحديد نظاميين للفوالق الرئيسي باتجاه (NW–SE) الثانوية البسيطة لاتجاه (NE–SW) ، مع إزاحة قليلة ، في منطقة البحث. تؤثر أنظمة الفوالق هذه على العواكس المختارة في منطقة الدراسة (اليمامة ، السلي). وفقًا للتفسيرالتركيبي للفوالق المختارة ، يتم إنشاء خرائط الوقت والسرعة والعمق. يكشف التفسيرالتركيبي لهذه العواكس عن طية غير متماثله تمتد في اتجاه E–W ، وتغطس باتجاه الجنوب الشرقي بزاوية ميل تبلغ حوالي 5 درجات ، و اتجاه الانحدار نحو NE–SW.

1. Introduction

Researches involving hydrocarbon reservoirs, stratigraphy, and structural imaging has relied on 2D seismic reflection surveys. This investigation uses 2D seismic reflection data from the Iraqi Oil Exploration Company to study the subsurface geological sitting of the Ad'Daimah oil field in southern Iraq.

It would mean that the goal is to get as close to the structural and functional details as feasible to a geological picture of the Yamama Formation in the southern Ad’Daimah oil field.

Seismic reflection surveys [1] have been the most extensively utilized and quite successful geophysical technique, providing a more accurate and detailed depiction of underlying geological formations (Kearey et al., 2002). It works much better when the oil is trapped in structural traps, yet it can also be used to identify and detail particular stratigraphic structures [2].

So, because geophysicists' ultimate objective in research is not merely the positioning and mapping of structural or determining the size and shape of structures, structural and stratigraphic seismic interpretations are indirect recognition approaches. The primary goal is to decide whether or not it contains hydrocarbons and whether there is a potential hydrocarbon location in the zone [3]. The Cretaceous sequence in Iraq has been the subject of numerous research since it is the most significant productive reservoir and includes around 80% of Iraq's oil reserves. The Yamama Formation, one of the most many carbonate reservoirs in south-eastern Iraq, houses the oil infrastructure of several nearby oilfields. [4]

The basic focus of this research is to analyze 2D seismic data and well logs from the Yamama Formation in the Ad'Daimah oil field to depict the Yamama Formation's subsurface structure. To identify the stratigraphic features in the research region, seismic attribute approaches were used in the 2D seismic section of the Dema survey, including Instantaneous Phase, Instantaneous Frequency, and these characteristics are crucial for identifying hydrocarbon accumulation on seismic sections [5]. According to geophysical research, the presence of hydrocarbon materials in a sedimentary formation's pores causes that formation's seismic velocity and bulk density to decrease [6]. Mound, Bright Spot and lens indicators were detected in seismic sections within the study area. A high amplitude anomaly in seismic waves may indicate the presence of hydrocarbons. Bright spots can be generated by events other than the presence of hydrocarbons, such as a change in lithology, but they can also be caused by huge changes in acoustic impedance and tuning effect, such as when a gas sand sits beneath a shale. [7].

2. Location and geology of study area

The study region is situated in the southern part of Iraq and is within the Mesopotamian basin of an unstable shelf, following Iraq's longitudinal tectonic classification [8]. Ad'daimah oil field is located in Missan governorate, approximately 80 km southwest of Amara city, as an extension of Hoor Al Baghdadiyah (a local term for a wetland portion that is saturated with water at all times). [9]. The UTM identifies the study area (Figure 1) coordinates, as shown in Table 1.

Table 1: The study area coordinates.

Points	Easting	Northing
A	690522	347704.2
B	732574	347696.9
C	732574	344144.8
D	690522	344144.8

Figure 1: location map of the study area

The Ad'daimah oil field was discovered in south-eastern Iraq, in the Missan governorate, roughly 80 km southwest of Al'Emara City. The explored region is characterized by Holocene alluvial deposits and sediments ranging in age from 0–150 m [9] and is surrounded by wetlands [10], numerous river tributaries, and initial Sumerian moral human archaeological sites. Well, Da-1 was drilled in 2012 on top of a structure anticline referring to the Ad'daimah field., which would be placed in the Gulf of Mexico.

The Zagros Fold Belt, which has a non-homogeneous anticlinal structural system running northwest-southeast, is located 60 kilometers north of Baghdad in southern Iraq, west of the governorate of Messan. Towards the west of the Missan governorate are two depositional basins of the Mesopotamian Foredeep Basin, primarily influenced by salt diapirs and underground movement [11]. The Zagros Fold Belt is a band in the eastern part of Mesan [12], [13] that is primarily affected by thrusting tectonism as part of having to close the Tethys Sea, mostly during the Alpine orogeny, by the process of converging continent to continent plate tectonization. The Ad'daimah area's geological sequence is shown by the profound oil well Da-1, which was built on the Ad'daimah structure and permeated a small number of meters of the Sulaiy Formation (Upper Jurassic) toward a total depth of 4,260 meters under sea level, as shown in Figure 2.

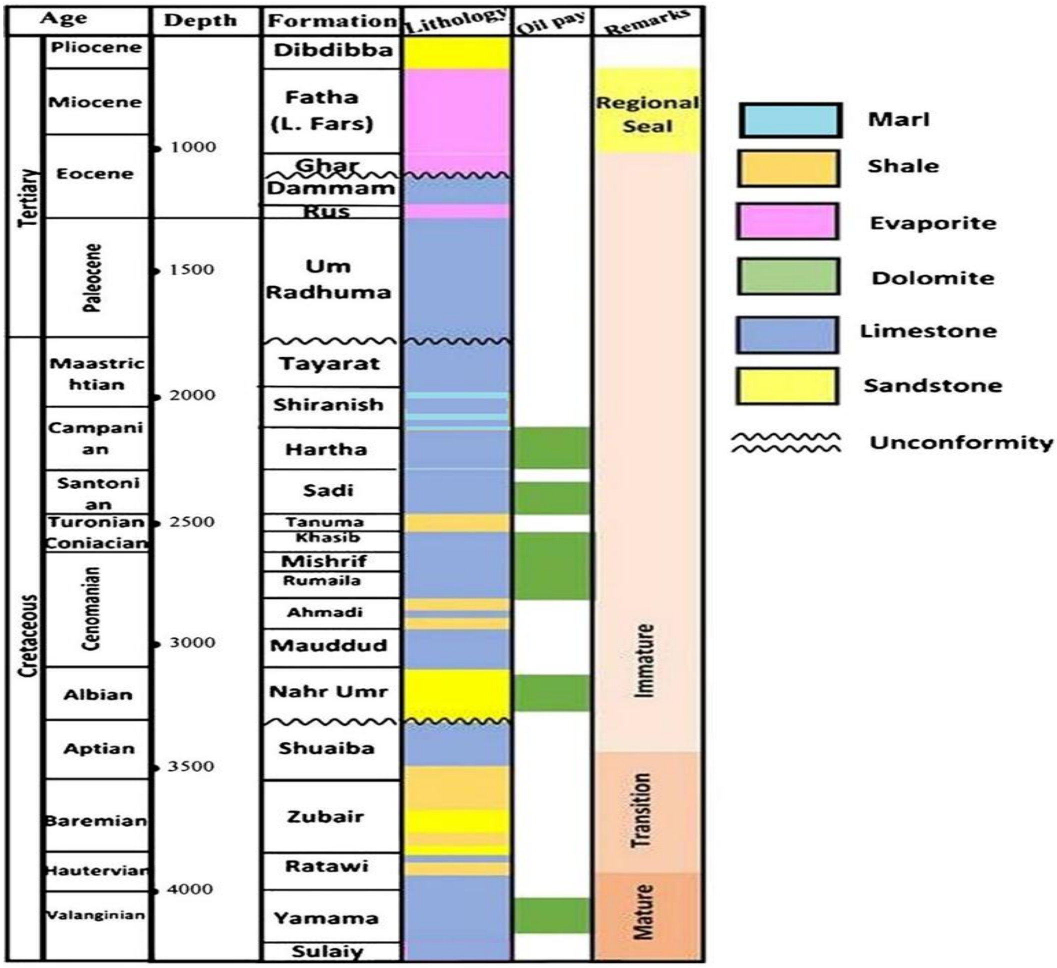


Figure 2: Well Da-1 of the Ad'daimah oil field stratigraphic column division [14]

The Late Tithonian-Early Turonian Megasequence (AP8) comprises the Late Tithonian Hauterivian formations of Sulaiy, Yamama, and Ratawi. Khasib, Tannuma, and Sa'adi formations in the Late Turonian-Early Campanian Sequence are part of the Late Turonian-Danian Megasequence (AP9) [13], [9]. The area located on the unstable shelf within the Tikrit zone, bounded from the south by the Al-Zubair zone and from the west by the Samawah-Nasiriyah zone, was displayed on a map of structural divisions by Al-Khadimi et al., 1996 (Figure 3).

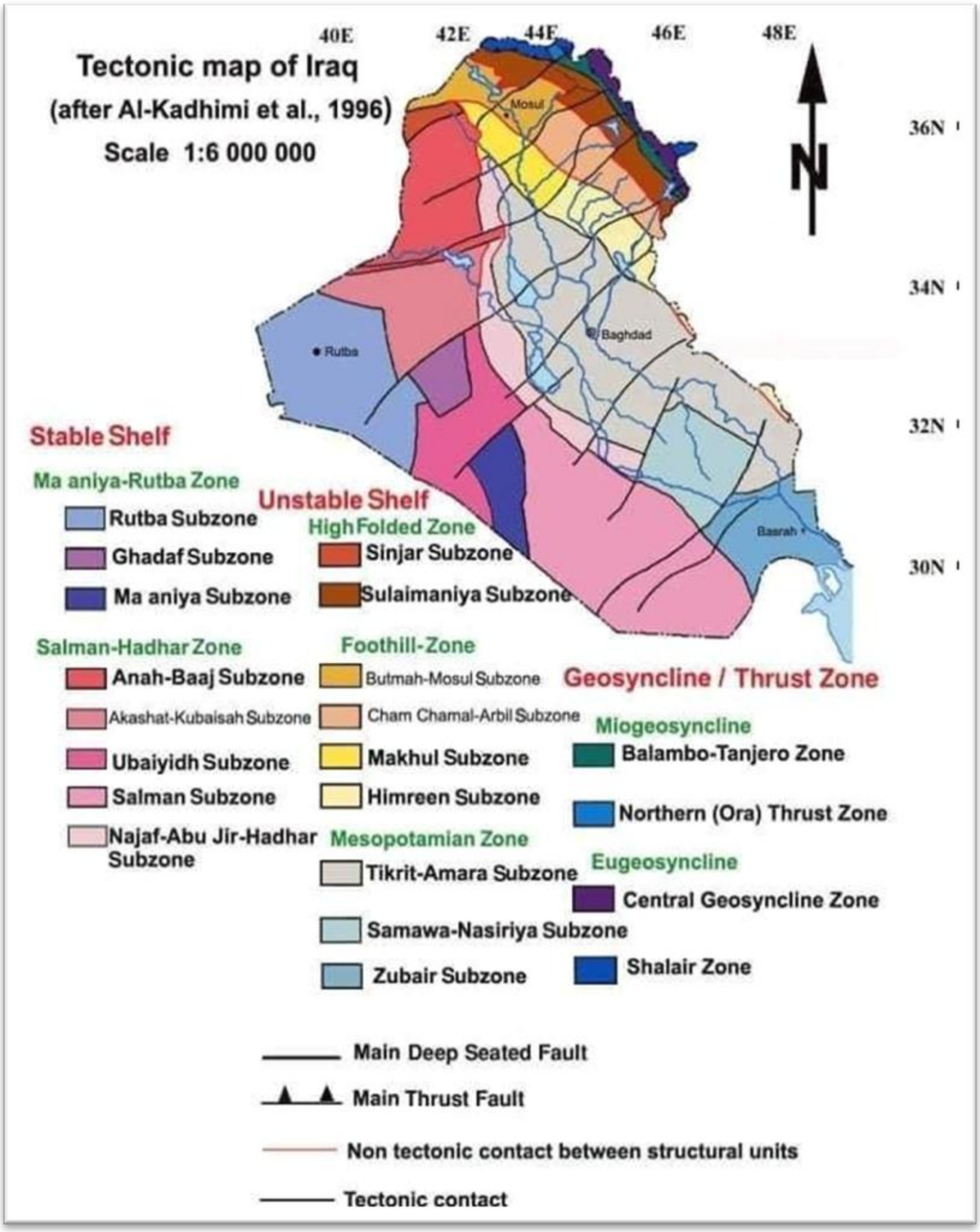


Figure 3: Structured divisions map [15].

3. Data and methodology

Ad'Daimah oil field, located in southern Iraq, which is around 65 km away from Amara, is the focus of the current research method of interpretation employed. This study was undertaken as a two-dimensional survey using the information acquired by OEC in 1979, including the seismic line (2HH-27, 2HH-29, 2HH31, fwr-wq14, fwr-wq15, fwr-wq17, fwr-wq18, fwr-wq20, fwr-wq22, fwr-wq24, h2SW, h8, and H9) with Da-1 well (Figure 4). The Oil Exploration Company in the Ministry of Oil was responsible for processing the data. 13 seismic lines were employed in the current investigation, dispersed throughout the study region in various directions following the plan taken into account during the preliminary survey planning.

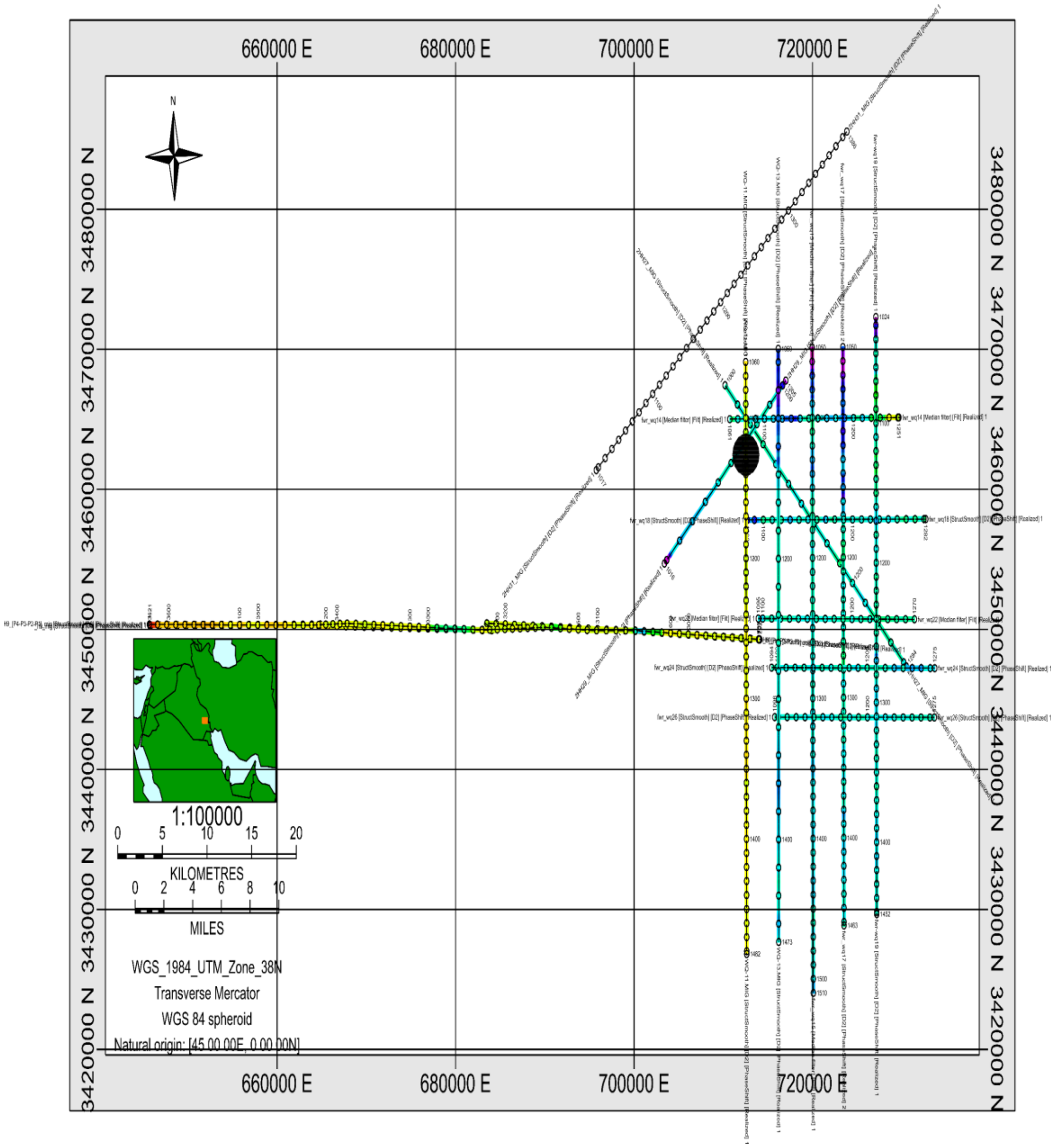


Figure 4: A base map for seismic lines in the study area. well Da-1 is represented by a black spot. The coloured lines represent lines utilized for the composite section.

The conversion of seismic data into geological terminology is known as geological interpretation. The interpretation of seismic datasets is carried out on an interaction workstation, a sophisticated computer with specialized programs that uses software with the interpreter to produce interpretation processes that are quicker and more precise. The primary steps in Figure 5 of the interpretation process applied in the present investigation are:

1- Inserting Da-1 well information, including (well top, check-shot, sonic log, and density log).
2- Loading the sets of the 2D seismic lines
2- Well to Seismic data tie (generated synthetic seismogram).
3- Identification and picking the interesting reflectors of this study, which are (the Yamama and Sualiy formations).
4- Construction two-way time (TWT) contour map for the picked horizons.
5-Construct the velocity model for the studied area. This map is used to convert the TWT

maps to the depth map.
5- Computing thickness by using an isopach map for Yamama Formation.
6- Extract average velocity and interval velocity from the velocity model as velocity logs.
7- construction 3D simple grid model for velocity modeling and comparison to litho-units and productive intervals.
8- Application of seismic attributes to the analyzed seismic section and identification of stratigraphy features from direct hydrocarbon indicator (DHI).

The Make simple grid process is an alternative to the Pillar gridding when you create 3D grids with no faults. Creating a simple 3D grid in this manner gives you access to the more rigorous volume calculations of the volume calculation process without the need to go through the Pillar gridding and make horizons processes. Consequently, Yamama – Sualiy zone has been performed in the 3D griding model with grid increment (50 *50), and each horizon has been layered with (5 layers) to resolve the property event well. The main problem in the project is that the average and interval velocity of well-log data does not reach the interest area (Yamama - Sualiy zone). Hence we convert the velocity model to well log form for each average and interval velocity. Then these logs have been upscaled as shown in Figure (6), these logs have been upscaled to utilize Gaussian random function simulation to distribute the well log information on a 3D grid geological model. Gaussian random function simulation differs substantially from the Sequential Gaussian Simulation (SGS) from the geostatistical software library GSLIB. Gaussian random function simulation was introduced in Petrel 2009.1.

- It is typically faster than SGS.
- It is not a sequential algorithm.
- It has been parallelized.
- It has a fast collocated co-simulation option.

A beneficial consequence of the central limit theorem is the existence of a class of random functions whose spatial distribution depends only on their first two moments. These are Gaussian random functions. Their main statistical properties are reviewed, the texture of their realizations is examined, and algorithms are proposed to simulate them, conditionally or not. Let's suppose that Y1....Yn, be a sequence of independent and identically distributed random variables. If their mean m is finite, then the strong law of large numbers says that the average (Y1 + ... + Yn)/n converges almost surely towards (m):

$$\lim_{n\to\infty} p\left(\frac{\frac{y_{1+\cdots+y_n}}{n}-m}{\frac{\sigma}{\sqrt{n}}}<y\right)={}^{G(y)} \qquad (1)$$

Where G denotes the standard gaussian distribution function, furthermore, it can wonder from what value of n onwards the distribution of (Y1 + ... + Yn) / n can be considered as gaussian for practical purposes. Provided that the variables have a finite third-order absolute moment m3 = E‖Yi - m‖^3, an answer is given by the Berry-Esseen theorem [16].

Figure 5: Flow chart used in current work

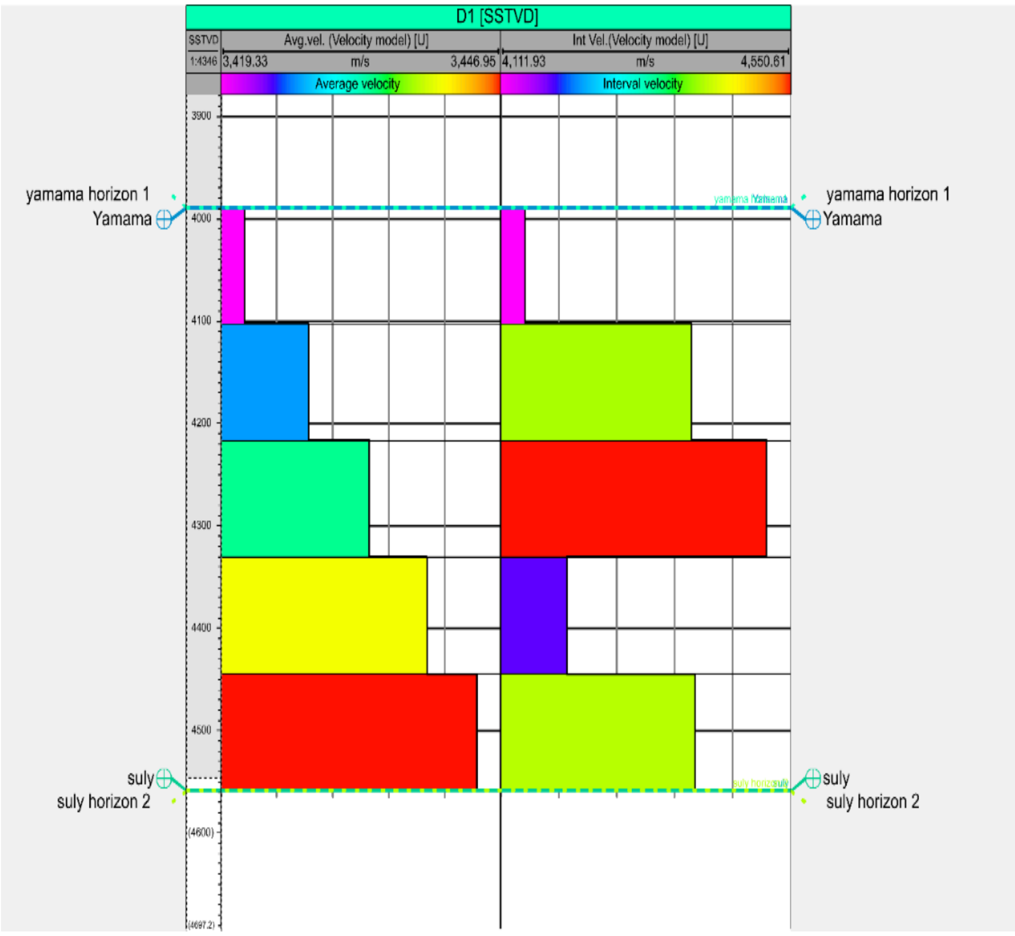


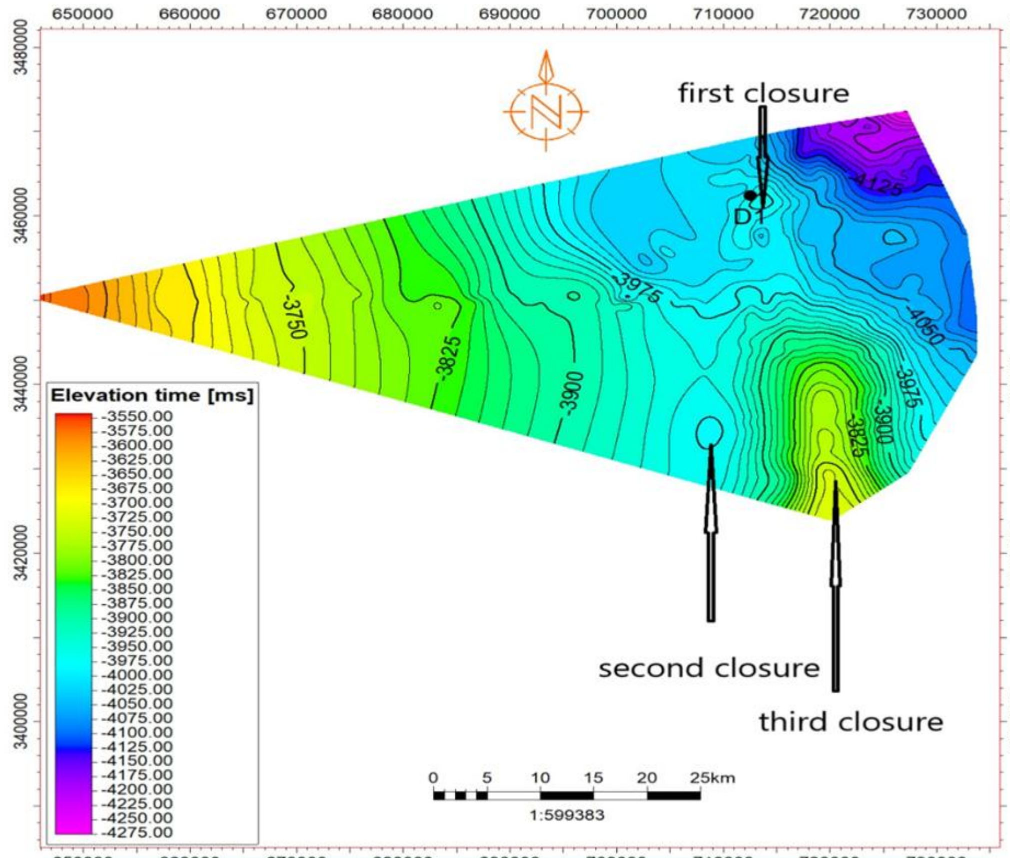
Figure 6: Upscaled well log for intervals and average velocity before 3D velocity modeling.

4. TWT maps interpretation

Three structure closers appear in Yamama (Figure 7-a) on the map, named the first closure in the northern part, the second closure and the third nose in the southern part of the map. The first closer is located to the south of the Da-1 well with dimensions of approximately 7100m in length and 2350m width. The second closer is located on the southern part of the study area map with dimensions of approximately 3450m in length and 2400m in width, representing a syncline structure. The third enclosure, in the southern part of the study area map represents an anticline structure with dimensions enclosed to 24050 m (length) and 17125 m (width). The TWT contour map of the top Sulaiy (bottom Yamama), is shown in Figure (7-b). This map indicates that the TWT values range from 4180 to 4740 ms with a contour interval of 10msc. The map shows structurally that the highest values are located on the field's west and southwest side, compared with the lower values on the east and northeast sides. the values around Da-1 well ranging from (4525-4624msec).

Three main structural closers appear in the area. The first one represents a structure located south of Da-1 well with a dimension of approximately 8200m long and 4750 in width. The second closer represents an anticline (fold) structure extending N-S, is located on the SE part of the map with dimensions of approximately 8700m in length and 3900m in width. The third nose enclosure SEW with dimensions 25800 m (length), to 17950 m (width) representing syncline. Other noses could be indicated in the eastern part of the study area with an enclosure of more than 4600ms.

(a)



(b)

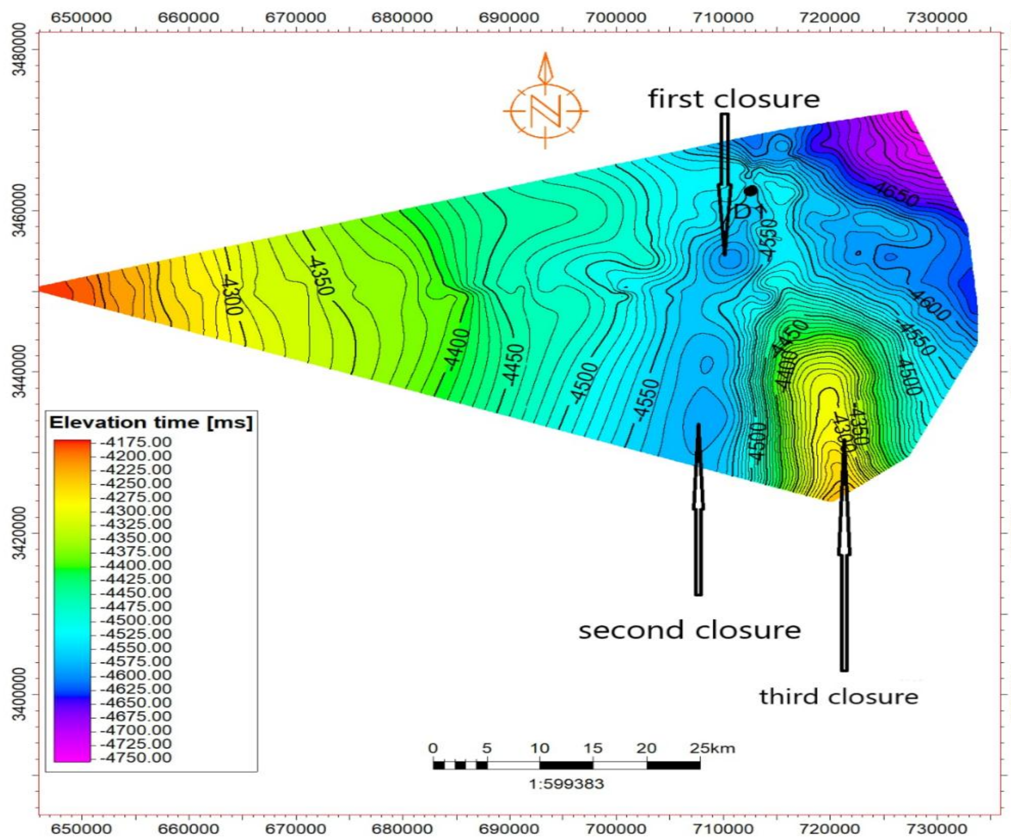


Figure 7: TWT maps where (a) of top Yamama, (b) top Sulaiy.

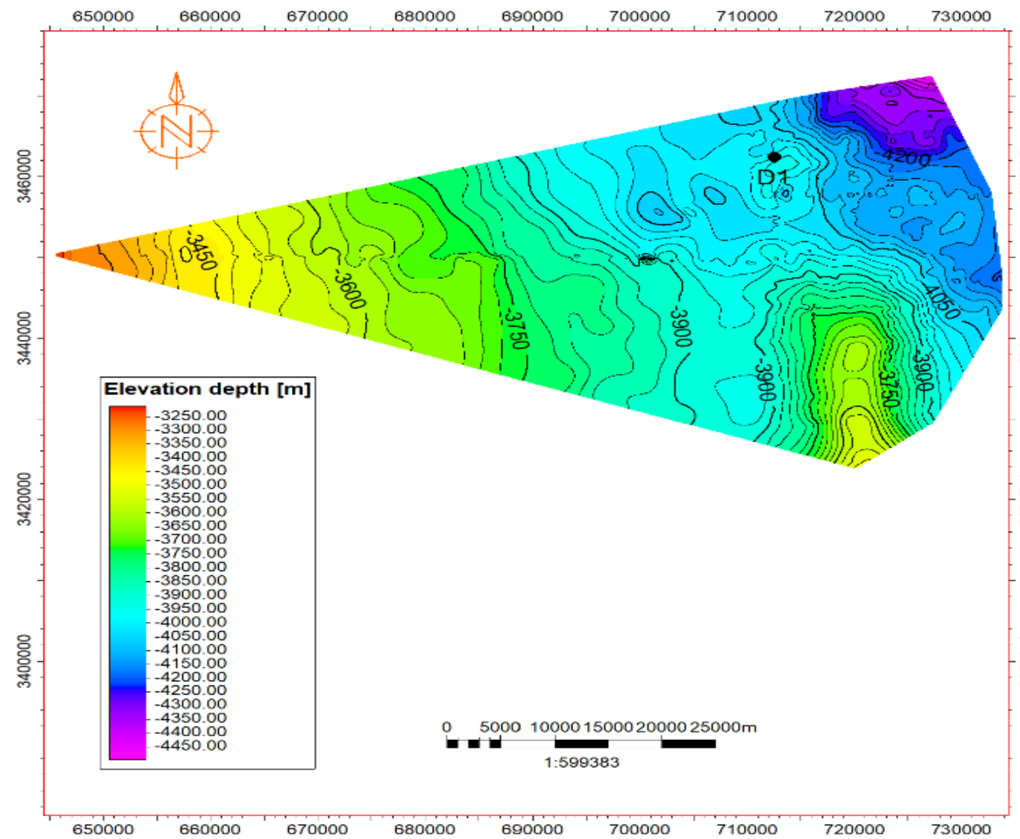
5. Depth maps interpretation

Yamama depth Map Figure (8-a) shows that Ad'Dimah structure consists of two irregular enclosures located southwest Da-1 well. Depth The depth map showed the presence of several main closure shapes trending in south and southwest direction directions and several irregular closures trending in N and NE directions. The depth map of Yamama illustrates that the depth increases toward the northeast part of the field, reaching out (4450 m) with a gradual reduction toward the southwest direction, reaching (3250 m). Generally, the depth increases toward the northern area around Da-1 well(4050m). The dip direction is toward NE-SW. Sulaiy depth map Figure (8-b) illustrates the general dip towards the northeast. The depth increases toward the northeastern part of the area reaching 4800 m, whereas the depth becomes less toward the southwest part to reach 3800m. The depth around Da-1 reaches 4650 m, with a general dip direction toward NE-SW.

6. Isopach map interpretation

The thickness map for Yamama Formation in Ad'Dimah oil field is shown in (Figure 9), which shows increasing in thickness toward the west and southwest 825 m, where the maximum thickness observed was (925 m), and with decreasing toward the east and northeast reaching out to (325 m). generally, the map can be divided into three parts: the southwest, which contains the highest thickness values. The middle part includes the moderate thickness, and the northeast part with the low thickness values. The lowest thickness is located in the far north (300m), with 600 m around Da-1 well.

(a)



(b)

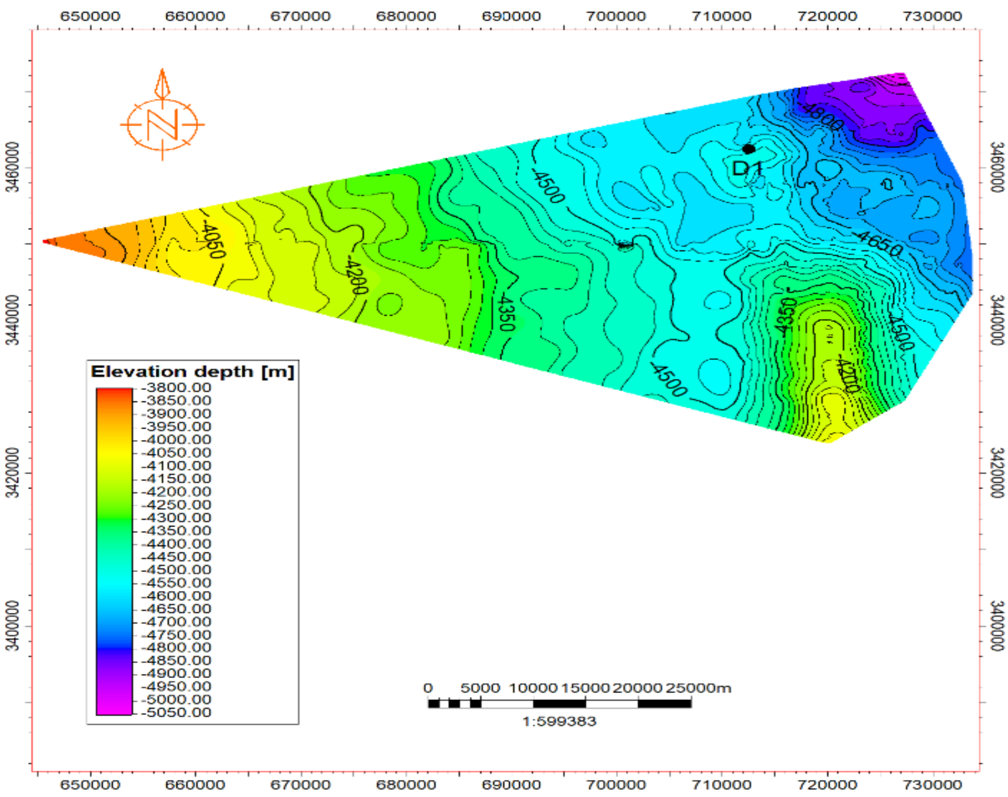


Figure : 8 Depth maps where (a) of top Yamama, (b) top Sulaiy.

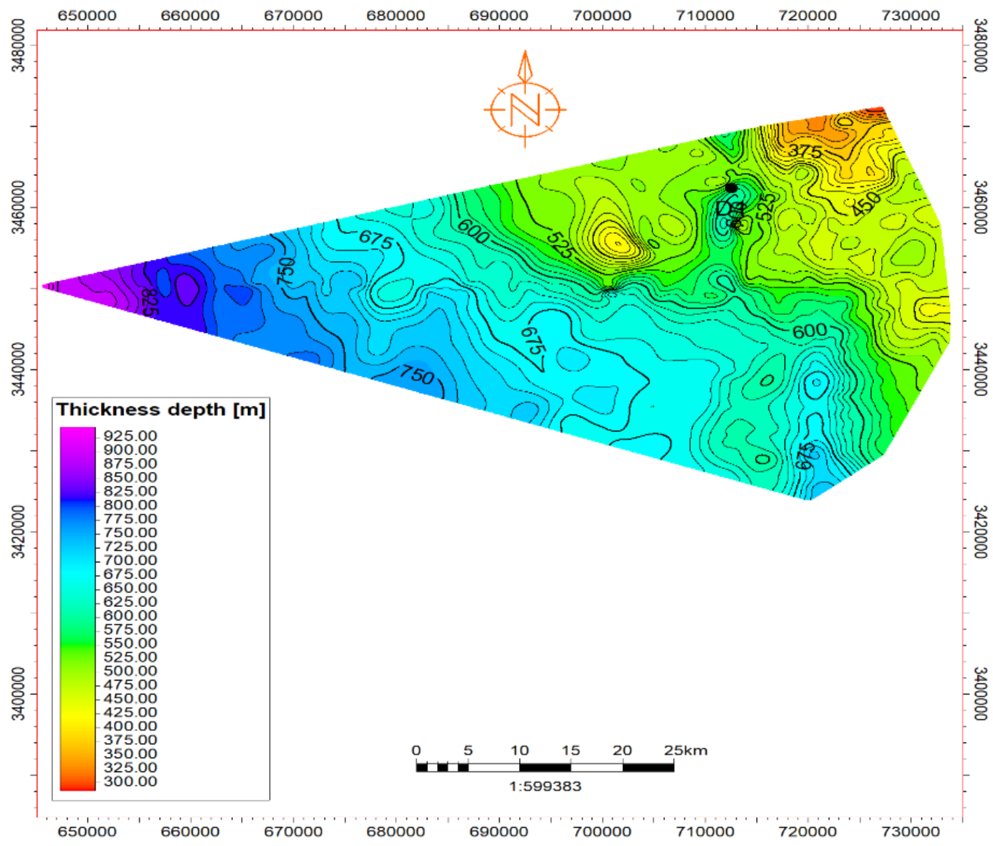


Figure 9: Isopach map for Yamama formation

7. 3D Velocity Model interpretation

The time of the interest horizons that were selected on the seismic data and their markers in the Da-1 well checkshot logs were used to determine the average velocity values of the interest horizons. Vertically, one observes high-velocity values at shallow reflectors (Yamama Fn.) (3422m/s) with a low positive gradient of velocity with the depth to be reached (3442m/s) at deep reflectors (Sulaiy Fn.). Throughout the study area (Figure 10- a). The slight difference in average velocity (Figure 10-b) is mainly due to shallow thicknesses or depths between two formations in the area of interest. In the horizontal direction, the average velocity decreases in the field's middle and NE direction and increases towards W and NW direction.

The interval velocity is generally dependent on the litho-units; consequently, the interval velocity of the Yamama- Sulaiy zone could be described as follow:
According to the interval velocity variation (Figure 11-B), two zones can be recognized. The first one was extended from (3951 m – 4120 m) this which includes (YA-1, Y-Barrier A1, YA2, Barrier A2, YA3, Barrier A3, YB1, Barrier B1), the main litho-unit is wackestone (figure 12) with interval velocity value ranging from 4150 m/s to 4250 m/s around Da-1 well. The second zone was extended from (4120 m to 4235 m). This includes (YB2, Y-Barrier B2, YB3, Y-Barrier B3, YC1, Y-Barrier C1). The litho-unit is packstone (figure 12) with interval velocity ranging from (4250 m/s – 4500 m/s). So, the packstone gives a higher interval velocity value than the wackestone unit. The main reason for interval velocity variation is due to the complexity of litho-units in the field, which means more than interbedded layers exist.

(a) (b)

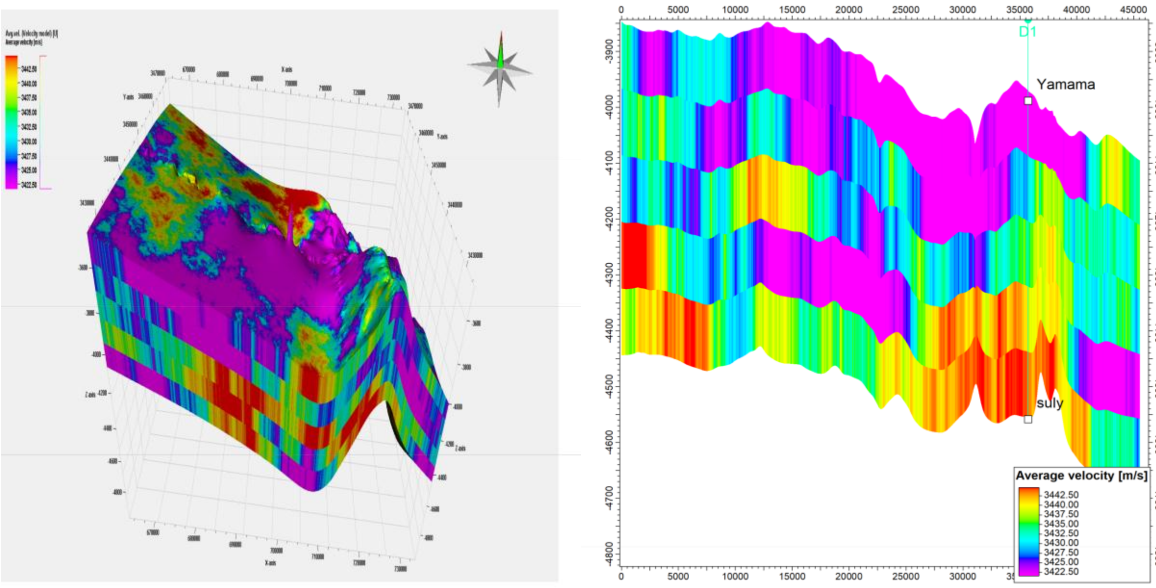
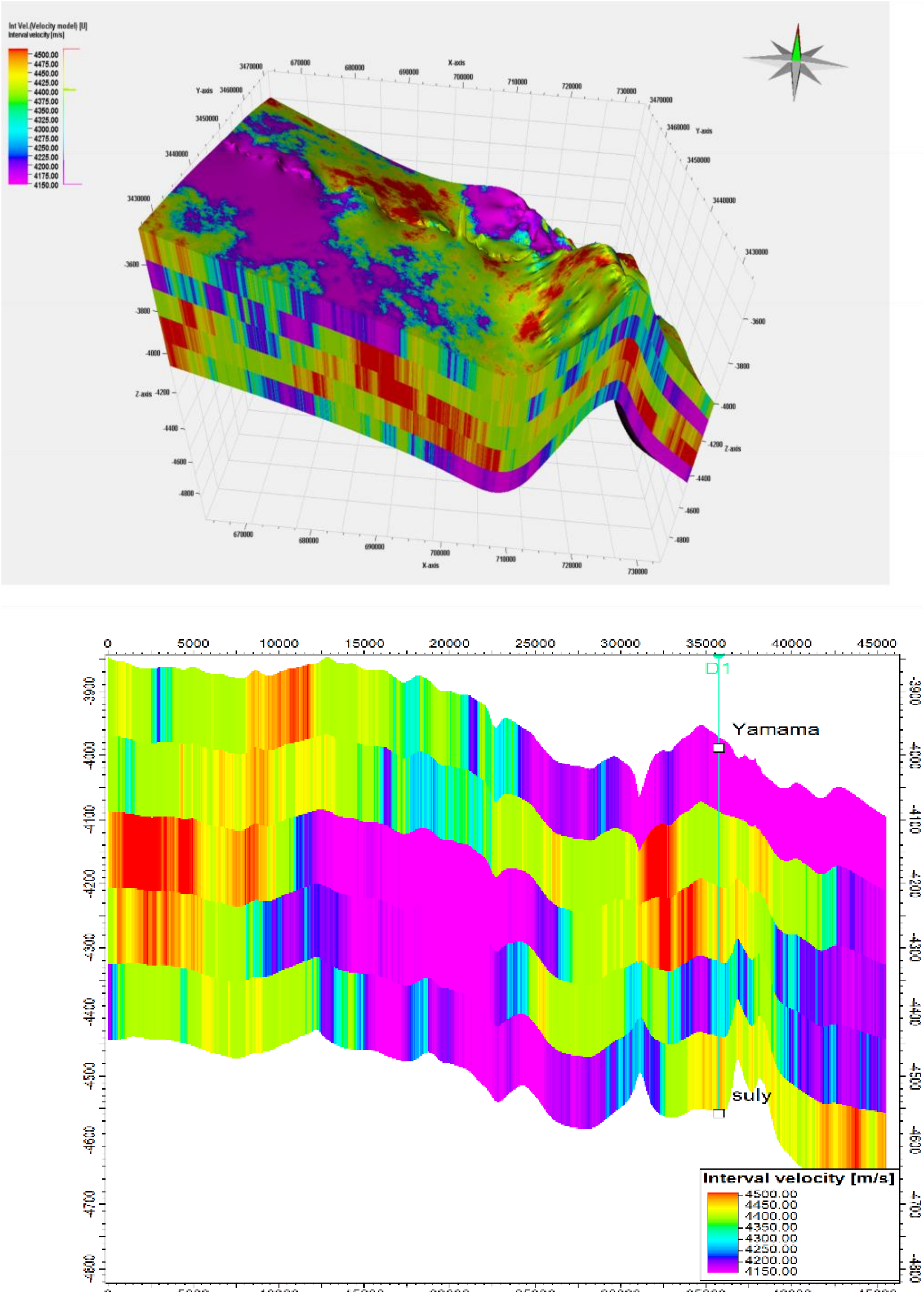


Figure 10: average velocity model, where (a) 3D model, (b) intersection pass though the well Da-1

The 3D velocity model of the Yamam- Sulaiy zone (figure 11-a) shows that velocity decreases in the southwest with a minimum value of 4150 m/s. The interval velocity value increases toward the northeast with a maximum value of 4500 m/s.

(a)



(b)

Figure 11: Interval velocity model, where (a) 3D model, (b) intersection pass though the well Da-1.

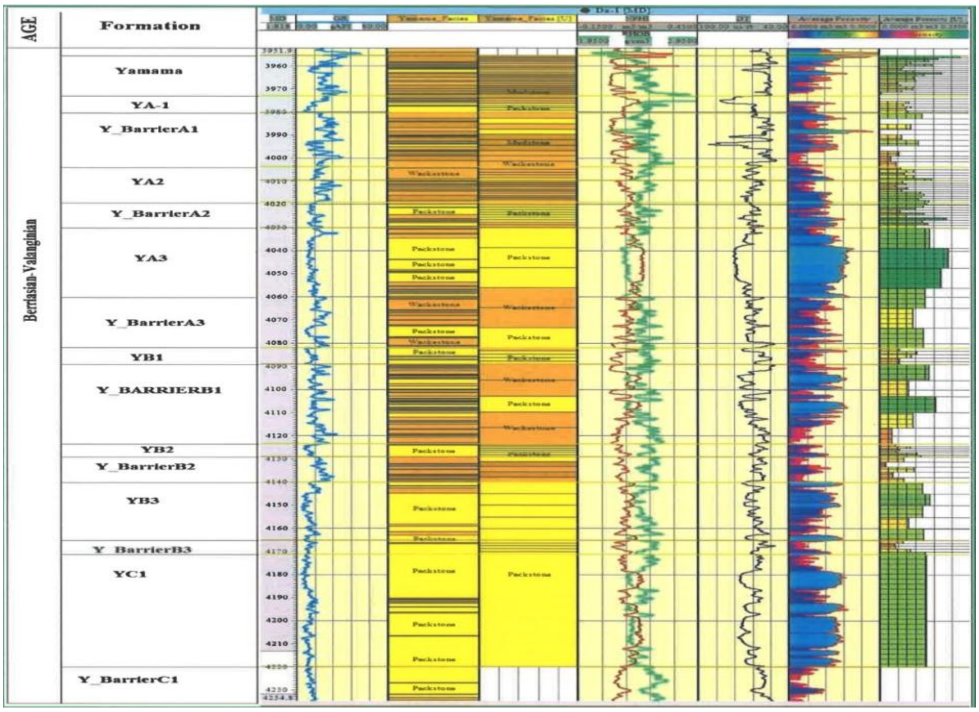


Figure 12: The litho-classification in Da-1 well

8. Structural Picture and Faults Identification

Ad'Daimah structure composes a fold (asymmetrical fold) (Figure 13) in which the axial plane is inclined relative to the median plane, and adjacent limbs dip in opposite directions**.** Four minor faults have been detected in the Ad'Daimah field, and two fault faults in line (2hh27-mig) (figure 14) with direction NE-SW. The third fault was in line (2hh31-mig) (figure (15) with direction NW-SE. The last one is in line (2hh31-mig) (figure 16) with direction SE-NW. The Najd Fault System may be a conjugate trend to the transversal fault system, which has been identified in the research region and includes the primary NE-SW tendencies. It is possible that the transversal fault systems formed in the Late Precambrian [8].

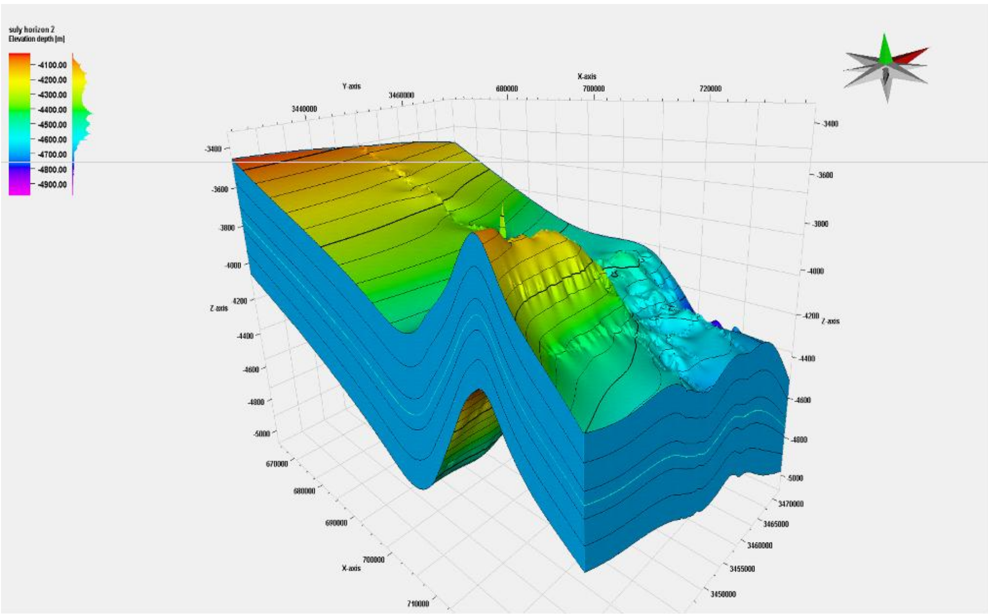


Figure 13: 3D simple grid view of Ad'Daimah structure fold in-depth domain.

Numerous smaller strike-slip faults were also discovered in the seismic sections under research; however, the three listed faults are the most significant and impact the study region from the surface to all reflectors below it. Around 670 Ma, the Najd System began as a sinistral strike-slip faulting system that was linked to intense ductile deformation that led to the emergence of gneiss domes [17]. An extensional system later developed from (640 -530 Ma.). Between the Jurassic and Quaternary, the Najd Fault System experienced vertical movement. The major fault system in the study area represents by The Tikrit-Amara Fault (figure 3) Zone that extends from the Jezira region in NW Iraq through Tikrit and Balad into Baghdad and Nahrawan. It continues along the SE trending stretch of the Tigris River between Kut and Amara. Major buried anticlines are located along this fault zone (Rafidain, Nahrawan, E. Baghdad, Balad and Tikrit). The seismic sections containing the faults have been converted to depth domain, and the faults depths of the fault are found within 3-4 km.

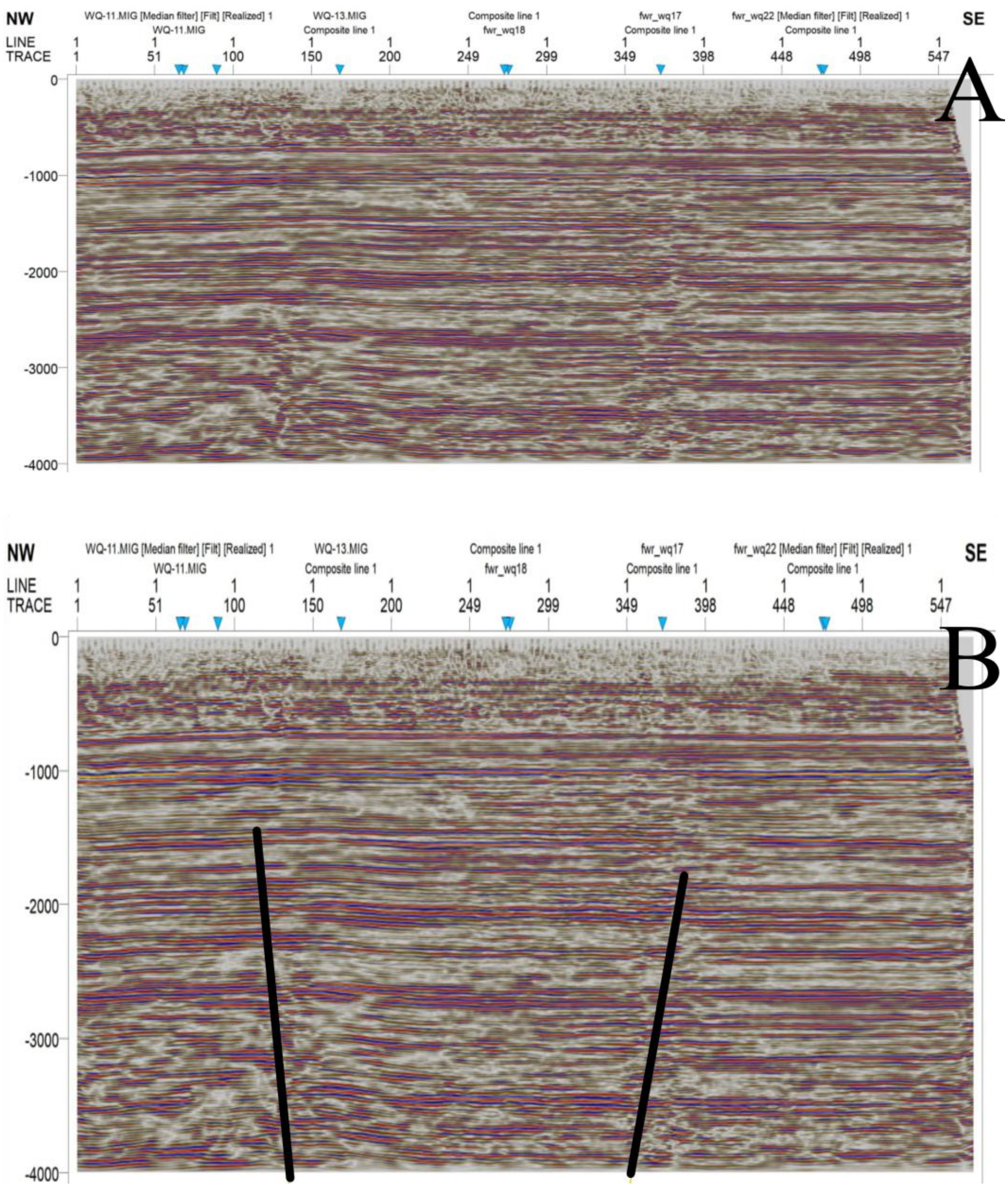


Figure 14: The seismic section 2hh27-mig with the picked faults.

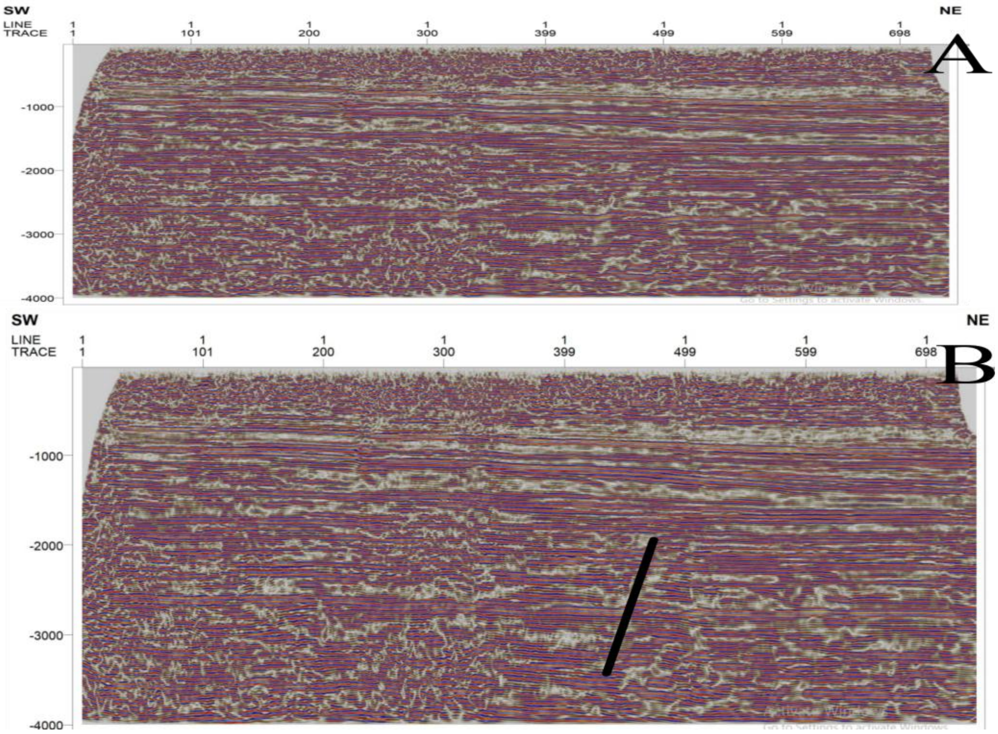


Figure 15: The seismic section in line (2hh31-mig) with the picked of fault.

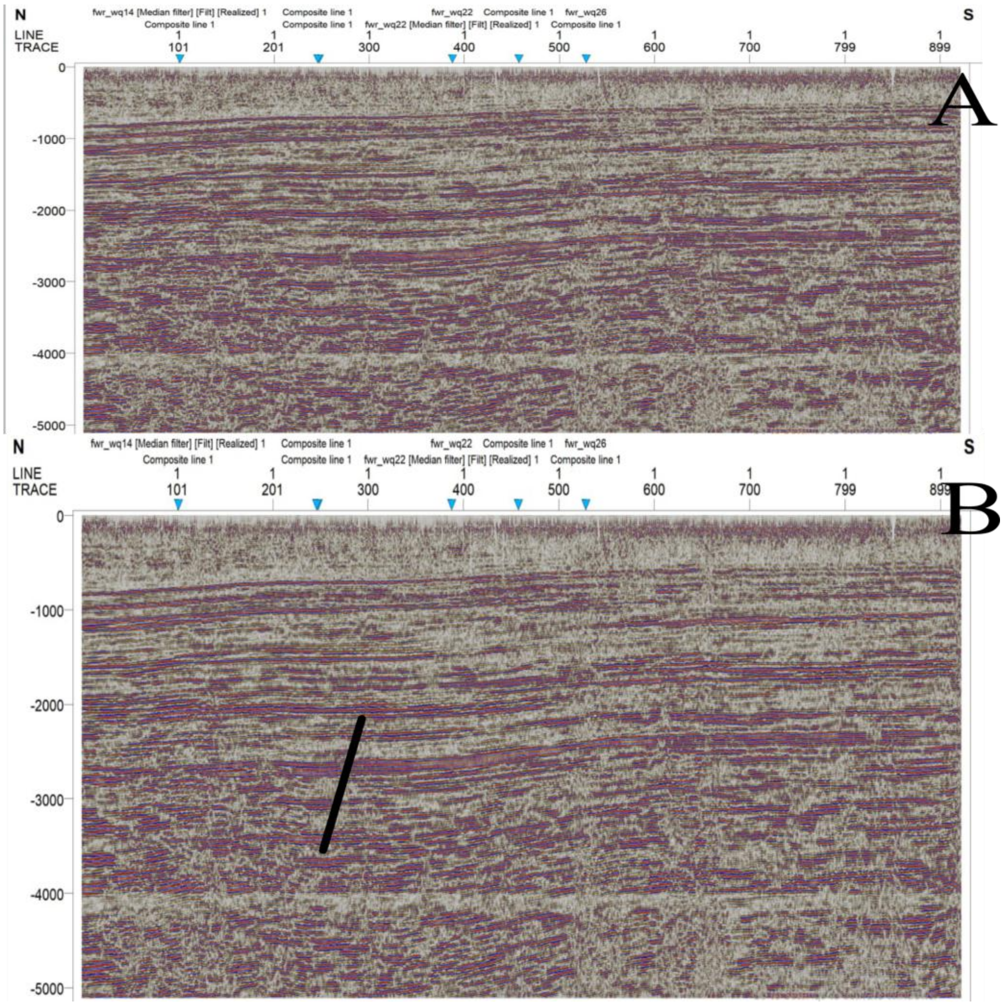


Figure 16: The seismic section in line (2hh31-mig) the picked of fault.

9. DHI Interpretations

The phase angle at any point along a trace, regardless of amplitude, is depicted by the seismic property known as the instantaneous phase. Instantaneous phase information is crucial to demonstrate and differentiate the endpoints of reflective continuity [4]. It reveals both powerful and weak events with equal strength so that various structural and stratigraphic aspects may be recognized [18]. A high amplitude anomaly in seismic waves may indicate the presence of hydrocarbons (Bright spots) extending 2635m through the seismic section, as shown in Figure 17. Highly cemented sands with a substantially higher acoustic impedance than the underlying shale cause dim (dim spot) areas (Figure 18). Where it seems flat (flat spot), flat areas (Figure 18) signify a hydrocarbon contact seismic response. Gas and oil, oil and water, or gas and water may come into contact. The mound phenomenon is found nearby the Da-1 well and along the NE direction in the field.

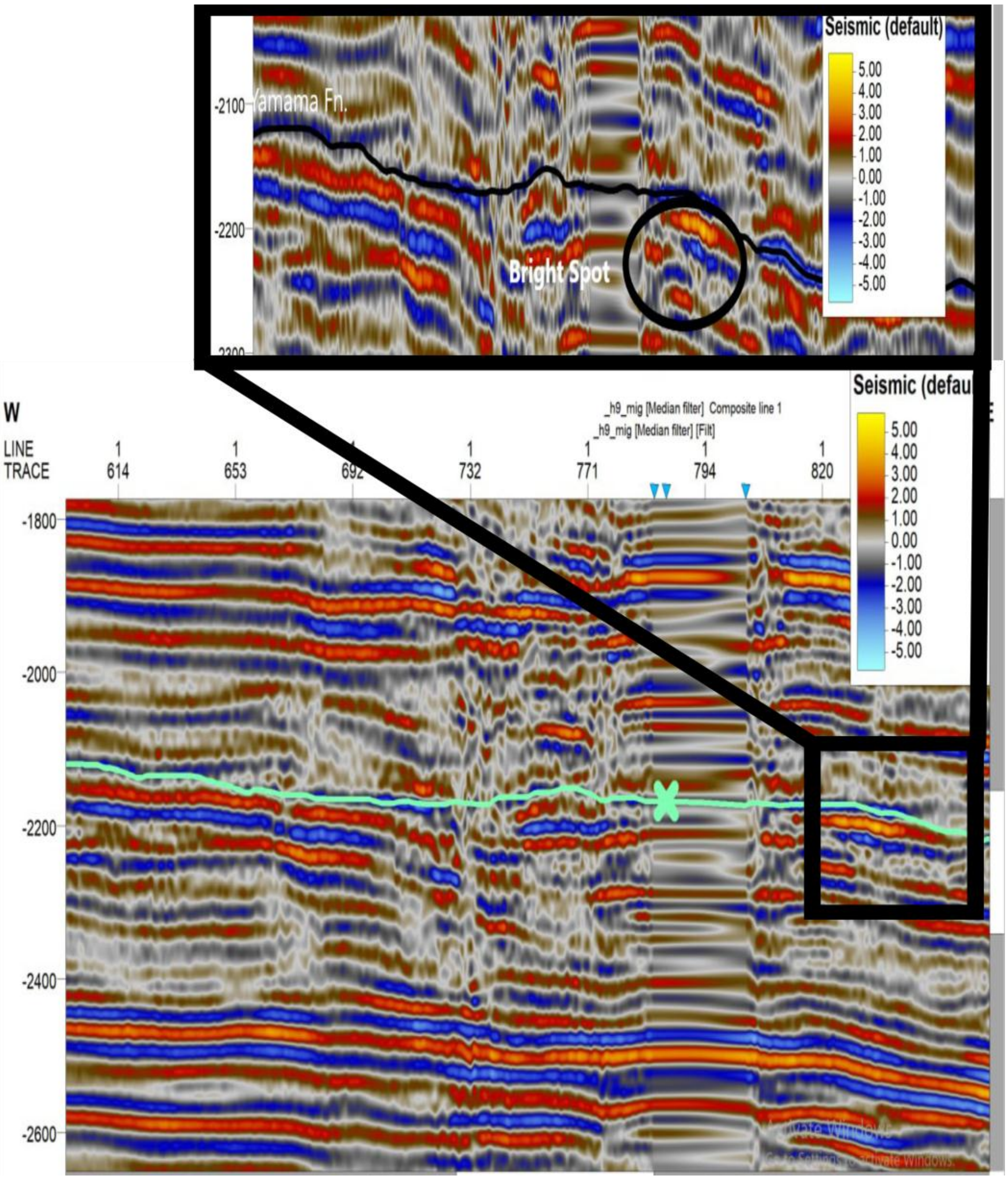


Figure 17: Seismic section within area in line (h9-mig). showing the bright spot.

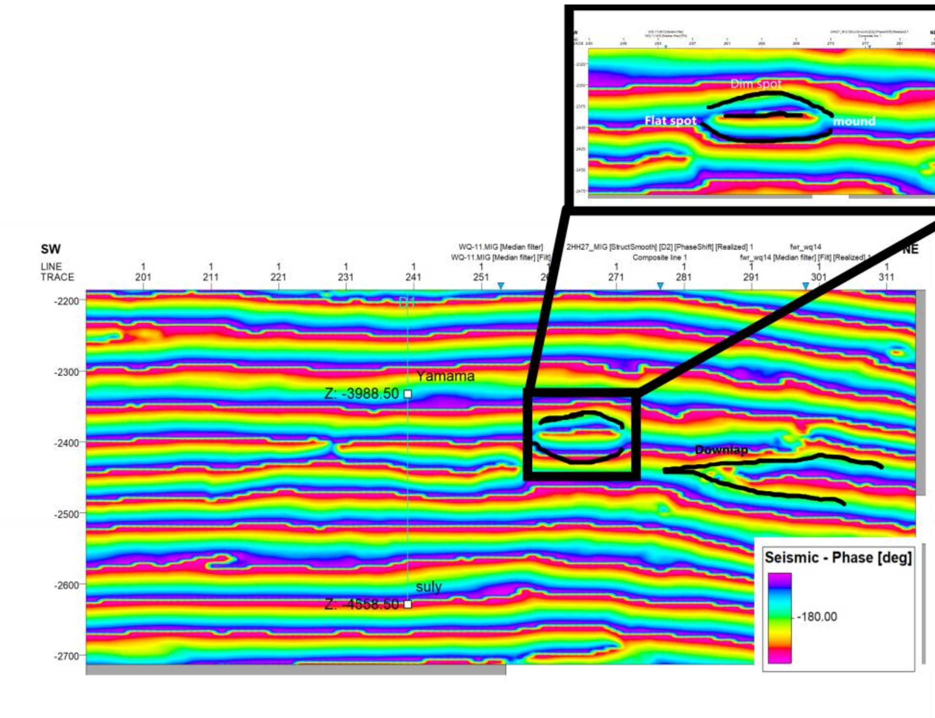


Figure 18: Instantaneous phase attribute section within the area in line (WQ-11). show the mound shape and down-lap.

The seismic section in the time domain is transformed into a seismic attribute with cubic frequency. As seen in Figure 19, the black and dark hues represent low-velocity rocks, indicating hydrocarbon concentration regions close to the well site. The presence of fluids causes the density of the rocks to decrease, which lowers the seismic velocity [19]. In contrast to the dark, which denotes a low likelihood of hydrocarbon accumulations, red rocks have a high velocity, hence low hydrocarbon possibility.

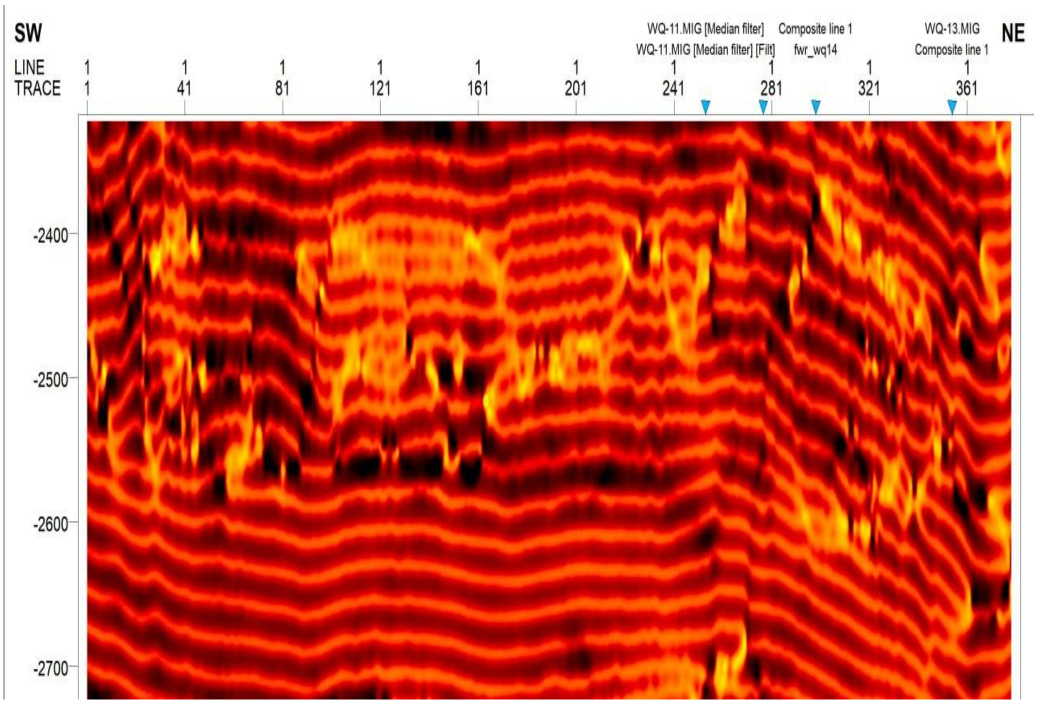


Figure 19: Instantaneous frequency attribute section within the study area in line (WQ-11).

10. Conclusions

TWT maps Yamama, and Suliay formation reflects many enclosures with increasing toward N and NE. Depth map maps show anticline structures trending east-west located on the north side of the study area with a general dip direction toward NE-SW.Yamam formation isopach map indicates that the formation's maximum thickness is 925 m in the western part of the field. In order to convert time horizons into a depth velocity model and to know the distribution of selected formation depths in the region, the average velocity model was used for this purpose. The average velocity model generally showed velocity increases with depth irregularly due to the heterogeneity of the sedimentary layers due to facies change and depositional system. The velocity model increases the average velocity values toward the northwest direction while decreasing in the southeast direction. The magnitude of average velocity for the Yamama- Suly zone model ranges from (3422m/s-3442 m/s). The interval velocity value reflects that litho-unit the packstone gives a higher interval velocity value than the wackestone unit. Ad'Daimah structure composes a fold (asymmetrical fold) effect by more than a set of minor faults (NE-SW, NW-SE, SE-NW). These faults include two major directions. Najd Fault System may be a conjugate trend to the transversal fault system. The faults depth in the seismic section was found within 3-4 km. Using seismic attribute techniques, including instantaneous phase, showed stratigraphic features such as mounds in addition to bright spot and lenses observed in origin sections, indicating hydrocarbon accumulations. The instantaneous frequency attribute also reflects a good indicator of hydrocarbon presence in the SW direction.

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