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Isopach Map of Mishrif Formation in Nasiriya Oil Field by Using 3D Seismic Data

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Abstract

The current study included interpretations of the three-dimensional seismic Data for the Nasiriya oil field implemented by the Oil exploration company in 2010 with a planned surface coverage area of 1273 km². The Nasiriyah field is located in southern Iraq within the Dhi Qar Governorate, about (10) km northwest of the governorate center (Nasiriyah), and the Muthanna governorate is located in the northwestern part of the field, which is approximately (15) km west of the governorate center (Samawah). The information from the wells (well velocity survey, formation depths, logs) was relied upon and entered into the seismic cube data to capture the top of the Mishrif Formation. In addition is to pick the top of the Rumaila Formation, which represents the bottom of the Mishrif Formation. The top and bottom Mishrif reflectors were picked, interpreted, and tracked within the region. The reflector's two-way time (TWT), velocity, and depth maps showed structural closure features in the center of the area, and the general direction of the closure is thenorthwest–southeast. The structural maps showed a general tendency towards the northeast. The isopach map showed that the thickness values of the Mishrif Formation increased to the west and northwest while the thickness decreased toward the east and southeast.

Keywords: Nasiriya Oil Field, 3D Seismic Survey, Mishrif Formation, Isopach, Southern Iraq.

الخارطة السمكية لتكوين المشرف في حقل الناصرية بأستخدام البيانات الزلزالية ثلاثية الابعاد

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الخلاصة

تضمنت الدراسة الحالية تفسير البيانات للمسح الزلزالي ثلاثي الابعاد لحقل الناصرية النفطي والتي نفذت من قبل شركة الاستكشافات النفطية في سنة 2010 بمساحة سطحية (1273) كم². يقع حقل الناصرية في جنوب العراق ضمن محافظة ذي قار ، على بعد حوالي (10) كيلومترات شمال غرب مركز المحافظة (الناصرية) ، وتقع محافظة المثنى في الجزء الشمالي الغربي من الحقل على بعد حوالي (15) كيلومترًا غربيًا. مركز المحافظة (السماوة). تم الاعتماد على المعلومات من الآبار (مسح سرعة البئر، أعماق التكوين، السجلات) وإدخالها في بيانات المكعب الزلزالي لغرض التقاط الجزء العلوي من تكوين مشرف. بالإضافة إلى انتقاء الجزء العلوي من تكوين الرميلة الذي يمثل قاع تكوين مشرف. تم اللتقاط اعلى واسفل عاكس المشرف وتفسيره وتتبعه ضمن منطقة الدراسة. أظهرت الخرائط الزمنية والسرعية والعمقية للعاكس وجود معالم إنغلاقات تركيبية في وسط المنطقة

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والاتجاه العام للإنغلاقات هو الشمال الغربي– الجنوب الشرقي. أظهرت الخرائط التركيبة اكثر ميلا بأتجاه الشمال الشرقي. أما بالنسبة لخريطة السماكة فقد أوضحت أن قيم سمك تكوين مشرف يزداد في الغرب والشمال الغربي بينما تنخفض السماكة باتجاه الشرق والجنوب الشرقي.

1. Introduction

The reflection method is the most successful seismic strategy for locating subsurface geology conditions conducive to the genesis of oil and gas [1]. The seismic method is the main important method of geophysical exploration because it has deep penetration ability and high resolution, can detect the physical properties of subsurface geology[2].

The process of acquiring geological data from seismic signals is managed by seismic interpretation. Seismic surveys typically involve three significant steps: collecting, processing, and interpreting seismic data. The reflected wave is created initially, and then it passes through a processing phase to build a stacked seismic section with a shape suitable for the interpretation step[3]. There are two fundamental parts of the seismic interpretation: structural analysis (reflector study based on reflection time) and the stratigraphic examination (or seismic stratigraphy), which is the examination of the reflection sequence as the seismic item of the lithology identification sedimentary sequence[4].

The Mishref Formation, which was deposited during the Cretaceous period, is one of the important geological formations containing oil in southern Iraq due to its rocky features and geographical extensions, making it a good reservoir for hydrocarbons, as it represents the second reservoir in economic terms after the Zubair Formation. Several studies have been conducted on various geological aspects of this formation in the various oil fields in southern Iraq, for example, the northern and southern Rumaila, West Qurna, Bazargan, Ratawi and Zubair fields. The Mishrif Formation is among the most significant reservoirs in the Middle East. About 30% of Iraq's oil reserves are in this formation[5].

The Mishrif Formation consists of limestone rocks of different facies, covering a wide range of sedimentary environments, from fresh water at the top of the formation to limestone deposited in deep marine environments, passing through the environments between them. Its rocks range from clayey limestone to granular limestone consisting of large shells of rudest that can be seen with the naked eye Bioclastic (Rudisted) Grainstone. The Mishrif represents a very complex sequence defined originally as complex of detrital limestone, containing sometimes algal, rudist, and coral-reef limestone, capped by limonitic fresh water limestone. This definition was given by[6]. The current seismic interpretation study aims to study the results of the seismic survey carried out in the three dimensions of the Nasiriya field with the results of the information of the drilled Nasiriya wells and updating the stratigraphic model of the Nasiriya field.

2. Location, Geology and Tectonic of the Study Area

Nasiriyah oil field is located in southern Iraq within the Dhi Qar governorate away from the governorate center (Nasiriyah), about 10 km northwest. Muthanna governorate is located in the northwestern part of the field and is approximately away from the governorate center (Samawah) by (15) km to the west (Table 1). The study area penetrates three rivers (Tigris, Gharaf, and the general estuary) in addition to the network of agricultural irrigation streams, especially the eastern part of the area, through which the international highway passes, as shown in (Figure 1) [7].

In agreement with the divisions of the tectonic map of Iraq [8], Iraq was classified into three tectonic provinces that trend northwest to southeast, parallel to the suture between the Eurasian and Arabian plates. These provinces are the thrust region, the Mesozoic unstable Shelf (Mesopotamian foredeep) and Mesozoic Stable Shelf. The map shows that the study region is flat. According to Iraq's longitudinal tectonic classification[9-10], the study region is located in the southern section of the country, inside the Mesopotamian basin of the unstable shelf (Figure 2).

Table 1: coordinates of the study area

ID	UTM-WGS1984 System-Zone 38	
	X(North)	Y(East)
A	3487463	568755
B	3487281	586908
C	3467212	622758
D	3453438	618106
E	3456357	580705
F	3466938	561731

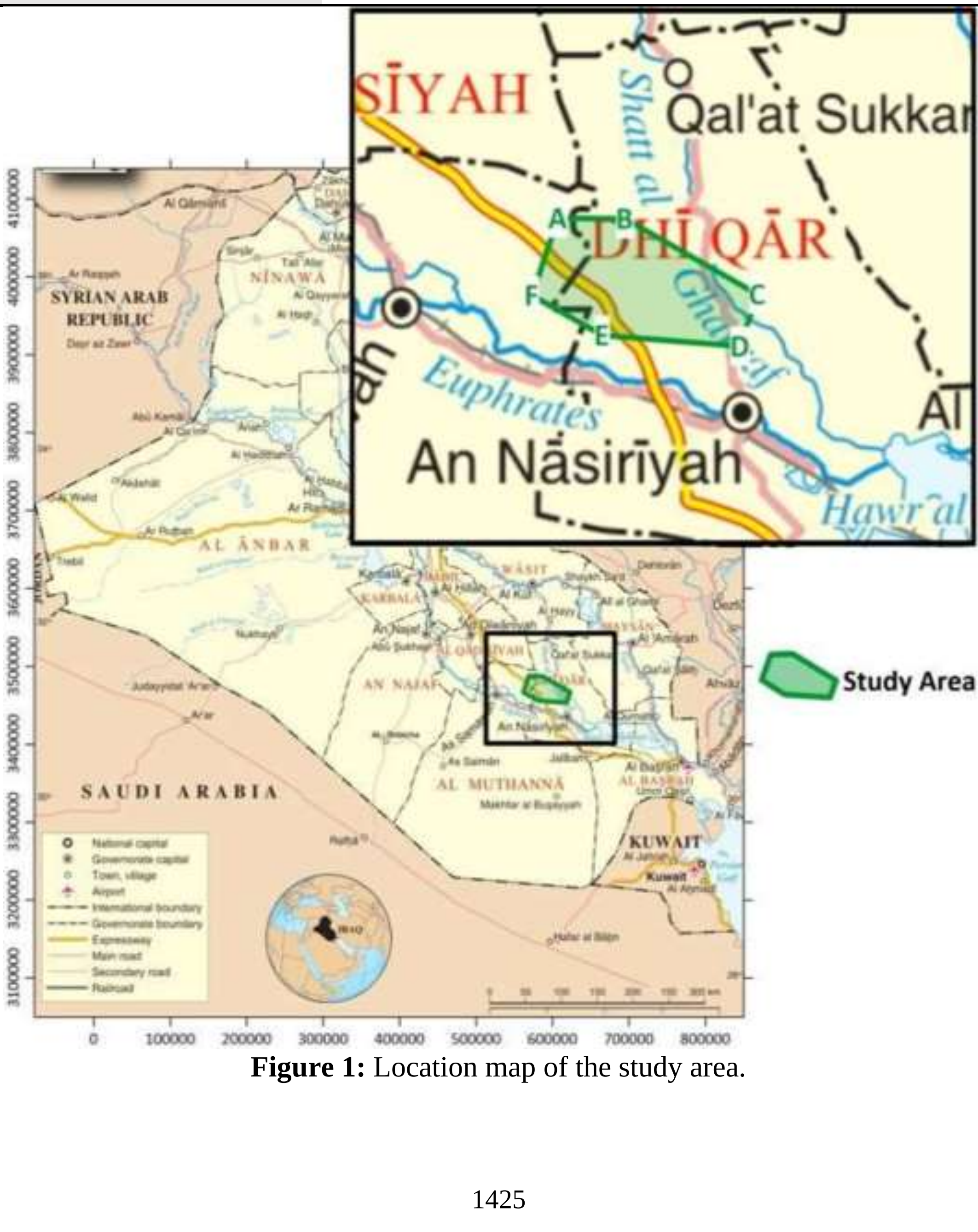

Figure 1: Location map of the study area.

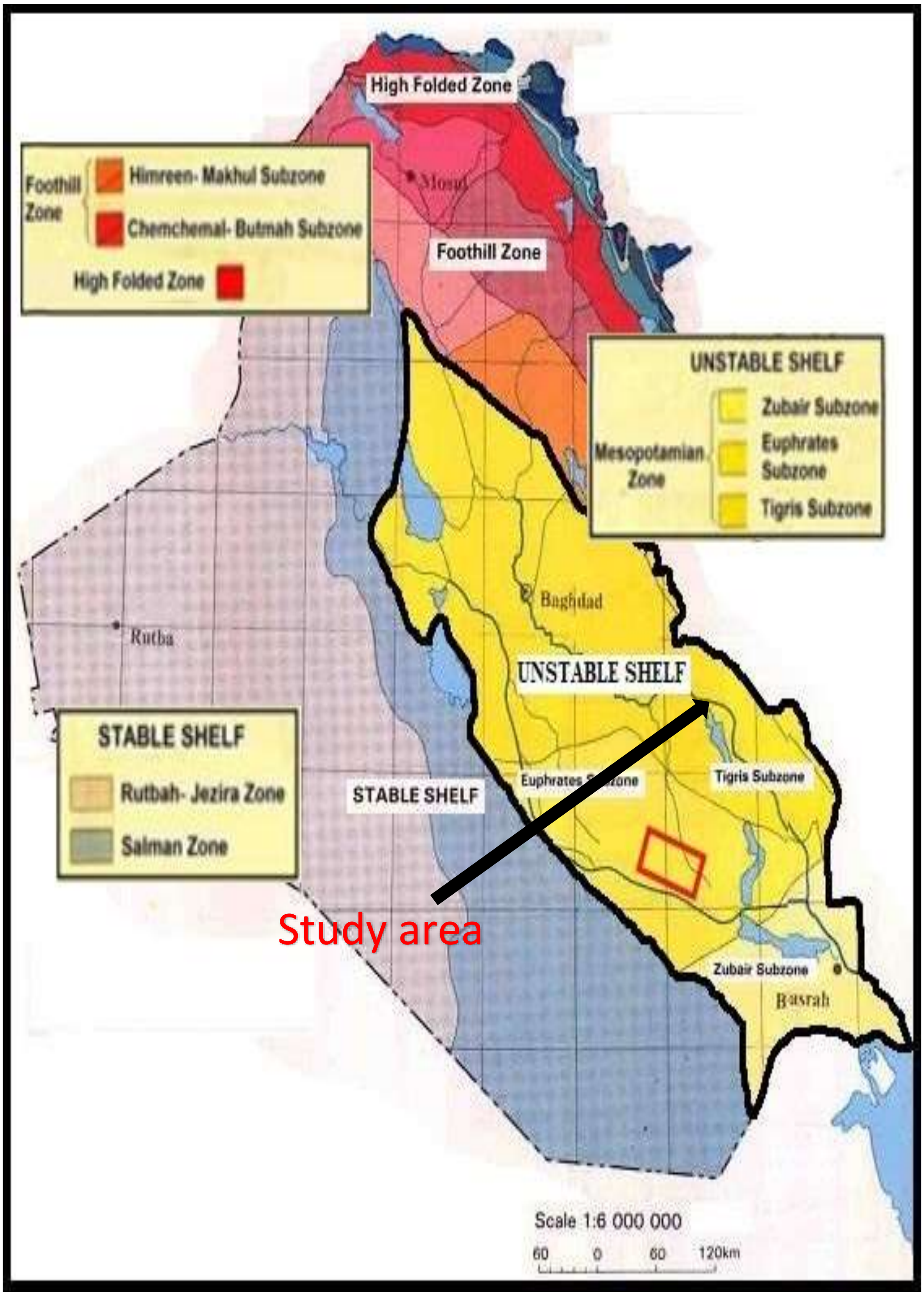

Figure 2: The Tectonic map of Iraq shows the location of the study area[11].

3. The seismic data used in the study:

1- The seismic data cube of the Nasiriya oil field three-dimensional area survey (Post Stack Time Migration).

2- The well-data (top formations, check shots, and logs) were used in the study.

3- All wells data were loaded into the seismic interpretation program work station (Petrel program, 2018) [12]. (Figure 3).

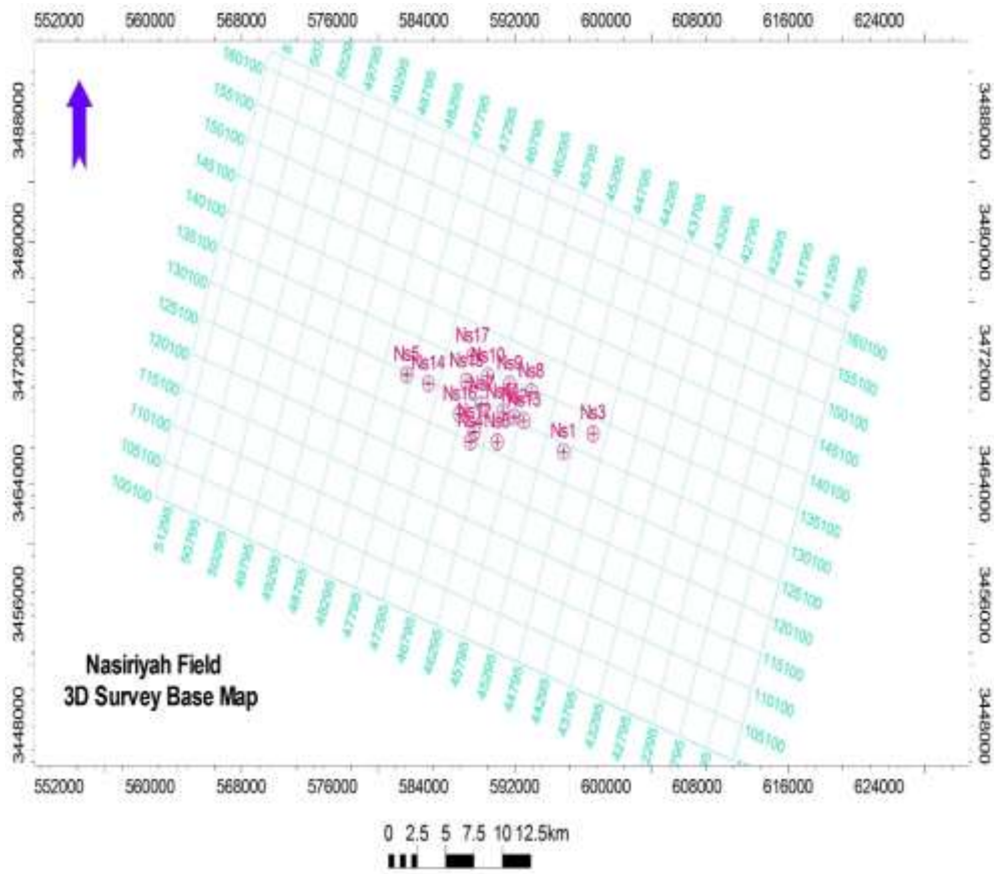

Figure 3: A a basic map showing the surface boundaries of the three-dimensional seismic survey and wells location used in the study program in the Nasiriya oil field.

4. The Interpretation Procedure

Seismic data was processed through a series of stages to arrive at the final results. The following are the main steps in seismic data interpretation: (Figure 4)

1- Uploading the 3D seismic cube for the study area and well data (well tops, check-shot, sonic log, and density log) to Petrel software.

2- Create a synthetic seismogram to get the seismic well tie.

3- Picking and Identifying the study that is interesting top and bottom of Mishrif reflectors.

4- Constructing a subsurface map for the above-selected reflectors in two-way time (TWT).

5- Creating an average velocity map from check-shot to convert time-domain TWT maps into depth domains to build an isopach map.

6- Creating depth maps for the investigated reflectors using the velocity model.

7- Creating Isopach map of the Horizon (Mishrif Formation).

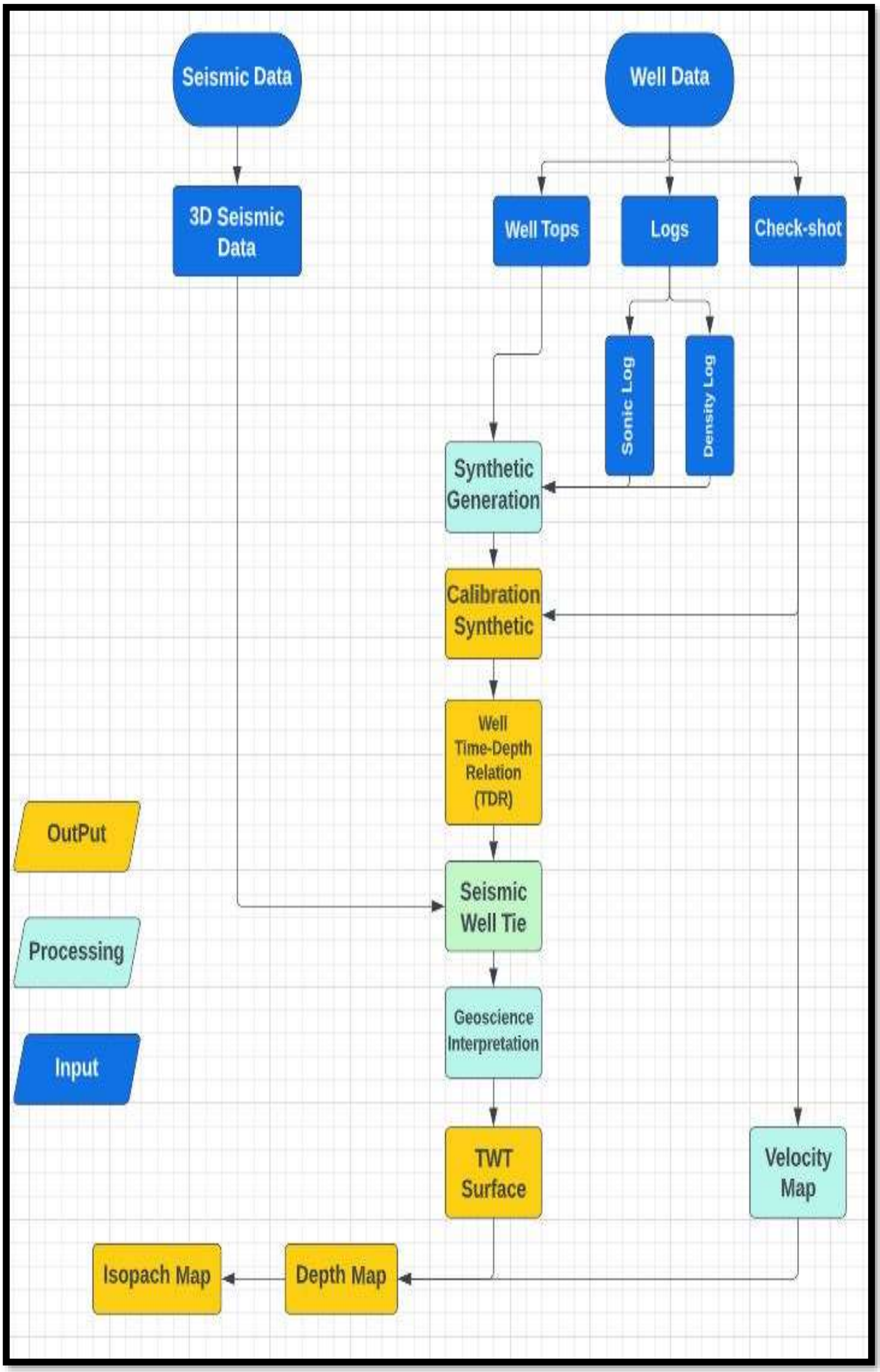

Figure 4: Flow chart of seismic interpretation procedure**.**

5. Structural interpretation of the picked horizons

The top and bottom of Mishrif reflector, which has good to very good quality and continuity, were installed and traced, and the interpretation was performed automatically and manually for the reflector (Figure 5).

The pieces that make up a petroleum or gas reservoir - the source rock, the reservoir rock, the seal and trap (sides, top, and bottom) extension of the reservoir - are identified by structural interpretation. However, simply mapping the reservoir's topography is insufficient. To understand how and when structures evolved, it is frequently required to map ranges of horizons above and below the objective [13].

After defining the studied reflectors using synthetic seismograms in the time domain for well (Ns-1), we selected these reflectors across the entire area and mapped the top Mishrif reflectors in the time domain, which were later converted to structural maps in the depth domain using velocity data for these reflectors. All maps use sea level as a reference datum. The structural characteristics of these structural maps are detailed further below.

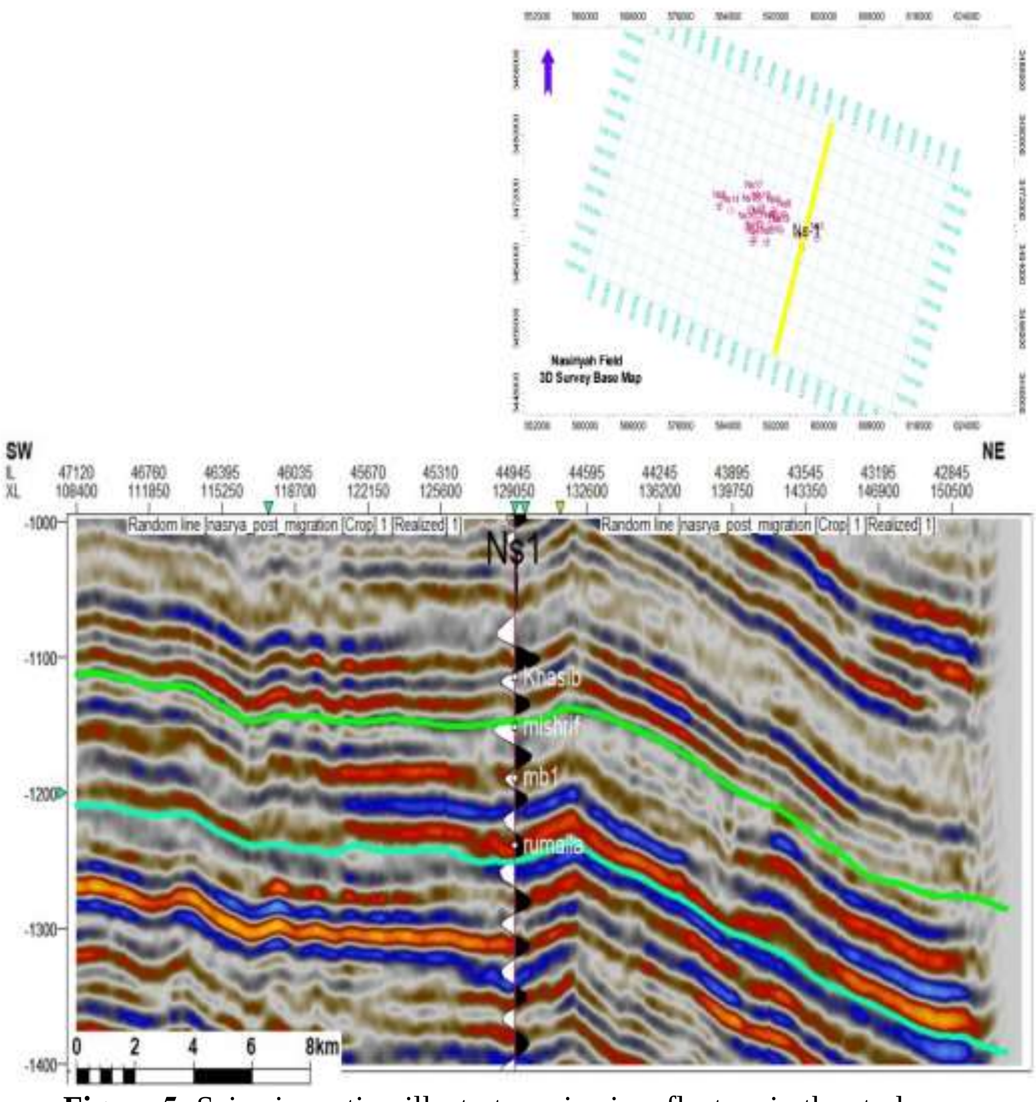

Figure 5: Seismic section illustrates seismic reflectors in the study area.

6. Two-Way Time (TWT) map of the top Mishrif reflector

The time maps are the first image of the research area's underlying geological features in the time domain. It is drawn by superimposing the time values of each shot point on the values at the line on the base map [14]. Petrel software was used to create TWT maps from selected horizons of the top and bottom Mishrif Formation. All maps utilize sea level as a datum plane, with contour intervals (10 ms).

Top Mishrif TWT

The TWT map (Figure 6) shows a general trend for the studied reflector towards the northeast, where the values of time levels increase in those directions and decrease towards the southwest, which ranges from (1050 to 1320) ms. The map showed that the field is an open closure from the western side that includes small closures. The general direction of the structure is northwest-southeast, and the first closure includes the wells (Ns – 1, 3). While the second closure which includes some small closures at the sites of other Nasiriya wells.

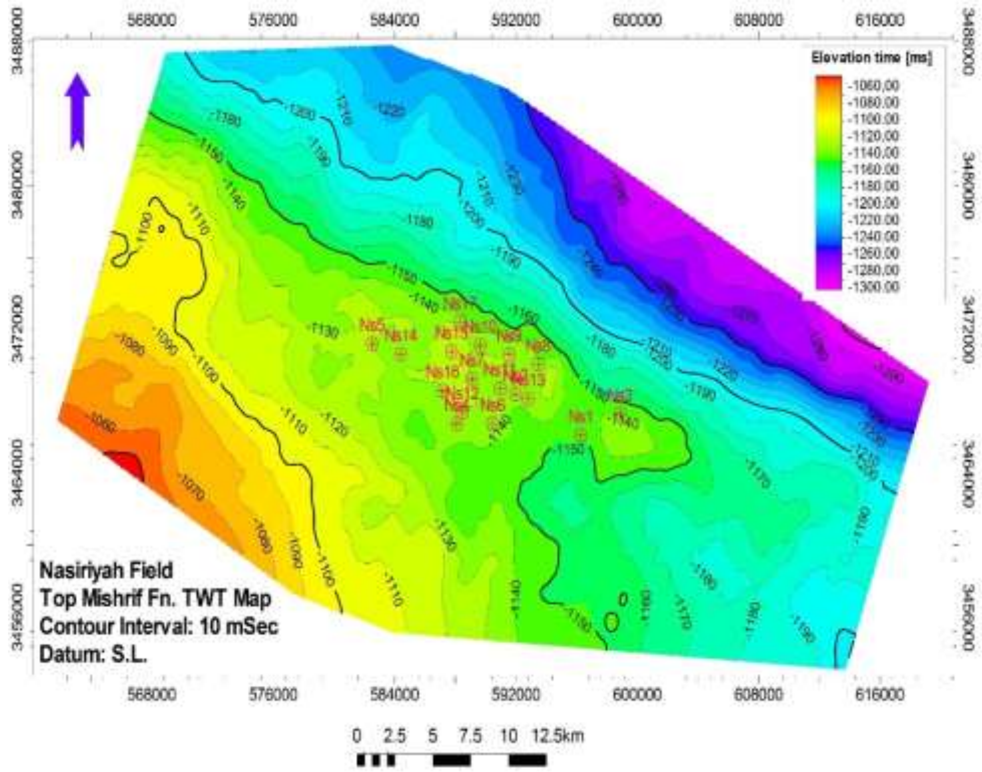

Figure 6: The Two-way Time (TWT) map of the top Mishrif Formation

TWT map of Bottom Mishrif (Top Rumaila)

The TWT map of the bottom Mishrif (Figure 7) generally shows the same trend as the TWT map of the top of the Mishrif for the studied reflector. The time increases towards the east and the northeast and decreases towards the southwest, ranging from (1150 to 1420) ms. The map shows that the field is an open closure from the western and southern sides that includes three closures at a well site (Ns-5), at well sites (Ns-7, 10, 15), and a well site (Ns-1, 3).

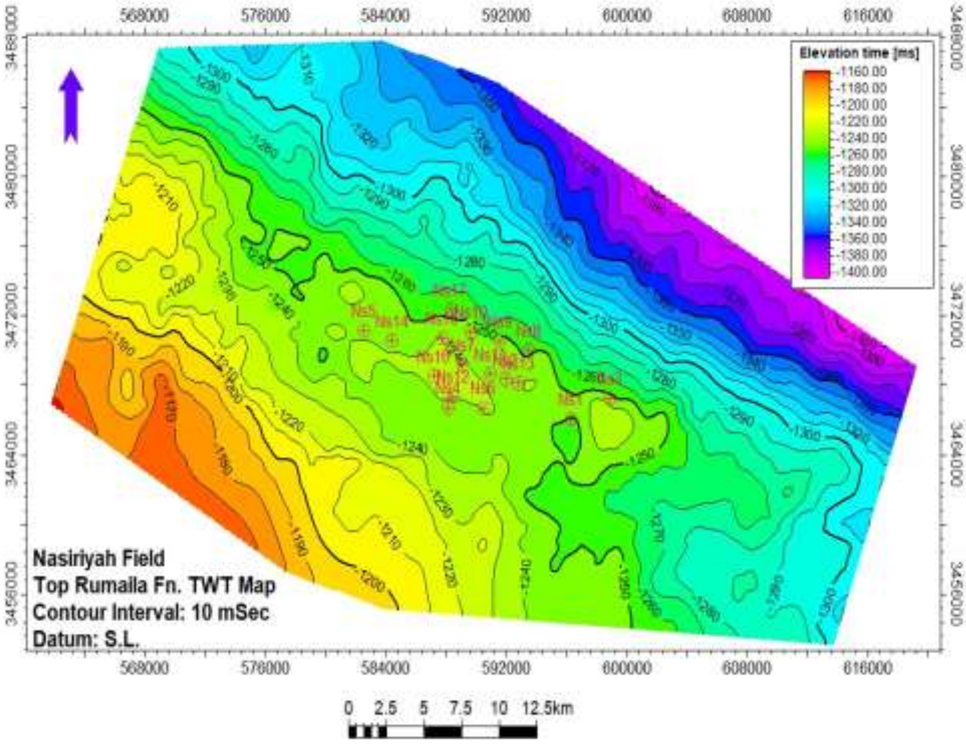

Figure 7: The Two-way Time (TWT) map of the bottom Mishrif Formation(Top Rumaila)

7. Velocity map

The velocity map of the study area was constructed based on the values of the average velocity of the Nasiriyah oil field wells located within the study area.

Average velocity map of Top Mishrif

The average velocity map for the top Mishrif Formation (Figure 8) shows a general, gradual increase in the average velocity values towards the west, reaching (3430 m/sec), and the velocity values decrease towards the east, reaching (3280 m/sec). The map shows that the magnitude of velocity values ranges from (3280 – 3440 m/sec). It is noted that the velocity values are homogeneous at the sites of Nasiriya wells, except for some wells with relatively higher velocity values.

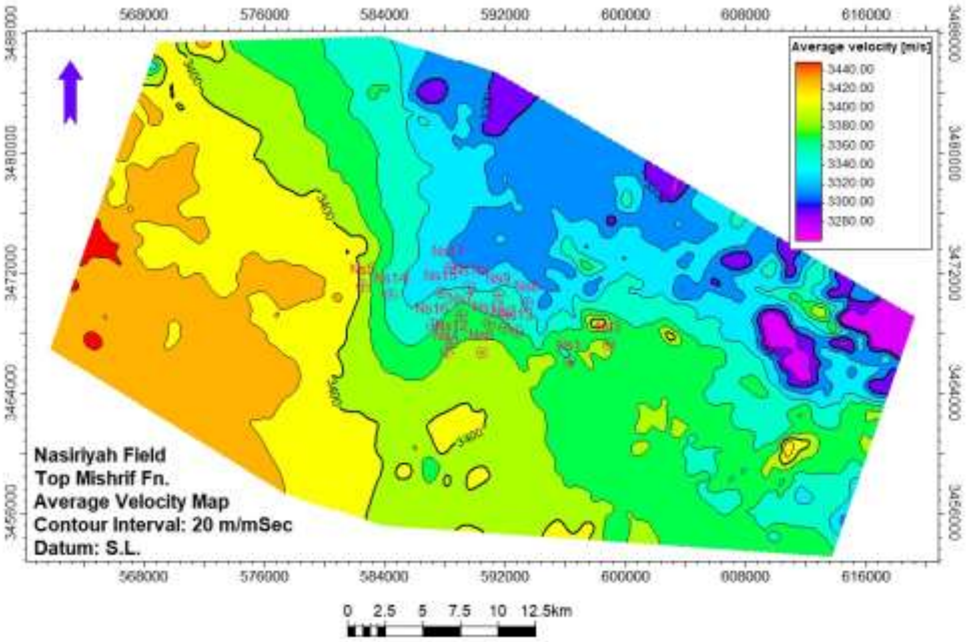

Figure 8: Average velocity map of Top Mishrif Formation.

Average Velocity map of bottom Mishrif (Top Rumaila)

The average velocity map for the bottom Mishrif (top Rumaila Formation) (Figure 9) shows the homogeneity of the average velocity values, as it increases in the western parts reaching (3440 m/sec), while decreases in the eastern part running 3120 m/sec of the Nasiriya field, the map shows that velocity values range from (3120 – 3500 m/s). It is noted that the velocity values are homogeneous in the locations of Al-Nasiriya wells.

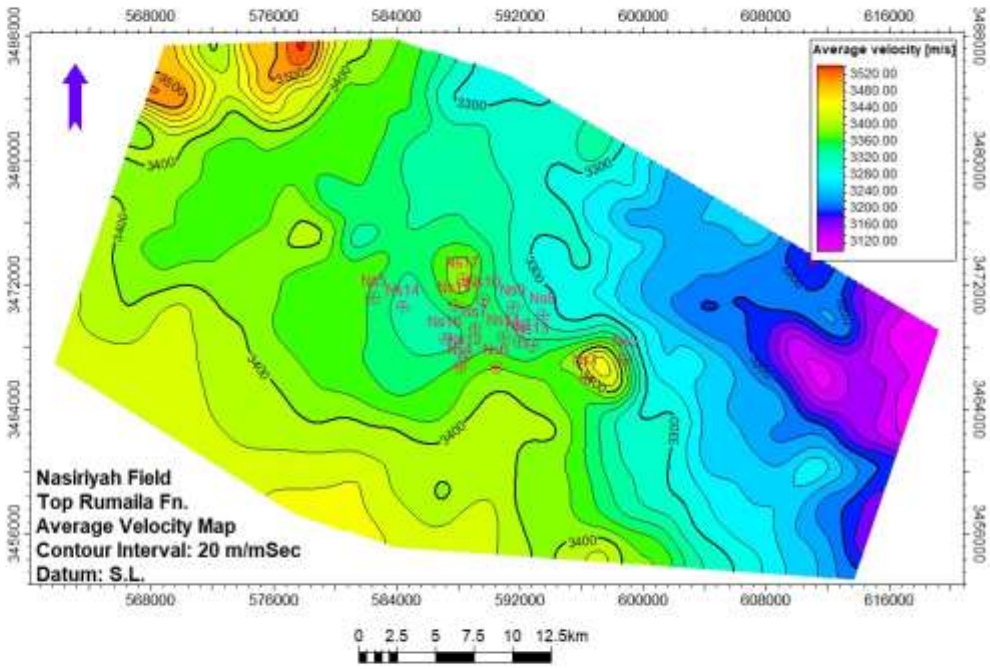

Figure 9: Average velocity map of bottom Mishrif (Top Rumaila Formation)

8. Depth map

After converting the structural map from the time domain to the depth domain using the velocity map, a level period of 20 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.

In depth conversion, we have used the average velocity function. The obtained depth maps for the studied reflectors are:

Top Mishrif Depth maps

This map is shown in (Figure 10) illustrates the general dip towards the northeast. The depth increases toward the northeastern part of the area reaching (2160m), and the depth increases toward the southeast to reach about (2030m), whereas the depth decreases toward the southwest part to reach 1800m.

The depth map showed the presence of several main closures with a dome shape. The first closure (a) is located near the well site (Ns – 3), while the well (Ns - 1) appears outside the boundaries of this dome. The second closure (b) embraces another group of wells, the Nasiriya oilfield (Ns - 7, 8, 9, 10, 14, 15, 16, 17).

Bottom of Mishrif Depth maps (Top Rumaila)

The depth map of the bottom Mishrif (Figure 11) illustrates the general dip towards the north and the northeast. The depth increases toward the north part of the area reaching (2320m), and toward the northeast to reach about (2280m), whereas the depth decreases toward the southwest part to reach 2000m.

Another large enclosure appears east of the Nasiriya oilfield area, starting from the east of the Ns-3 extend to the southeast, including several small closures. The same previous closures are still appearing in the depth map of the bottom Mishrif. The first closure includes two domes, including the wells site (Ns - 2, 3, 5, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17). The second closure is located near the well site (Ns – 3), and the location of the well of (Ns - 1) appears on the edge of its foothills towards the southwest of the enclosure. It is worth noting that this enclosure appears as a syncline as the depth increases to the center of the enclosed.

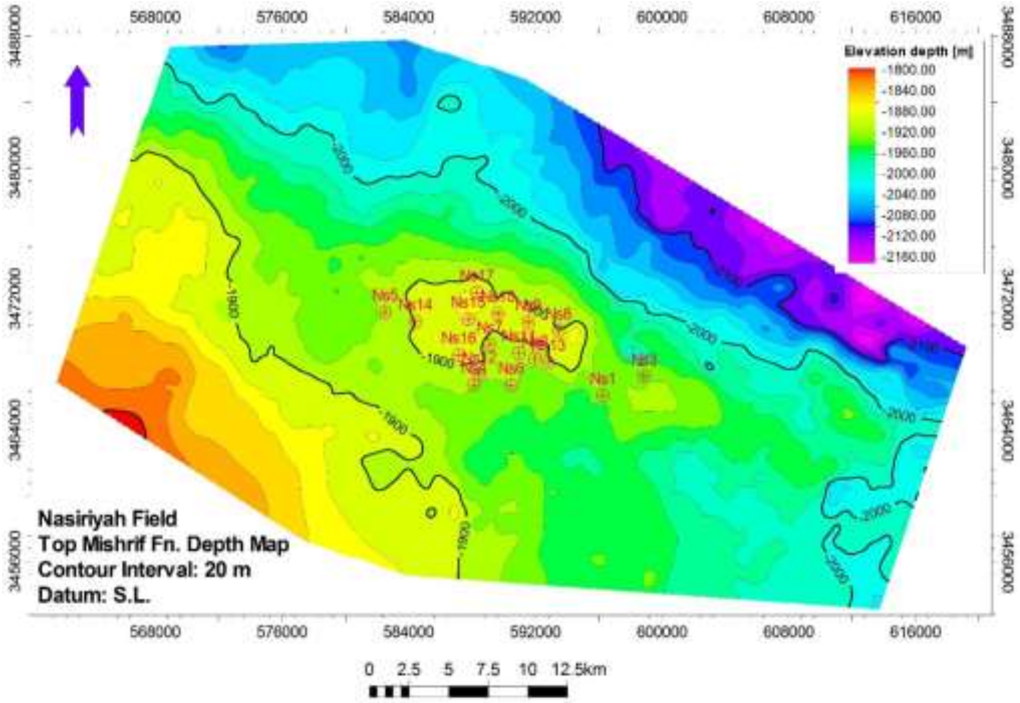

Figure 10: The depth map of Top Mishrif Fn.

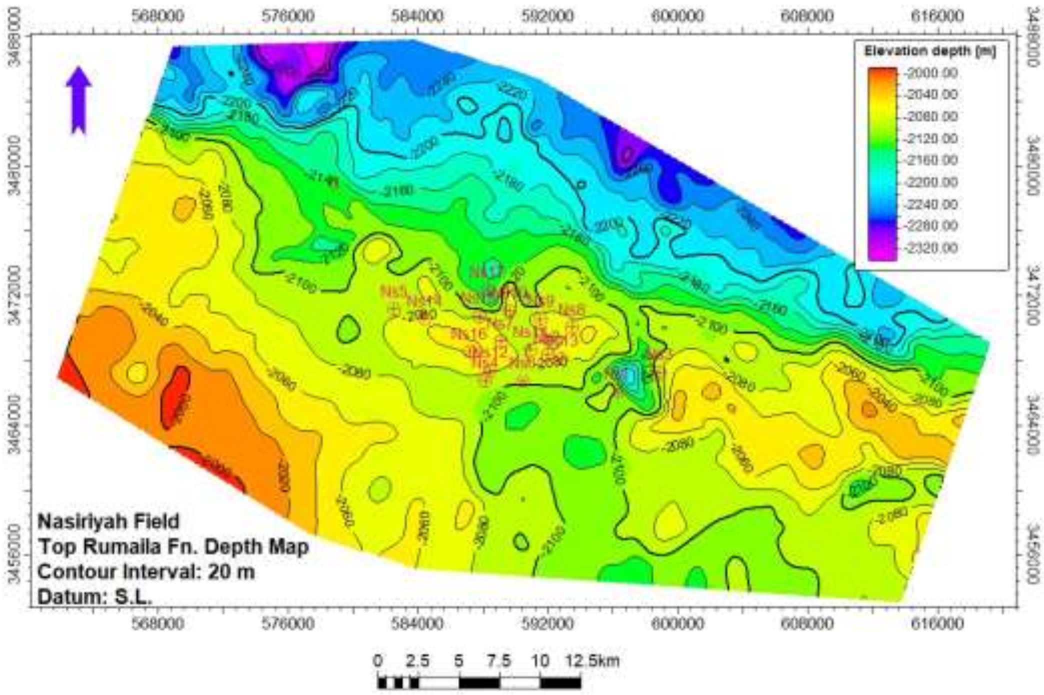

Figure 11: Depth map of bottom Mishrif (Top Rumaila Formation)

9. Isopach map

Isochron and average velocity maps are used to create isopach maps [15]. Isopach Map with a contour interval of 20 m and reference surface is sea level (Figure 12). The figure shows that the thickness of the Mishrif Formation increases to the west direction of the wells of the field, reaching about 280 m, and the northwest reaches 180m, while it decreases in the southeast part to reaches 20m, so the thickness values range between (20-280) m.

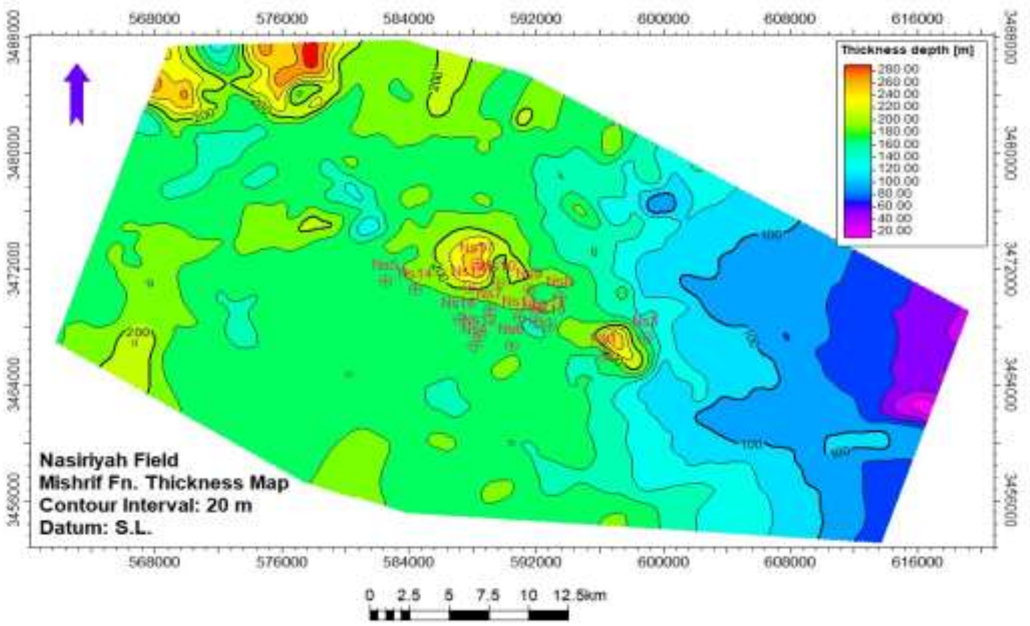

Figure 12: Isopach map of Mishrif Formation in the depth domain.

10. Conclusion

- Time, velocity, and depth maps of the Mishrif reflector were created.
- The TWT and depth maps showed that the field is an open closure from the western side that includes small closures. The general direction of the structure is the northwest–southeast. these closures are located at the well site (Ns – 1, 3) and located at the wells site of Nasiriyah (Ns - 7, 8, 9, 10, 14, 15, 16, 17)
- isopach map shows the thickness of the Mishrif Formation increased in the west direction of the wells of the field, reaching about (280 m), and the northwest reached 180m, while it decreased in the east and southeast parts reaches to (20m), so the thickness values range between (20-280) m.

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