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Seismic and Velocity Study of Luhais Oil Field Using Velocity Model

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Abstract

In this study, a qualitative seismic velocity interpretation is made up through using 2D-seismic reflection data on Luhais oil field in southern of Iraq which is situated at about 105 Km to the east from the Basra city. Luhais oil field was chosen to study the type and nature of the distribution of the seismic velocities of Nahr Umr and Zubair Formations in order to show its explorational importance, where these formations contain abundant quantities of hydrocarbons. Picking of the tops of Nahr Umr and Zubair was carried out from the synthetic seismogram which is calculated from sonic-logs and check shot of well Lu-2. Velocity model was obtained via using an implementation of Petrel program version, 2013 and was corrected according to tops well that drilled in the study area. Average velocity slices (vertically and horizontally) and maps are carried out from the velocity model.

Keywords: velocity model, depth conversion.

دراسة زلزالية وسرعية لحقل اللحيس النفطي باستخدام موديل السرع

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الخلاصة

تم أجراء دراسة تفصيلية نوعية سرعية في التفاسير الزلزالية وذلك من خلال أستخدام بيانات الانعكاس الزلزالي الثنائي الأبعاد لحقل اللحيس النفطي في جنوب العراق والذي يبعد شرقا عن مدينة البصرة حوالي 105 كم. لقد تم أختيار حقل اللحيس النفطي لأجراء دراسة عن نوع وطبيعة توزيع السرع الزلزالية لتكويني نهر عمر والزبير وذلك لأهمية المنطقة من الناحية الاستكشافية. أذ يحتوي على كميات وفيرة من الهيدروكابونات خصوصا في تكويني نهر عمر والزبير. في بداية البحث تم عمل الأثر الزلزلي المصنع للبئر المحفور ضمن منطقة الدراسة (لحيس-2) بأستخدام المجس الصوتي والسرع الزلزالية للبئر المذكور. وعلى ضوء ذلك تم تعريف والتقاط العواكس الزلزلية المطلوب دراستها في هذا البحث وهي (أعلى عاكس نهر عمر، أعلى عاكس الزبير). كذلك تم بناء موديل سرع ضمن تطبيقات برنامج (Petrel) والمصحح نسبة الى أعماق التكوينات المستحصلة من الابار المحفورة ضمن منطقة الدراسة ومنه تم عمل شرائح سرعية معدلية (عمودية وافقية) وخرائط سرع معدلية.

Introduction

A seismic reflection method is a technique used to investigate the subsurface by analyzing the seismic response of waves reflected from rock interfaces of different velocities and densities [1]. This method relies on the differences in the velocity of the propagated seismic elastic wave through different geological or man-made materials. The primary object of geophysical interpretation is usually to provide contour maps show the depth to series of reflectors which have been picked on the seismic sections [2]. Velocity model is a new tool to capture uncertainty in interpretation and integrate these measurements into modeling workflow. Velocity model is building for several purposes (e.g.,

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depth conversion, and accurately estimate geologically important seismic events such as change in facies , fracture, faults, unconformities and identify structural closures for better hydrocarbon target [3].

The current research is an interpretation study which deals with seismic velocities by generating velocity model and employing the modern program to determine the velocity distribution in Luhais oil field. Generally, the Luhais oil field is one of the complex subsurface structures. The aim of this research is to apply a new software interpretation system (Petrel) to improve the structure image of Luhais oil field by using velocity model. Also, to demonstrated the velocity distribution of seismic velocity. In study area, only two check shot (Lu2 and Lu21) are present and these wells does not represent the velocity of all study area, therefore the velocity model are used. Luhais oil field is situated in southeast Iraq, approximately 105 Km west of the city of Basra and 350 Km southeast of Baghdad. The Luhais oil field lies within Zubair subzone of the Mesopotamian zone in the unstable shelf [4].

From structural point of view, Luhais structure is asymmetrical antiform with dip of less than one degree on both flanks. Large scale faulting cannot be recognized on seismic at Luhais, but regional maps suggest structural a grain striking NE-SW, NW-SE and N-S [5]. The irregular shape of the Luhais structure as compared to another adjacent structure such as Ratawi, Rumaila and Zubair leads to the belief that there is a compound geological force led to form this irregular shape. In other word there is a more than simply horizontal force in addition to the vertical force which may produce the complexity of the structural subsurface image of Luhais structure [6]. Concerning the surface geology of Luhais area, the most part of the field is covered by a layer of gravel and sand (Dibdaba formation) that return to Pleistocene deposits while the southeast and east part are covered by a layer of Boulders and gravel of Holocene deposited, as well as sand dunes covering the southwest and south part of the Luhais area [7]. The target zone (Nahr Umr and Zubair formations) is of lower Cretaceous age. The lithology column of most wells showed that the most formations are consist of limestone, sandstone and evaporates rocks. Moreover, in Luhais oil field a 49 wells was drilled which show that the stratigraphic variation in the field is similar to the stratigraphic variation of adjusting area such as north and south Rumaila oil fields. The well Lu-1 was drilled in 1961 and Lu-21 in 1986 clarified that the major amounts of hydrocarbon accumulations are exist within Nahr Umr and Zubair formations.

Method of work

In the following paragraphs, the main steps of interpretation process used in the present study are:

1. Inserting the available well information including (well tops, check shot, sonic logs and density logs) and loading of the seismic data of 2D survey (29 lines).
2. Seismic well tie to the generated synthetic seismogram.
3. Identification and picking of the reflectors which are bounded the Lower Cretaceous succession which include Nahr Umr and Zubair Formations.
4. TWT Map constructed by the gridding achievement of picking reflectors (Nahr Umr and Zubair horizons).
5. Preparing velocity model, slices and maps to study the behavior and variation of different velocity types at the interval of interest over the study area.
6. Using of velocity model & gridding out of the studied reflectors (Nahr Umr, Shauiba and Zubair) to construct average velocity maps. This followed by carrying out gridding in the time domain to obtain depth maps, see Figure-1.

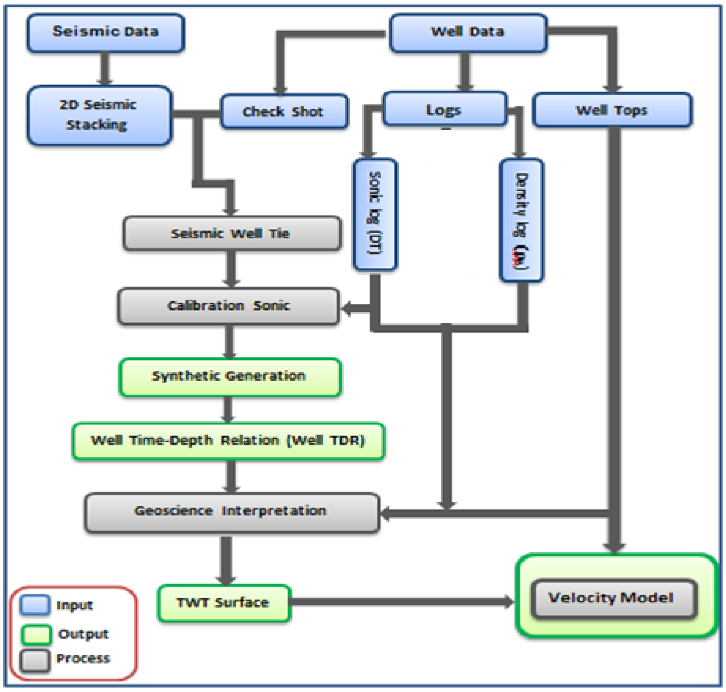

Figure 1-Flow chart of seismic reflection interpretation procedure.

Results and Discussion

A- Base map Preparation

A processed seismic data are loaded in the interactive workstation of interpretation in SEG-Y format. In present work 29 seismic lines and 21 wells was loading using Petrel program. This current base map clarifies the boundary of the study area, 21 wells and 29 seismic lines in Luhais oil field, Figure-2 shows the base map of the study area in UTM coordinate system.

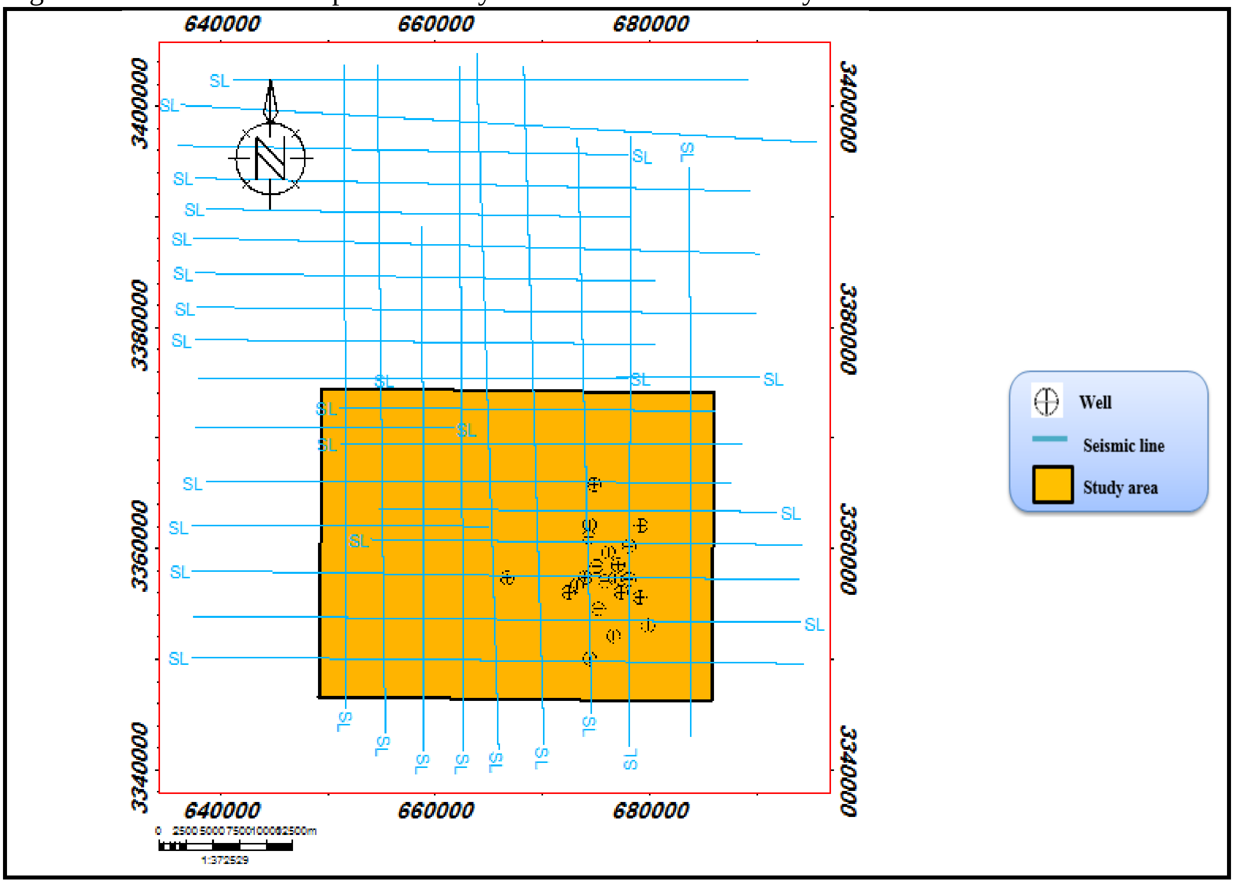

Figure 2- Base map of Luhais oil field

B- Synthetic Seismogram Generation

The most controlling in mapping the subsurface, is the greater the accuracy of the maps. Controlling can be enhanced by the correlation of seismic data with borehole data by using the synthetic seismogram which is considered as the primary means of obtaining this correlation. In the current study, synthetic seismogram was generated for well Lu-2. From application of Petrel software the seismic well tie tool allows the interactive check shot calibration of sonic log data, analytical wavelet creation, statistical and deterministic wavelet extraction and synthetic seismogram generation of 2D seismic data. Seismic-to-well tie is the key at any stage of the development of a field and is an essential step of the seismic interpretation workflow, bridging the gap between the time and depth domains [8]. Synthetic seismogram that is created by convolving a seismic wavelet, preferably one extracted from the seismic data to which the synthetic will be correlated, with a reflection-coefficient (RC) series generated from acoustic impedance (AI) data calculated from calibrate sonic and density logs collected during a borehole evaluation program [9]. Estimation of the embedded wavelet in seismic data by matching seismic reflectivity with well logs reflectivity tying the well to the seismic data. As shown in Figure-3 the resulted synthetic seismogram clarify tops of Nahr Umr and Zubair correspond to trough, while Shuaiba correspond to peak. This variation in polarity is mainly due to variation in lithology from one formation to another. In Figure-4 the seismic section (SL29) is displayed which pass through the Lu-2 well location. On this section a comparison between seismic section trace and synthetic traces, is made and geologic formation are indicated.

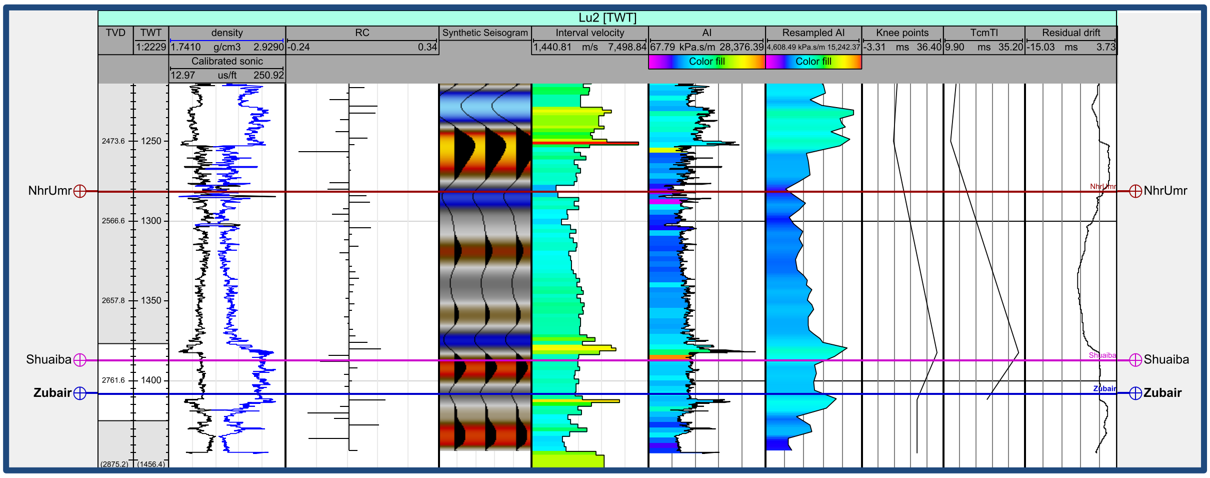

Figure 3-Synthetic seismogram generation of Lu-2 well.

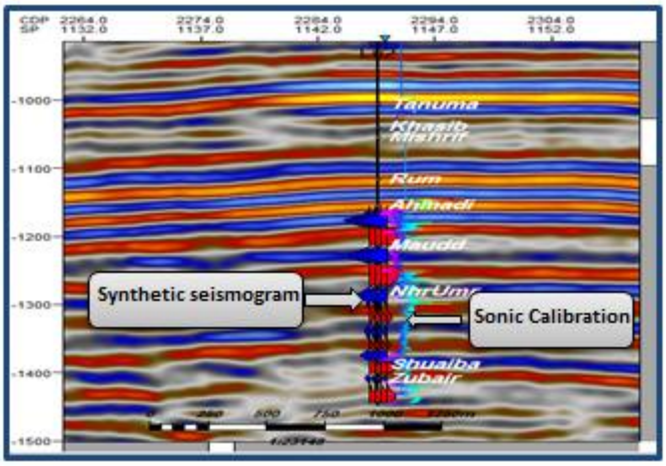

Figure 4- Comparison between seismic section (SL29) with synthetic traces of well (Lu-2)

C- Two Way Time (TWT) maps construction

Using Petrel program, two (TWT) maps have been constructed from the picked horizons (Nahr Umr and Zubair) respectively using a sea level as a datum plane, with contour interval (10 msec). Generally, all the studies shown in the TWT maps which are described below shows a structure plunged in the NE of the study area and the magnitude of enclosure increased with depth with appears new enclosure. The Luhais structure appears as an irregular enclosure shape which has many axis direction. This structure is situated in the east part of the study area with a contour enclosure value of 1300msec at Nahr Umr horizon, while contour enclosure value of 1460 ms, note Figures (5and 6). Moreover, the West Luhais structure appears at Nahr Umr horizon having a small enclosure at site of Lu-4, while appears as a structural nose at Zubair horizon extending in W-E trend at the site Lu-4.

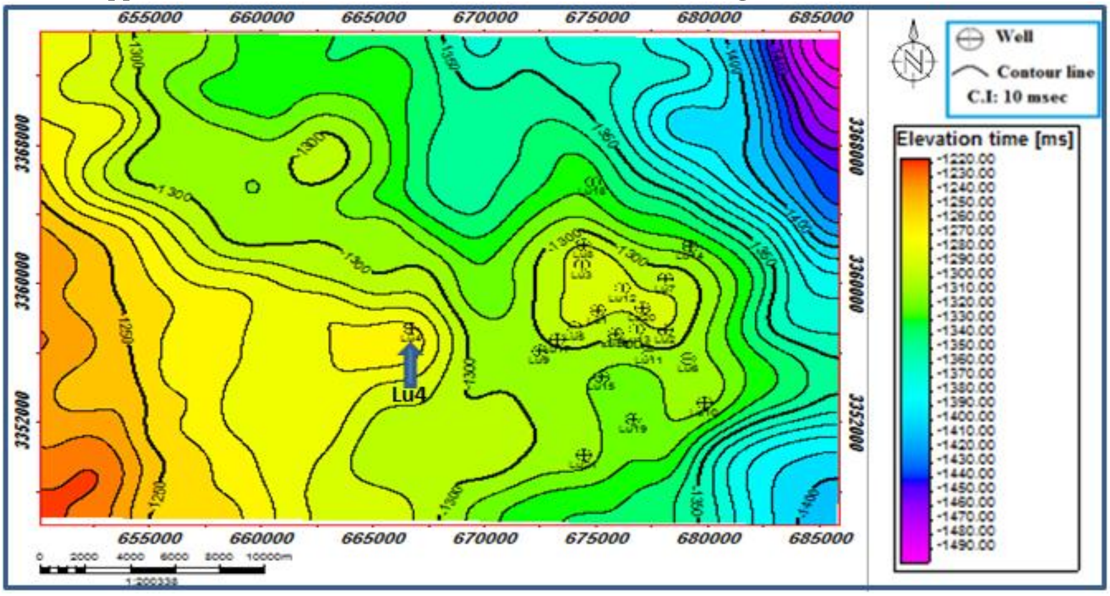

Figure 5-Nahr Umr two way time map.

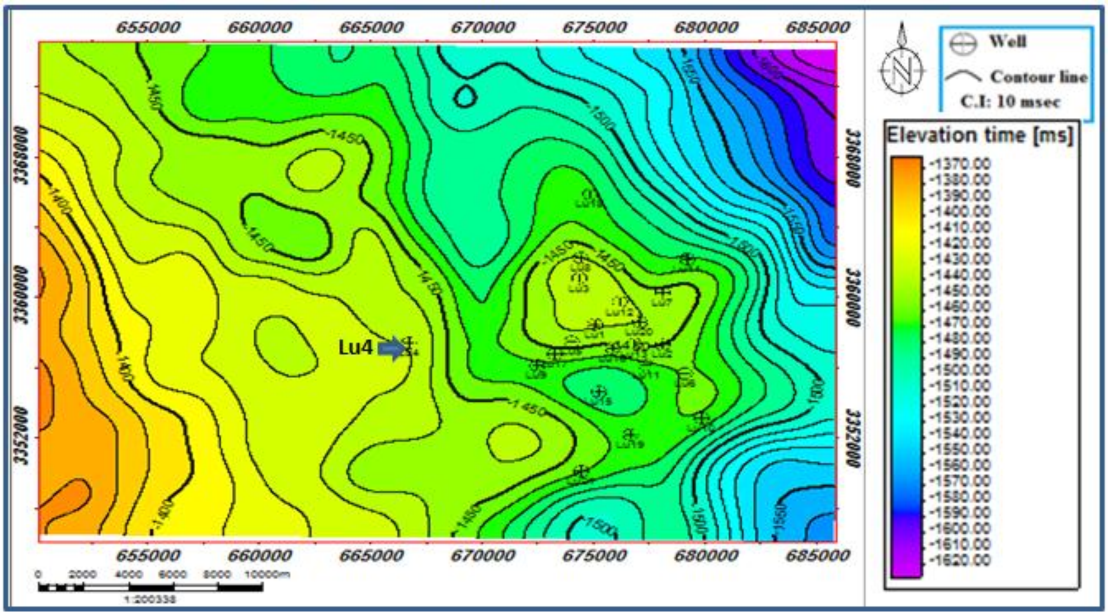

Figure 6-Zubair two way time map.

D- Velocity Model Construction

Velocity model carried out using Petrel software, we have created a velocity model in Petrel software by inserting surfaces which were picked in time domain and well tops of Nahr Umr, Shuaiba and Zubair horizons. The best equation that velocity model relies on it and represents the variation and distribution of velocity with depth must be choosed. There are only six equations available in Petrel software and one of them must be choose, see Figure-7. To select a best equation that represents the variation of velocities with depth, a test on these six equations must be executed without doing correction to well data. The best equation indicates a less variation between well tops and our picked horizons. Consequently the ($V=V_0=V_{int}$) equation was choosed that represents the variation of velocity in Luhais oil field choose, that is available in Petrel software. Finally, pusedo average velocity model cube is constructed which explains the distribution of velocities in both vertical and horizontal directions that equivalent to boreholes velocities. Generally, from the data cube of average velocity value that ranged from1310 to 1600 ms, one observes that the average velocity is decreased toward in the northeast direction of the region, while it increases toward southwest of the region, note Figure-8.

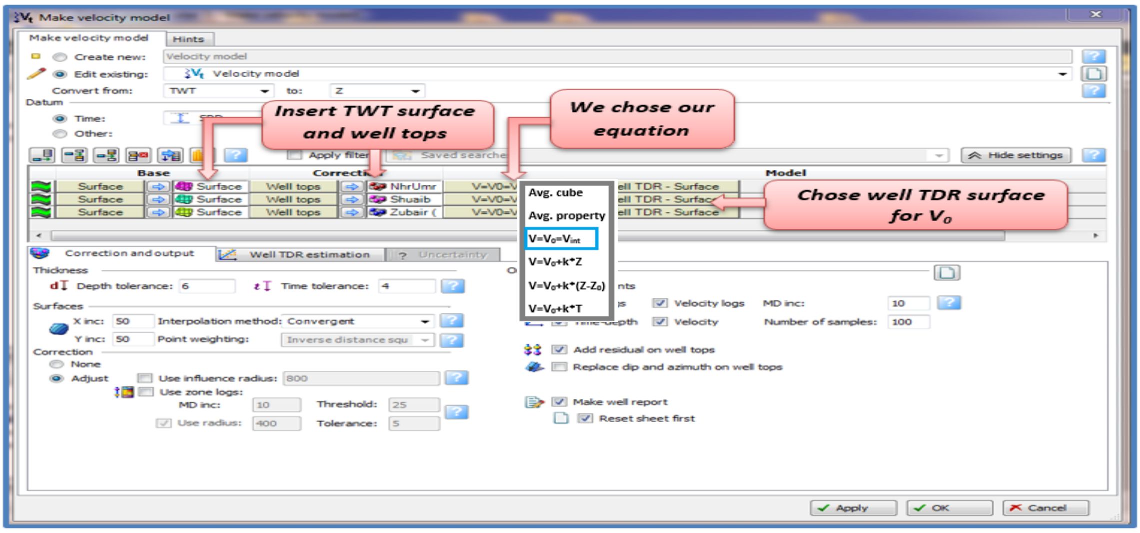

Figure 7- Velocity model generation within Petrel software.

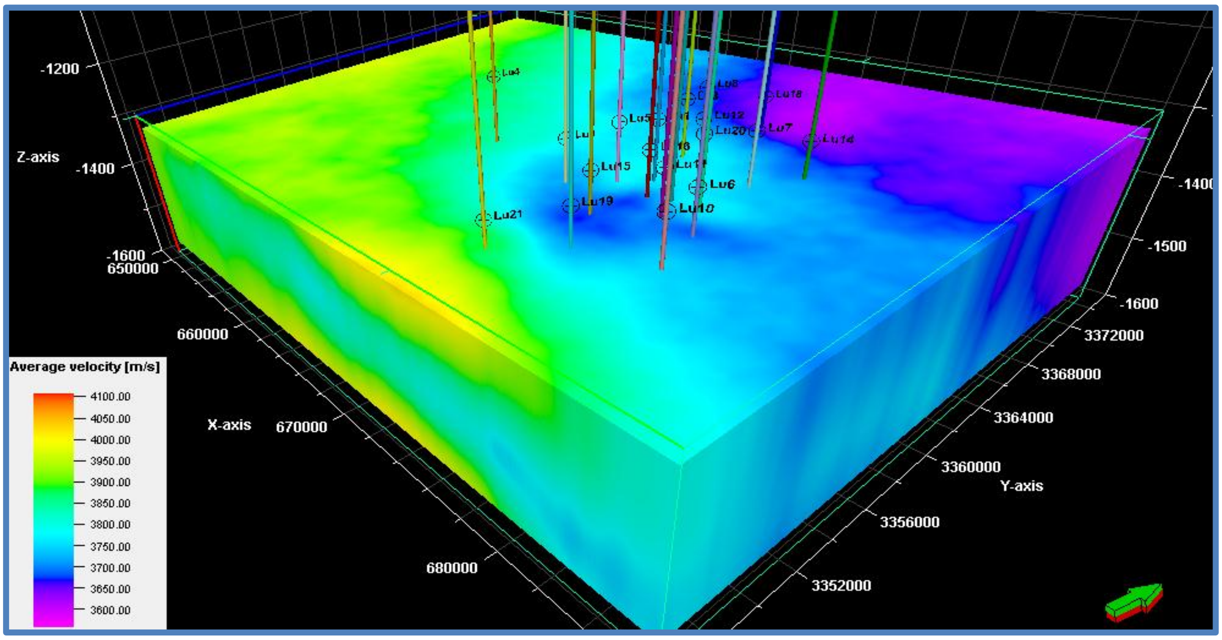

Figure 8-Pusedo average velocity cube of Luhais area

E- Construction of Average Velocity slices: Two kinds of slices are constructed by using velocity model in Petrel program, which are:

1- **Horizontal Slices:** The horizontal velocity slices give important information about velocity behavior laterally with various depths. Eight horizontal average velocity slices are prepared by using velocity model in Petrel program. These slices were extracted of all Luhais area of a limited time window ranged between 1225 to 1575 msec with time interval of 50 msec form one slice to another. All horizontal slices exhibit the seismic average velocity declining toward the NE part of the study area, also low anomaly zone appears at wells. These slices shows the velocity values rise toward SW (at time 1225, 1275 and 1325 ms) and (at time 1375, 1425 and 1475 ms) toward the west whereas, (at time 1525 and 1575) toward the west and south. Figure-9 shows the horizontal average velocity slices from 1225 to 1575 msec.

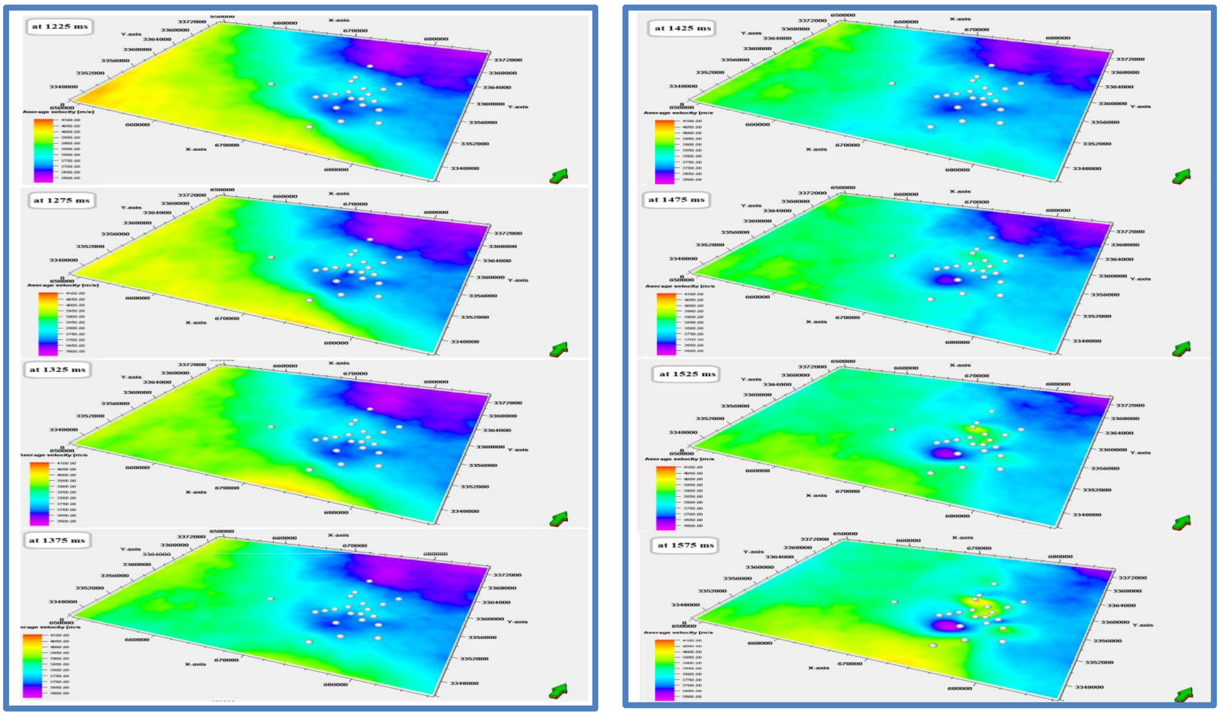

Figure 9-Horizontal average velocity slices from 1225 to 1575 msec.

2- Vertical Slices: Many vertical slices pass through a layered average-velocity model of Nahr Umr, Shuaiba and Zubair are prepared. Two slices extended toward E-W (inline) and two slices extended toward N-S (cross line) were established. These slices show the variation of velocity in vertical and lateral directions in the region. Figure-10a shows the decreasing of average velocity values at the top of the Nahr Umr formation especially, at well Lu-16. Also, low velocity zone appears in Zubair formation toward the east. While the average velocity values increase in the central zone of Nahr Umr formation. Figure-10b demonstrated two high velocity zones in the Nahr Umr formation, which are located to the west and the other one near well Lu-20. While, the velocity values decrease at the top of the Nahr Umr formation, especially, toward east, as illustrated in Figures (10a) and (10b) which represent inline slices. Figure-12a shows the high velocity zone in Nahr Umr formation at the sites of well Lu-13 and Lu-20 where, the velocity values decrease toward the north. Moreover, low velocity zone appears in Zubair formation at Lu-7and Lu-12 sites. In Figure-12b, a low velocity zone at the top of the Nahr Umr formation especially at wells Lu-6 and Lu-14 is shown, while a high velocity anomaly appears in between wells Lu-6 and Lu-14.

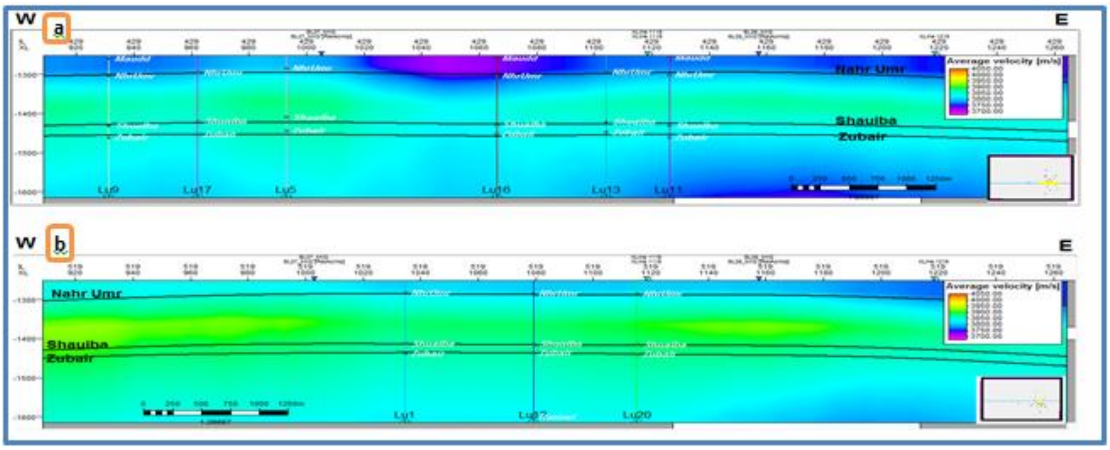

Figure 10-Two vertical average velocity slices toward West to East (inline)

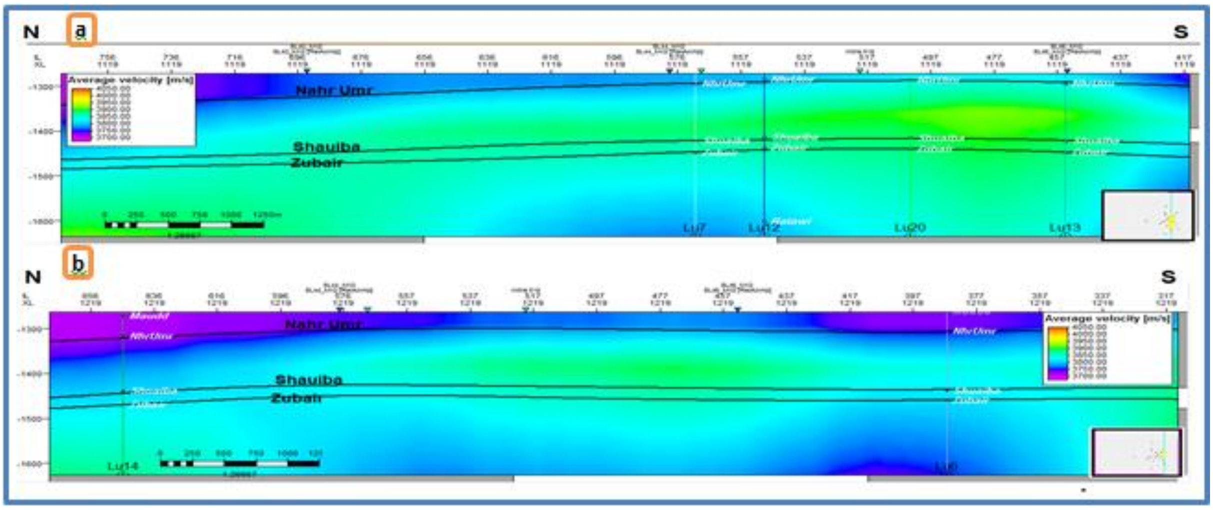

Figure 11- Two vertical average velocity slices from South to North (cross line).

F- Average Velocity Maps Construction: A velocity model was applied to create the average velocity maps. The constructed average velocity maps by using velocity model of Petrel program, these maps have been carried out for the interval limited between sea level and the top of Nahr Umr and Zubair Formation using contouring interval of 20 m/s are described in the following paragraphs:

1- Nahr Umr Average Velocity Map: In this map shows that the lower value of average velocity of 3620 m/s is located in the northeast part of the study, see Figure-12. In addition, low average velocity values equal to 3700m/s appear as enclosure at site of well Lu11 and Lu-6. This enclosure include two small enclosures located at well Lu-15 and near Lu-16 and reached to 3680 m/s. On the other hand, the average velocity values increased toward southwest part reaching a value of 4040 m/s, where high average velocity anomaly of 3780 m/s is shown below well Lu-3. The higher observed average velocity value reached to about 12% more than the lower value in the study area. This increment may be due to the increasing of thickness and porosity of the formation.

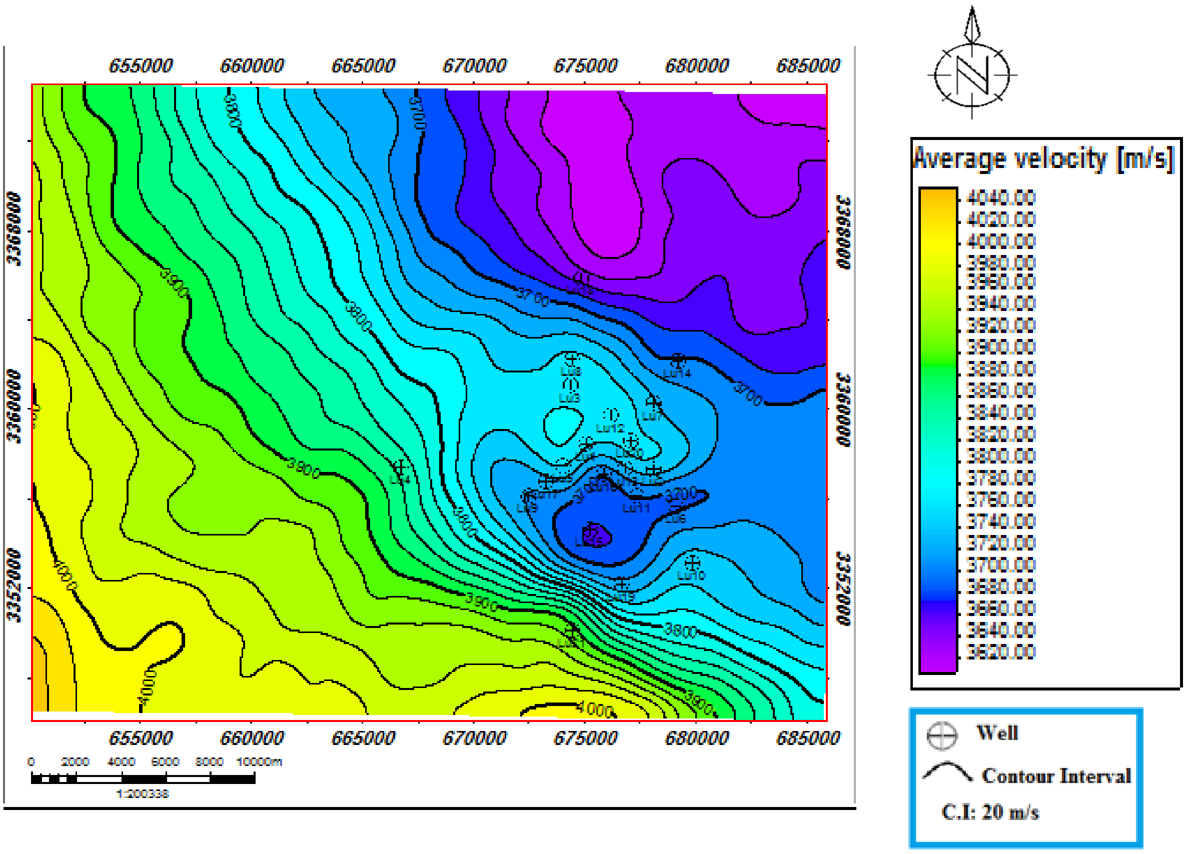

Figure 12- Average velocity map of top Nahr Umr

2- Zubair Average Velocity Map: This map is clearly indicates that the average velocity values are ranged between 3940 and 3660 m/s, note Figure-13. Generally, average velocity values are shown to be increased in the west part of the area, while it decreased towards the northeast part of the area. A low velocity anomaly of 3680 is observed in northeast part of the study area. Also, the central part of the area include two velocity enclosures; the upper enclosure has a high average velocity value of about 3780 m/s, while the lower enclosure has low value of 3720ms at the sites of wells Lu-15 and Lu-11. The highest value of the average velocity is of about 8% more higher than the lower value of average velocity.

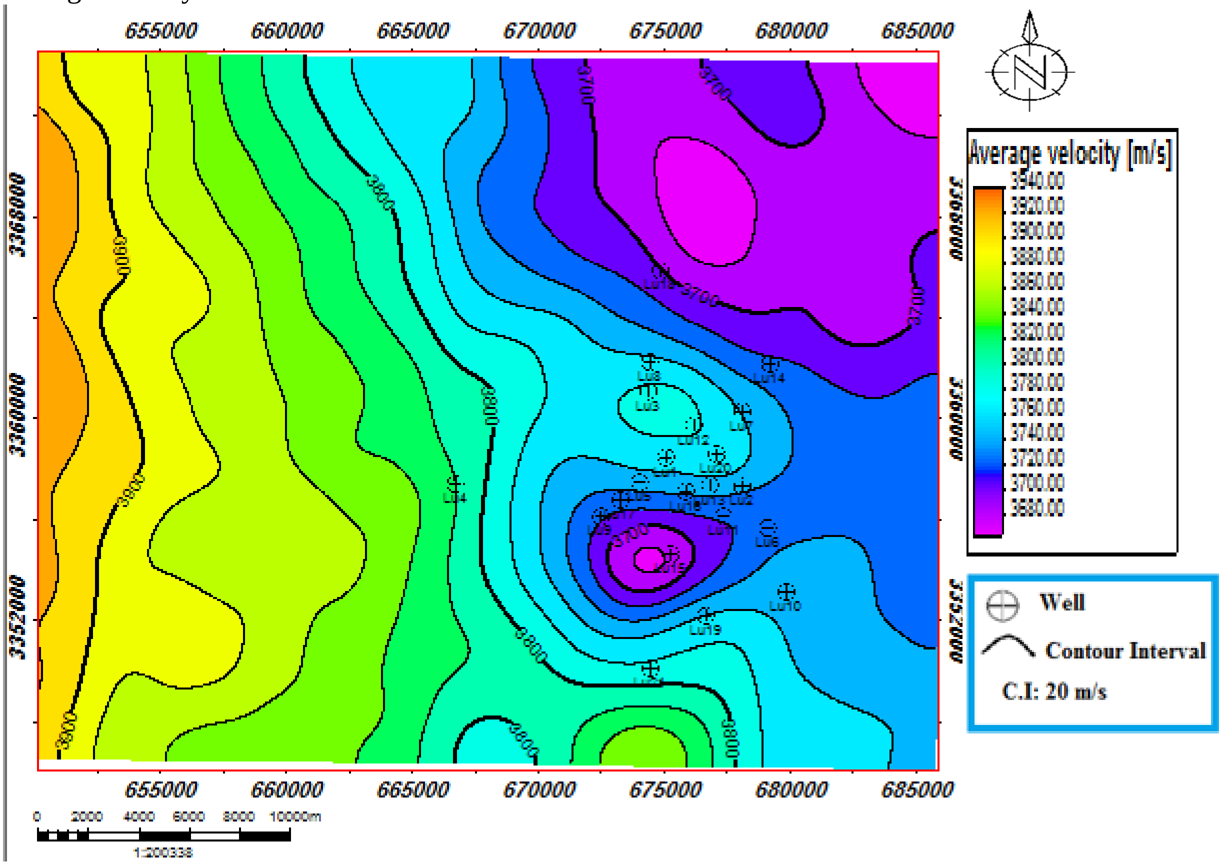

Figure 13- Average velocity map of top Zubair.

G - Depth Maps Construction

In general, depth estimation can be done via a wide range of existing methods, but it can be separated into two broad categories: 1) Direct time-depth conversion 2) Velocity modeling for time-depth conversion [10]. In the current study, we have used velocity model for time-depth conversion proposed by Petrel program. Two depth maps have been constructed starting from sea level datum till the top of Nahr Umr and Zubair Formations using a contour interval of 20 m. All these maps show that the Luhais structure is of large irregular enclosure trending in the N-S direction these depths maps are described in the following paragraphs:

1- Nahr Umr Depth Map: This map is given in Figure-14 which shows general increasing of depth toward the northeastern part of the area reaching a depth of 2700 m. Also, the depth increases toward the southeast to reach about 2660 m, whereas the depth is reduced toward the crest of the structure reaching a value of 2400 m near well Lu-16.

2- Zubair Depth Map: This map is given in Figure-15 which shows the general trend of depth increasing towards the far northeast part of the area and reached to 2960m, and increasing toward the southeast reaching a value of about 2920m. On the other hand the depth decrease toward the southwest reaching to 2680m while it decreases toward the crest of structure reaching 2700m near the well Lu-15.

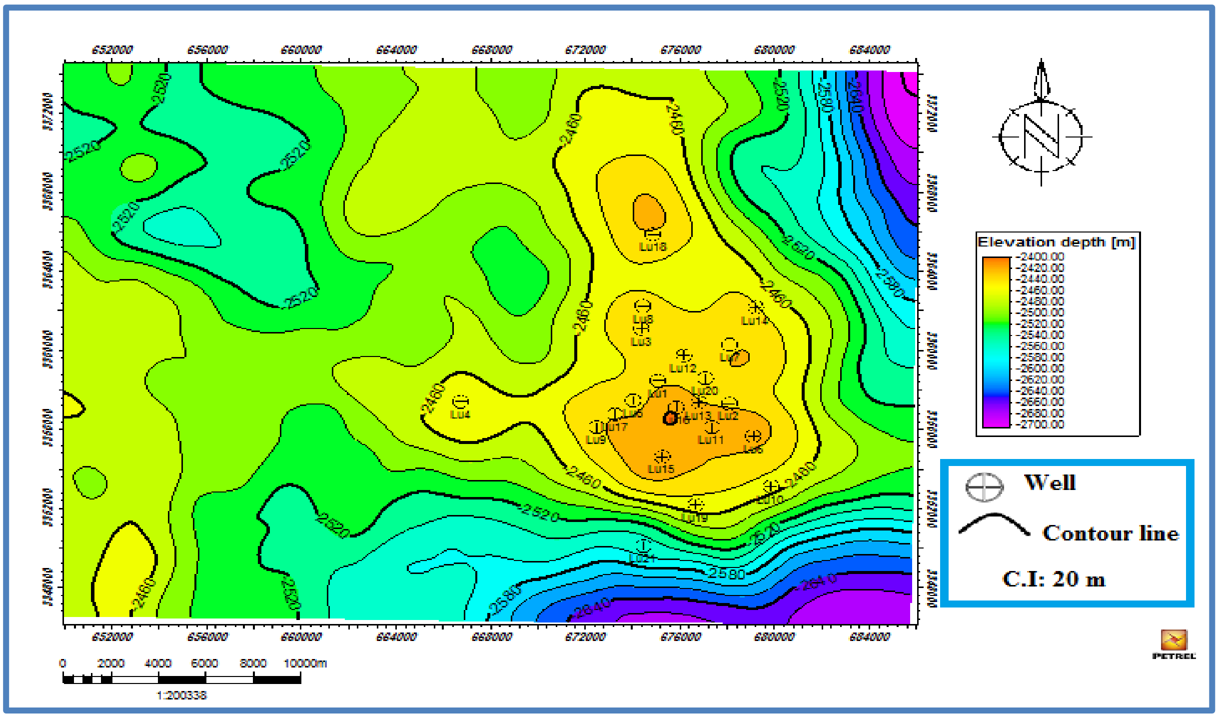

Figure 14-Depth map of top Nahr Umr Formation.

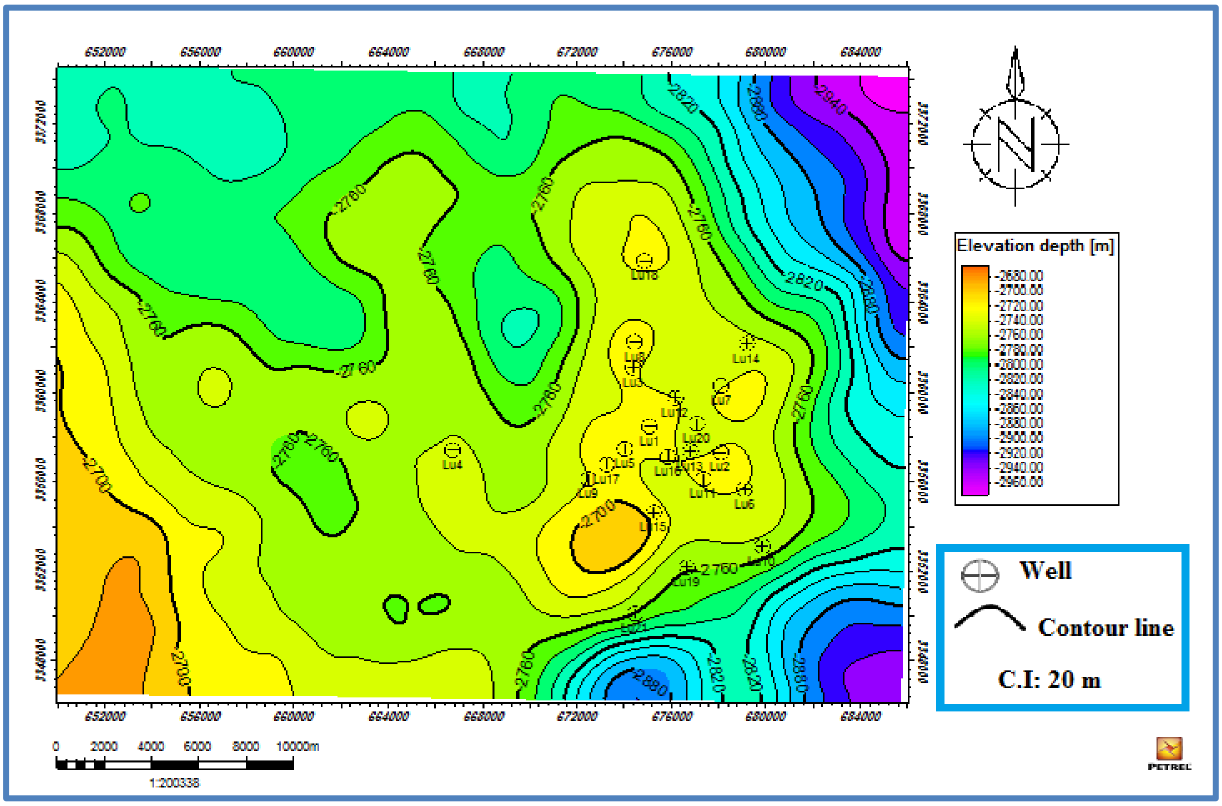

Figure 15- Depth map of top Zubair Formation.

Conclusions

Based on the results and discussions given in this study the following major conclusion can be made:

1. The constructed velocity models for depth maps gave a high conformable results with the depths of geological formations deduced from wells data.
2. Examination of time maps indicates that Lahais structure is of irregular shape. Where it characterized by many axes oriented in different directions. Whereas, in depth domain the

structure seems to be more smoothed of elliptical shape having a folding axis oriented in the N-S direction because of variation of the seismic velocites information.

3. A general agreement between time and depth maps is obvious. These maps reveal a general dipping of the horizons including the reservoir units towards the NE. In addition to the structure crest zone, the SW part of the field is structurally higher than the NE part.

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