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3-D Seismic Interpretation of Hartha Formation at Nasiriyah Oil Field, South Iraq

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Abstract

This study deal with structural and stratigraphic analysis of the seismic reflection data for Hartha Formation at Nasiriyah field, the area of seismic data is about (1237) km2. Nasiriyah oil field is located in Dhi Qar Governorate, southern Iraq, and the oil field is located to the East of Euphrates River of about (38) km northwest of Nasiriyah city. which includes twenty-four (24) wells. In some wells there are oil evidences in Hartha Formation at Nasiriyah oil field, for this reason, Hartha Formation is studied.

Two reflectors are picked (top and bottom Hartha) they are defined by using synthetic seismograms in time domain for wells (Ns-1, and 3). Time and depth of Hartha Formation are drawn using velocity data of reflectors. The structural interpretation shows top and bottom of Hartha Formation. The Nasiriyah structure appeared as several regular enclosures shapes, their general trend northwest-southeast. The structure has three enclosures situated on five wells. The general dip towards the northeast. Variance seismic attributes technique are used; instantaneous frequency, instantaneous phase and chaos are done to verify and confirm this structural interpretation .

Two coral Rudist (mound) accumulations are determined and interpreted. In addition, flat spot phenomenon has been observed which is located in northeast of the well site Ns-4 which represents a Direct Hydrocarbon Indicator (DHI) that refers to the presence of hydrocarbons.

Keyword: 3-D Seismic Interpretation, Nasiriyah Oil Field, Attributes.

دراسة زلزاليه ثلاثية الابعاد لتفسير تكوين الهارثه في حقل الناصرية النفطي جنوب العراق

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الخلاصة

تتعلق هذه الدراسة بالطريقة الزلزالية الانعكاسية والتفسيرات التركيبية والطباقية لتكوين الهارثه في حقل الناصرية بمساحة(1237) كم2، يقع حقل الناصرية النفطي في محافظة ذي قار في جنوب العراق. ويقع الحقل إلى الشرق من نهر الفرات، على بعد حوالى 38 كيلومترا شمال غرب مدينة الناصرية، التي تضم أربعة وعشرين (24) بئرا. ظهرت شواهد للنفط في بعض الآبار ضمن تكوين الهارثة في حقل نفط الناصرية، لهذا السبب، تم دراسة تكوين الهارثة.

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تم تحديد العاكسين اللذين يمثلان اعلى واسفل تكوين الهارثه باستخدام الاثر الزلزالي المصطنع في المجال الزمني للآبار (ناصرية–1،ناصرية–3) في المجال الزمني، تم رسم خرائط بالمجال الزمني والعمقي. أظهرت التفاسير التركيبية للعاكسين اعلى واسفل تكوين الهارثة. بأن تركيب الناصرية يتكون من عدة انغلاقات منتظمة الشكل، بالاتجاة الشمال الغربي– الجنوب الشرقي. يتكون التركيب من ثلاث انغلاقات تقع في منطقه الابار الخمسة، واتجاة الميل العام نحو الشمال الشرقي. وقد استخدمت تقنية الملامح الزلزالية وهي (instantaneous phase)، (instantaneous frequency) و (chaos) لتوضيح الصورة التركيبية.
وقد لوحظت ظاهرتين من تراكمات الشعاب الرودستية(mound) تم تحديدها وتفسيرها.بالاضافه ظاهرة التسطح(Flat spot) التي تقع شمال شرق بئر (ناصرية–4) وتعتبر احدى المؤشرات تواجد النفط.

Introduction

[i]The seismic methods are used in geophysical exploration due to their depth penetration and high resolution to identify subsurface geology and physical properties of the materials present. The seismic investigation plays a significant role in solving various problems of structural and subsurface geology, and acquiring ever increasing importance in the solution of engineering geology problems. Among geophysical techniques, seismic reflection method becomes the most widely method used in prospecting hydrocarbon accumulation [1].

Seismic interpretation (SI) refers to the extraction of geological information from the seismic data and comes after seismic data acquisition and processing, is usually supported by other non-seismic data such as gravity, magnetic, well-log, and geological data [2].

There are two main approaches to the interpretation of seismic sections: structural analysis, which is the study of reflector geometry on the basis of reflection times, and stratigraphic analysis (or seismic stratigraphy), which represent the analysis of reflection sequences as the seismic expression of lithologically-distinct depositional sequences [3].

3D seismic data have become the key tool used in the oil and gas industry to understand the subsurface. In addition to providing excellent structural images, the dense sampling of a 3D survey can sometimes make it possible to map reservoir quality and the distribution of oil and gas [4].

In view of the economic importance Hartha Formation, is considered as an important stratigraphic unit that contains hydrocarbon accumulation in central and south part of Iraq. This formation is characterized by good reservoir's specifications to store hydrocarbon. In some wells oil evidences are shown in Nasiriyah oil field. For this reason, Oil Exploration Company (O.E.C) in cooperation with University of Baghdad aims to study the oil bearing formation using new seismic approaches.

This study comes as complementary to many of the studies carried out by a number of researchers, where it focuses on structure and stratigraphy analysis of Hartha Formation, to improve and develop the Nasiriyah oil field by giving more accurate subsurface geologic image.

Location of the study area

Nasiriyah oil field is located in Dhi Qar Governorate, in southern Iraq. The field lies east of the river Euphrates, about 38 kilometers northwest of Nasiriyah city, which includes (24) wells. The studied area is about (1237) km^2 as shown in Figure -1.

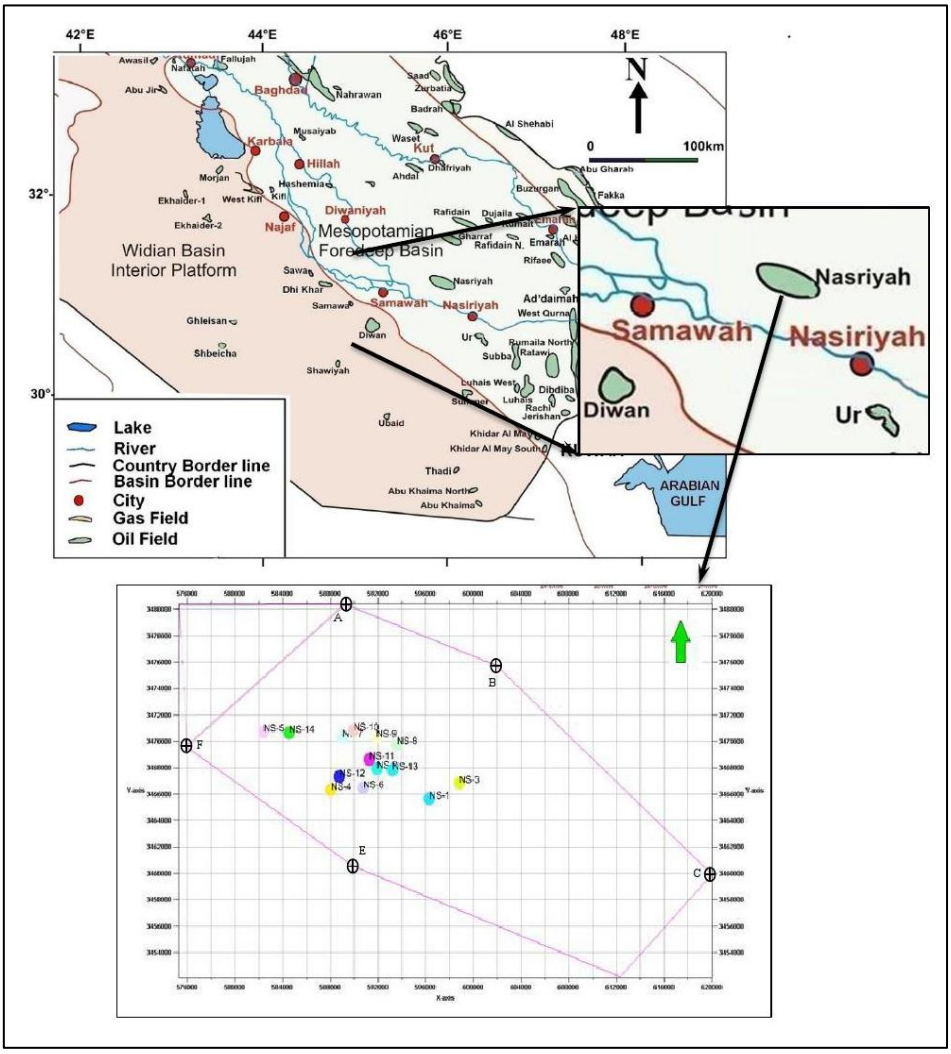

Figure 1- Location of study area, after [6]. including the selected wells in Nasiriyah oil field.

Data Acquisition

A. Base map preparation

The 3-dimensional data cube was loaded on petrel in time domain by seismic interpretation program IESX and in SEG-Y- formula. This process is called (project creation) for achieving the interpretation process on an interactive workstation. After that, the base map of the study area is constructed. This process includes entering the first and last inline numbers, the first and last cross line numbers, the separated distance between bin size along inline direction and cross line direction, Figure-2.

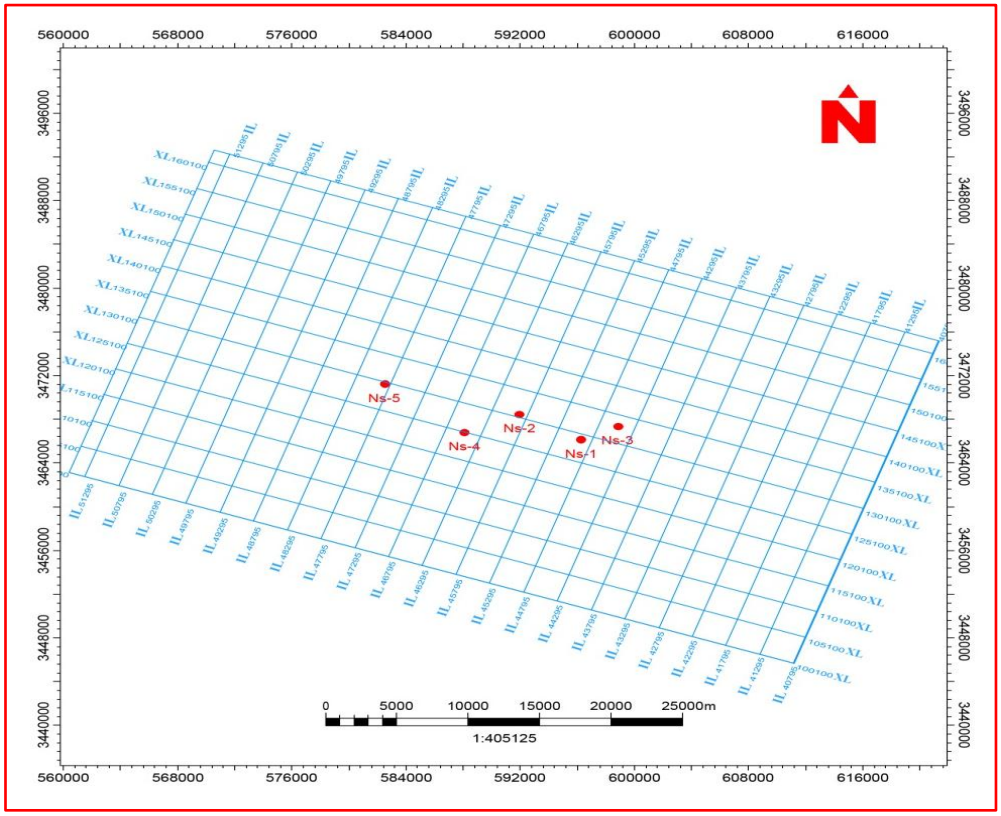

Figure 2- Base map of Nasiriyah oil field.

B. Synthetic seismograms Generation.

[7] referred to the main steps for generation of the synthetic seismogram using the acoustic impedance(z) and reflection coefficient (Rc_i . Convolution process between the reflection coefficients and experimentally selected wavelet is made to obtain the synthetic seismogram. The sonic log data are compared with the well velocity survey, which represents the direct method to obtain the geological velocity (average velocity) of geological strata. These have ability to extract the relation between the time and depth functions in the well location.

According to [7] we can calculate acoustic impedance(z) and reflection coefficient (Rc_i), as following:

$$z = \rho \times v$$

$$Rc_i = \frac{(\rho i+1)(vi+1) - \rho i\, vi}{(\rho i+1)(vi+1) + \rho i\, vi}$$ Where;

v: is seismic velocity., ρ: is density measured from log.

(ρi' ρi + 1) the density at the interval (i), (i+1)

(vi' vi + 1) the velocity at the interval (i), (i+1)

In the current study, synthetic seismogram was generated for well Ns-1 and Ns-3 as shown in Figure -3 and 4, where the density log, sonic log and check shot (interval velocity, average velocity and one-way time) of well Ns-1& Ns-3 are used to generate the synthetic seismogram. In Figure -5 the seismic section is displayed, which pass through the Ns-1 well location. On this section a comparison between seismic section trace and synthetic traces, is made up and geologic formations are indicated.

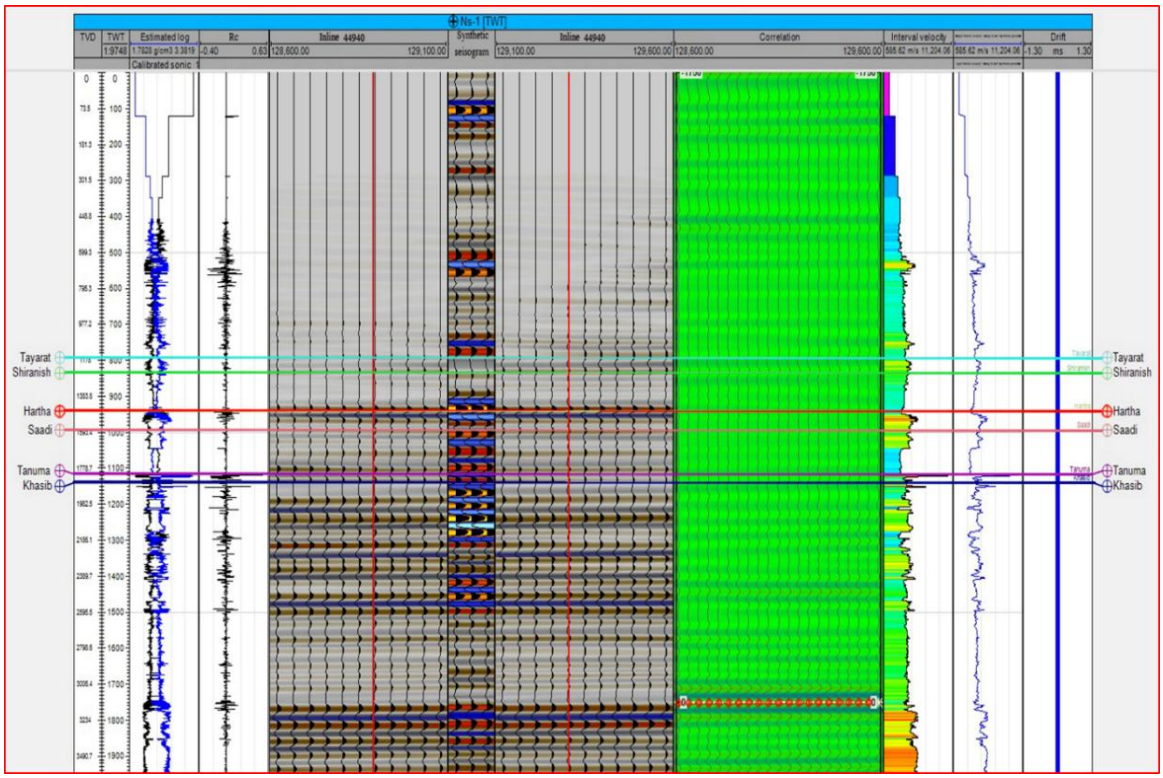

Figure 3- Synthetic seismogram generation of well Ns-1.

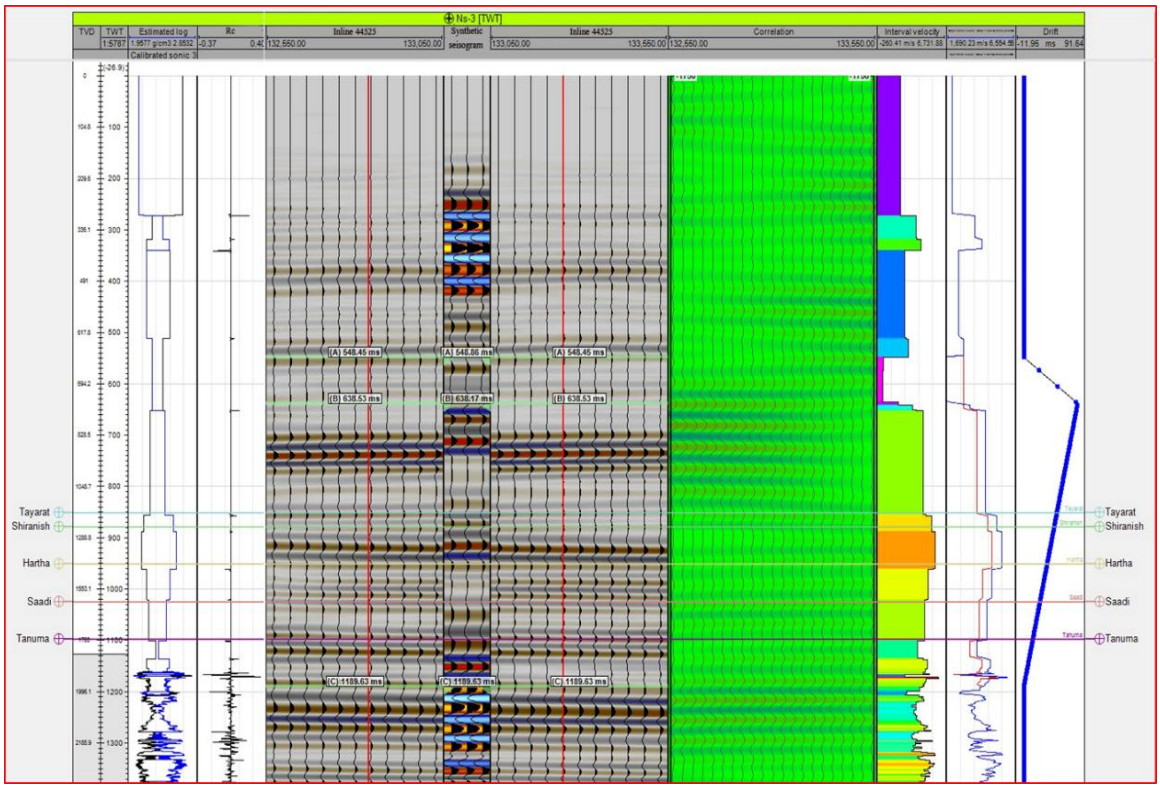

Figure 4- Synthetic seismogram generation of well Ns-3.

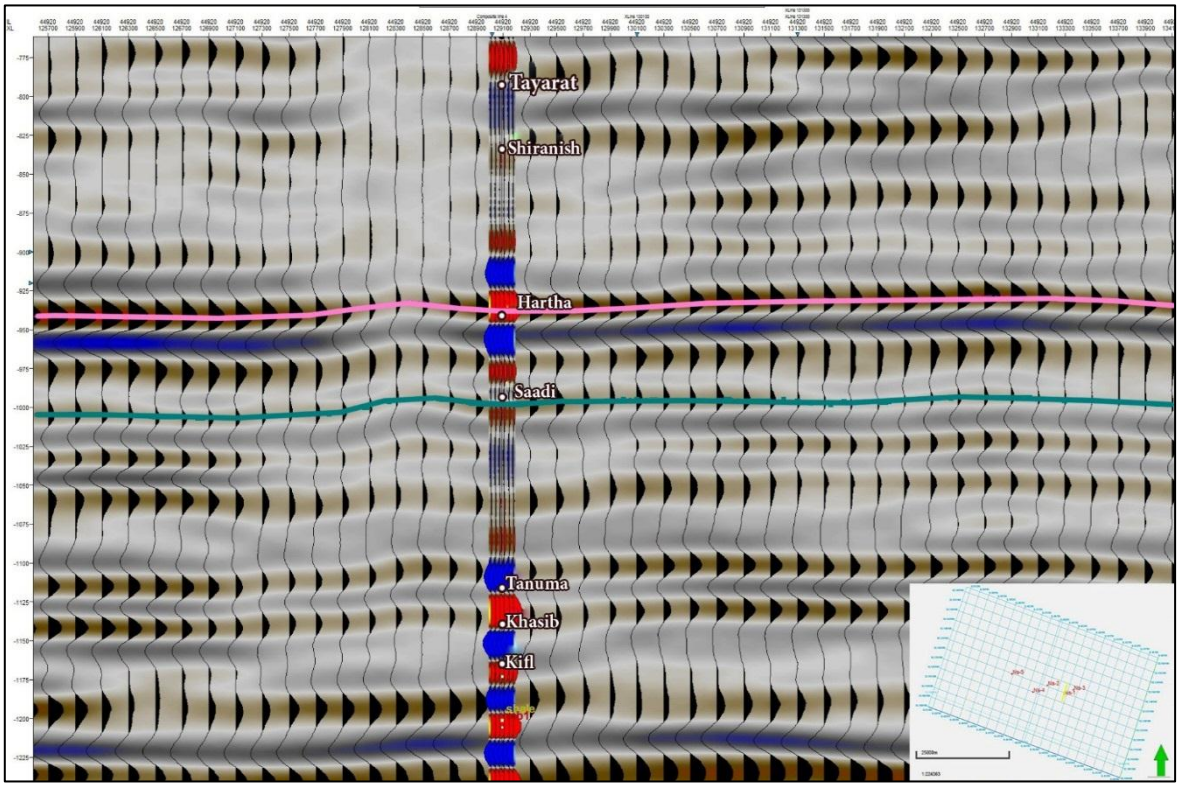

Figure 5-Seismic section with synthetic traces and Markers of well Ns-1.

Structural Interpretation

C. Two-Way Time (TWT) contour maps construction

The TWT contour maps for Top and Bottom of Hartha Formation are prepared to get the subsurface structural picture with contour interval (10 msc.), these maps show the Nasiriyah structure appear as several regular enclosures shapes, the general direction is in the northwest - southeast. The structure has three enclosures situated in five wells area, the general dip towards the northeast, as shown in Figure -6 and 7.

D. **Depth contour maps Construction**

The velocity model is used for time-depth conversion by Petrel program. Two depth maps have been drawn for top and bottom of Hartha Formation using a contour interval of 20 m. All these maps show that the Nasiriyah structure is as several regular enclosures shapes trending NW-SE direction, as shown in Figure -8 and 9.

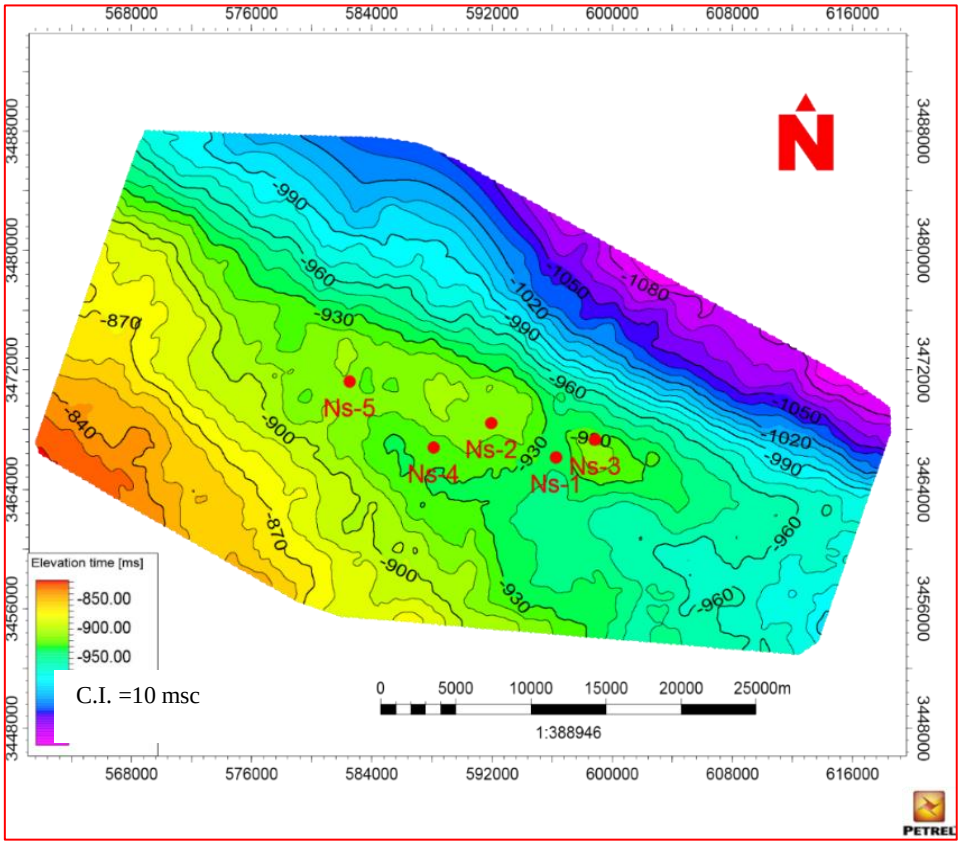

Figure 6- Two-way time (TWT) contour map of Top Hartha.

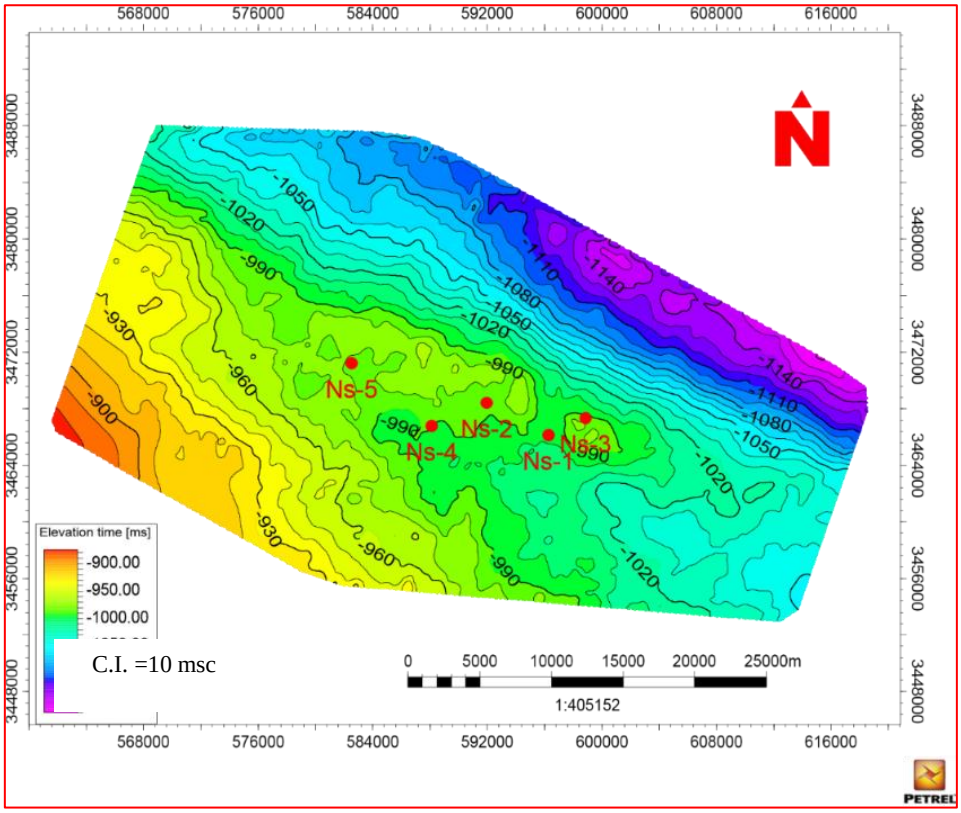

Figure 7- Two-way time (TWT) contour map of bottom Hartha.

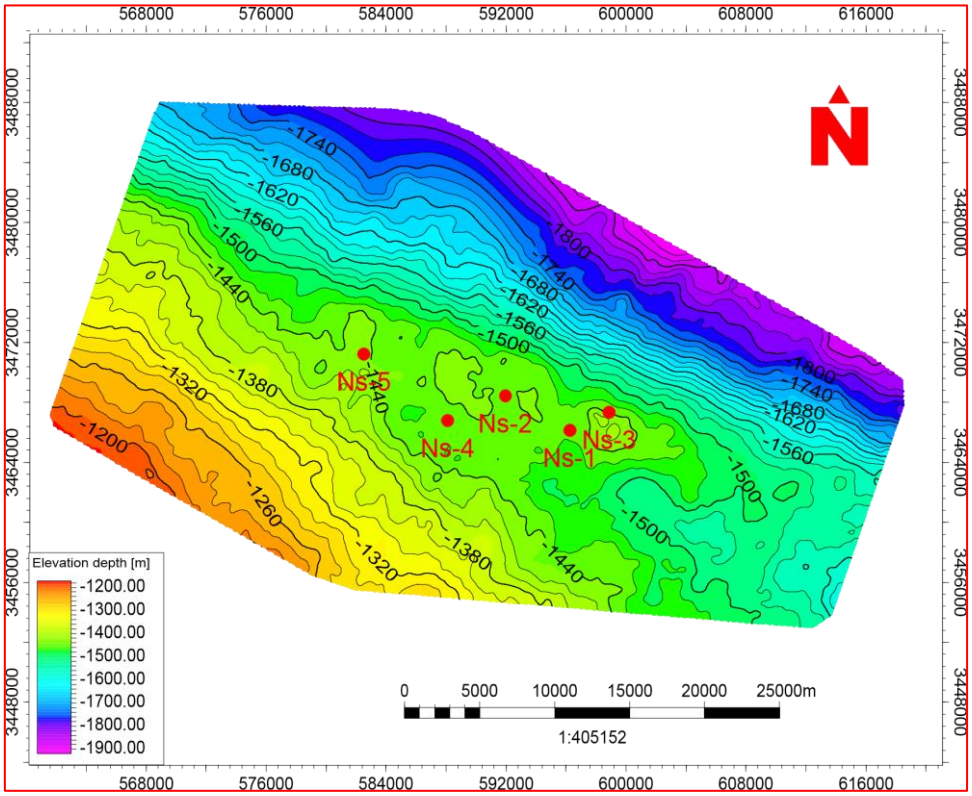

Figure 8- Depth contour map of top Hartha.

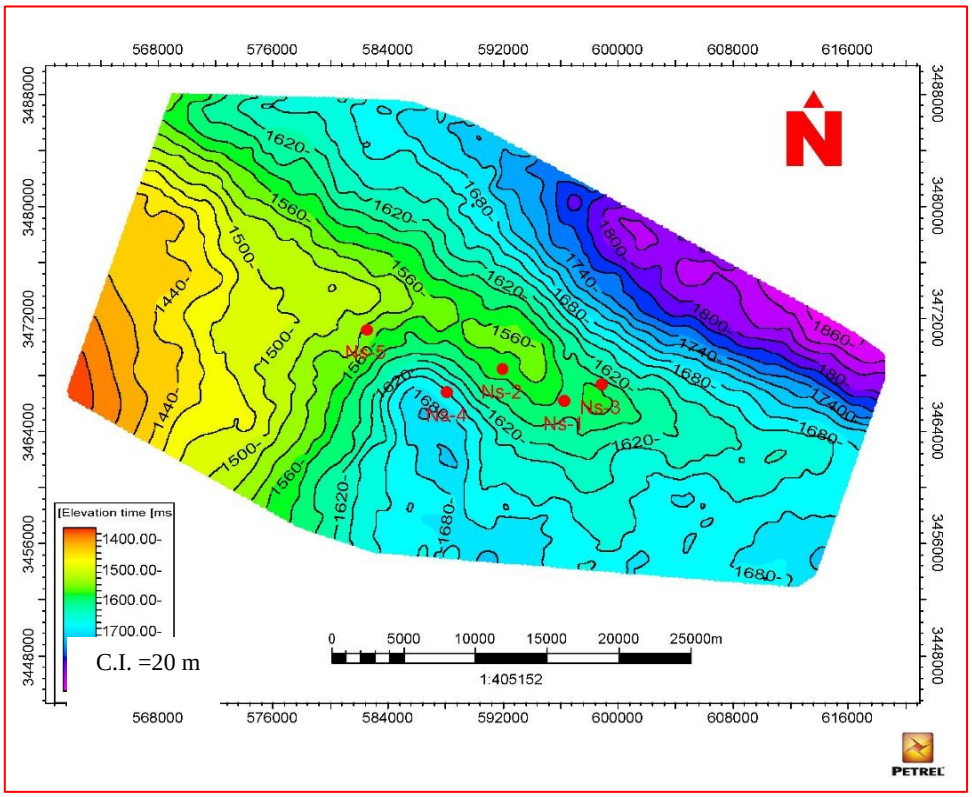

Figure 9- Depth contuor map of bottom Hartha.

E. Attributes interpretation

Seismic attributes techniques were applied on Nasiriyah oil field 3D seismic volume, which include instantaneous phase, instantaneous frequency and chaos in time domain. these types of attribute are important to detect the hydrocarbon accumulation on seismic sections, [8].

Instantaneous Phase attribute

The seismic cube in the time domain is convert to cubic phase seismic attributes which shows change in phase of waveform. In the horizontal distribution zero phase represents a change in petrophysical properties in lateral distribution due to deposition condition. The sharp change in phase (Positive to Negative) is represents one of indicators of contact rock areas with hydrocarbons, so there is a clear change in the phase of waveform around five well sites as, shown in Figure -10.

Instantaneous Frequency attribute

The seismic cube in the time domain is convert to cubic Frequency seismic attributes. As shown in Figure -11, the black and dark color reflects rocks of low velocity, this indicates hydrocarbon accumulation areas near five wells site, the rocks density reduces due to presence of fluids, thus, the seismic velocity is decreased, [9]. The red color refers to rocks of high velocity compare with black color, which indicate weak probability of hydrocarbon accumulations

Chaos attributes

The seismic cube in the time domain is convert to cubic chaos seismic attributes. As shown in Figure -12 , the rocks density reduces due to presence of fluids, thus, the seismic velocity is decreased. Consequently, the white color reflects rocks of low velocity, this indicates hydrocarbon accumulation areas near five wells site. The black color refers to rocks of high velocity compare with white color, which indicate weak probability of hydrocarbon accumulations.

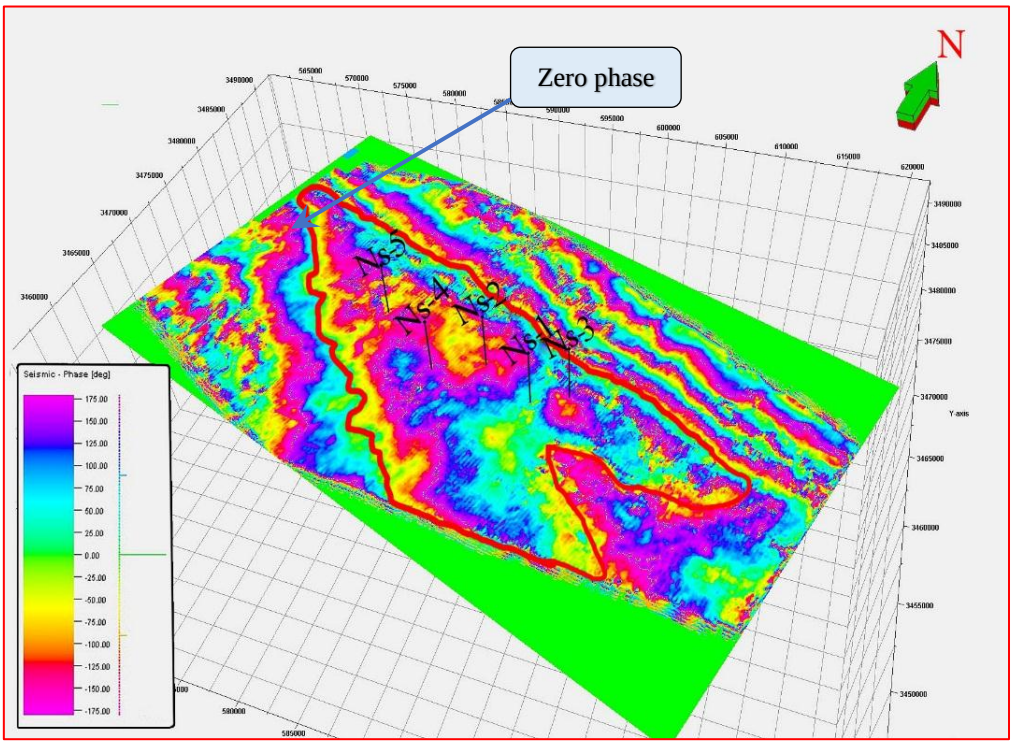

Figure 10- Time slice phase attribute of top of Hartha.

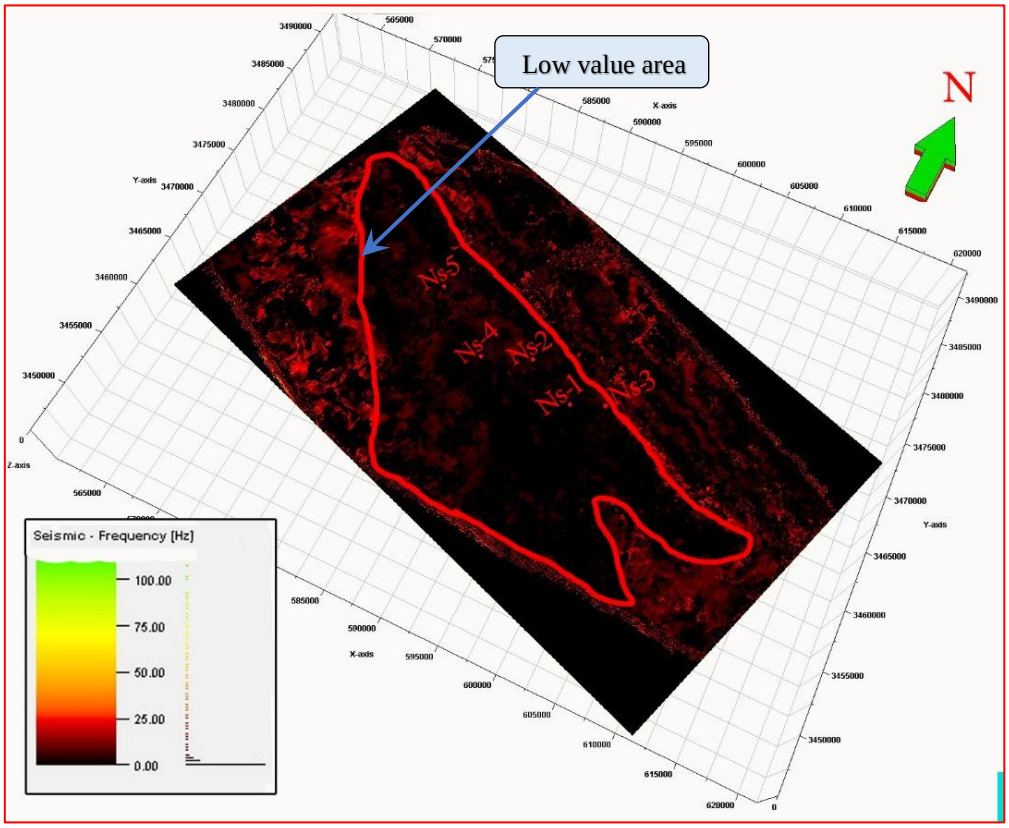

Figure 11- Time slice frequency attribute of top of Hartha.

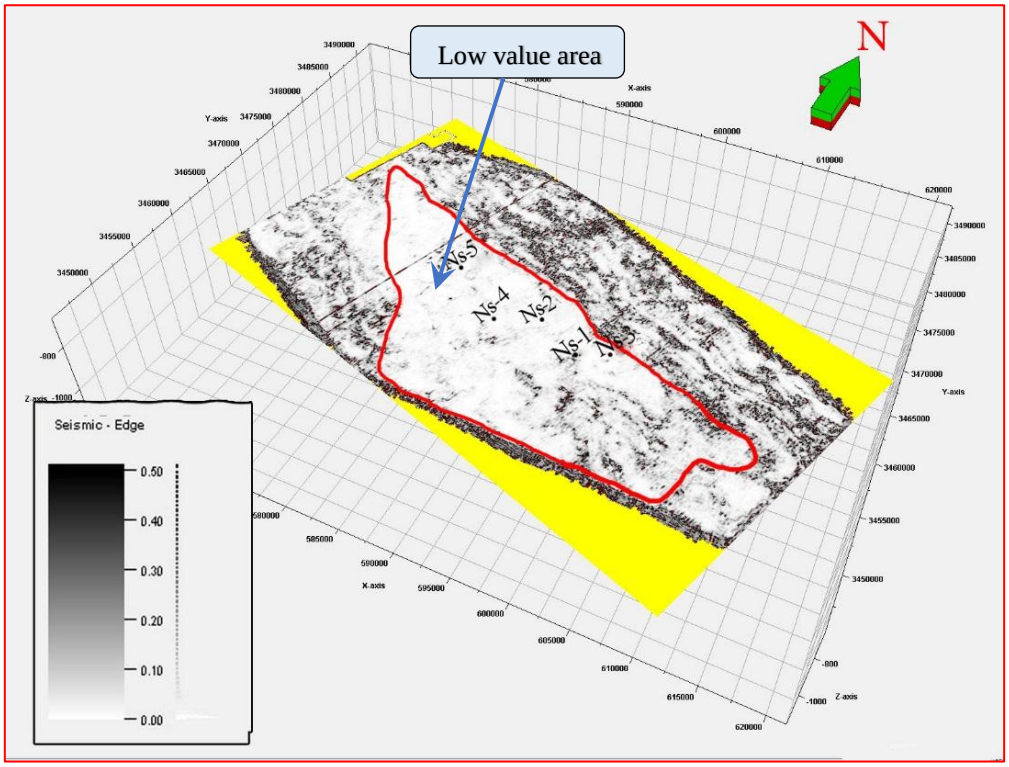

Figure 12- Time slice chaos attribute of top of Hartha.

Stratigraphy and hydrocarbon indicators

Stratigraphy phenomena and hydrocarbon indicators have been identified on the seismic sections within Hartha Formation depending on the geometry (or character) of reflections, their amplitudes, their velocities, and the tectonic site, they can be explained as follows;

1. (Mound & Sag) phenomenon has been observed in (Eye Shape), this phenomenon starting from Inline 47545 and ending in inline47895, which is located in the south part of the well Ns-5 site. as shown in Figure -13. These phenomena can be regarded as mound stratigraphy traps.
2. Mound phenomenon was observed in Inline 46165, which is located in between well Ns-4 and Ns-2 sites, as shown in Figure -13. These phenomena can be regarded as mound stratigraphy traps, underlying by flat spot which represents direct hydrocarbon indicator (DHI).
3. Flat spot was observed, which represents direct hydrocarbon indicator in Inline 46440, that is located in northeast well Ns-4 site, as shown in Figure -13).

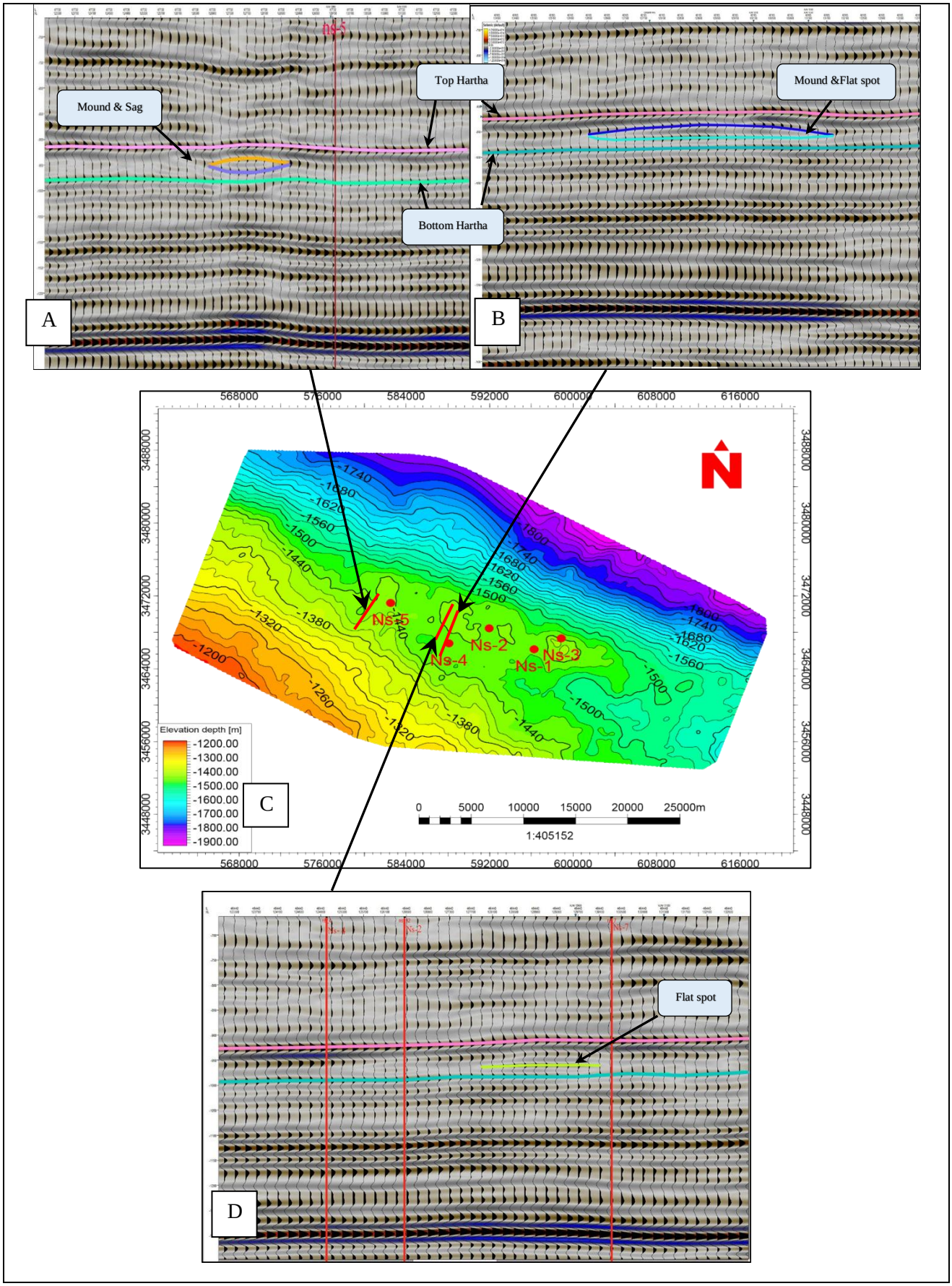

Figure 13- A. seismic section of the Mound & sag, **B**. seismic section of the Mound & Flat spot, **C**.Depth map of top Harha, **D**. seismic section of the Flat spot**.**

Conclusion

Based on the results and discussions given in this study the following major conclusions are made;

1. Two reflectors, top and bottom of Hartha Formation are defined by using synthetic seismograms in time domain for wells (Ns-1, and Ns-3).
2. Two Two-Way-Time (TWT) contour maps have been constructed from the picked horizons (top and bottom of Hartha reflectors) respectively using sea level as a datum plane. This maps show structurally the highest area is located on the south and southwest side of the field, compared with the lower area in the southeast side (basin). Nasiriyah structure appears as several regular enclosures shapes, the general trend is in the northwest - southeast. The structure has three enclosures situated in five wells area, the general dip towards the northeast.
3. Two depth maps represent the top and bottom of Hartha Formation were constructed which lead to illustrate the structural configuration of Nasiriyah area. In general, the structure has a general trend in the northeast-southwest direction, while it shows a regional dipping toward the east and northeast. Moreover, depth maps reveal that the minimum depth values are noticed at the west and gradually increase toward the east and northeast. In going further to the east and northeast direction, the deepening increases which reflects the transition from the continental slope towards the basin. The structure is has three enclosures situated in five wells area
4. Seismic attributes techniques were applied on Nasiriyah oil field 3D seismic volume, which include instantaneous phase, instantaneous frequency and chaos in time domain. This attributes show low values near five wells site areas, this indicates hydrocarbon accumulation.
5. stratigraphic features has been observe two mounds, mound with sag near well Ns-5 and mound with flat spot near well Ns-2, which is represent as mound stratigraphy traps.
6. There is a direct hydrocarbon indicator (flat spot), which is located in northeast well NS-4 site. that represents a fluid contact in reservoir. These may be either gas/oil, gas/water and oil/water contacts.

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