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3D seismic reflection study for subsurface structural picture of Dujaila Oil Field, South of Iraq

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Abstract

This research represents a 3D seismic structural study for 602.62 Km2 of Dujaila Oil Field which is located 55 Km Northwest of Mysan province and 20 Km Southwest of Ali-AlSharki region within unstable Mesopotamian basin.

Synthetic traces are prepared by using available data of two wells (Du-1, Du-2), in order to define and pick the reflectors. Two reflectors are picked that represent the top and bottom of Mishrif Formation, in addition to five units within this Formation are picked, they named Units 1, 2, 3, 4, and 5.

Time maps for the top and bottom of Mishrif reflectors are drawn to get the structural picture, these maps show general dip of layers toward NE, and thus, there are two enclosure domes in the middle of Dujaila Oil Field where two wells (Du-1, Du-2) are found.

Keywords: 3D Seismic reflection , Dujaila Oil Field, Mishrif reflector Structural Picture.

دراسة زلزالية انعكاسية بالابعاد الثلاثة للصورة التركيبية تحت السطحية لحقل الدجيلة، جنوب العراق

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الخلاصة:

هذا البحث يمثل دراسة زلزالية تركيبية بالابعاد الثلاثة لمساحة تغطي 602.62 كم^2 من حقل الدجيلة النفطي الواقع 55 كم شمال غرب محافظة ميسان و20 كم جنوب غرب منطقة علي الشرقي ضمن حوض الرافدين غير المستقر.

تم إعداد الآثار المصنعه باستخدام البيانات المتاحة من البئرين (Du−1,Du−2)، لغرض تعريف والتقاط العواكس. تم التقاط اثنين من العواكس و تمثل اعلى واسفل تكوين المشرف، بالإضافة إلى خمس عواكس ضمن هذا التكوين تم التقاطها، سميت وحدات 1، 2، 3، 4، و 5.

رسمت الخرائط الزمنية لأعلى وأسفل عاكس المشرف للحصول على الصورة التركيبية، وتبين هذه الخرائط ميل الطبقات نحو الشمال الشرقي، وكذلك توضح الخرائط انغلاقين من القباب في منتصف حقل الدجيلة النفطي حيث موقع البئرين (Du−1,Du−2) .

Introduction

The goal of seismic exploration is to map geologic features associated with hydrocarbon deposition, generation, migration, and entrapment, and also to characterize the static and dynamic characteristics of subsurface reservoirs [1]. So, to find locations of oil and gas accumulations or produce them, we will need to understand subsurface geology. The most reliable and most used technique for petroleum exploration is the seismic method [2].

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The time taken for the sound to travel from the source down to the reflecting interface and back to the surface tells us about the depth of the reflector, and the strength of the reflected signal tells us about the change of rock properties across the interface [3].

The seismic reflection exploration method passed through numerous development stages from mid last century to the present time including the field survey, data processing and interpretation. The recording developed from analog to a digital, multiple coverage appeared and used digital recording which helped to expand the role of electronic computers in seismic workshop, a Common Depth Point (CDP) technique is also used [4].

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 [5].

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 stratigraphical analysis (or seismic stratigraphy), which is the analysis of reflection sequences as the seismic expression of lithologically-distinct depositional sequences [6].

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 [3].

Location of the Study Area

Dujaila Oil Field is located about 55 km North-West Maysan province and 20 km South-West of Ali-AlSharki region within unstable Mesopotamian basin as shown in the figure-1.

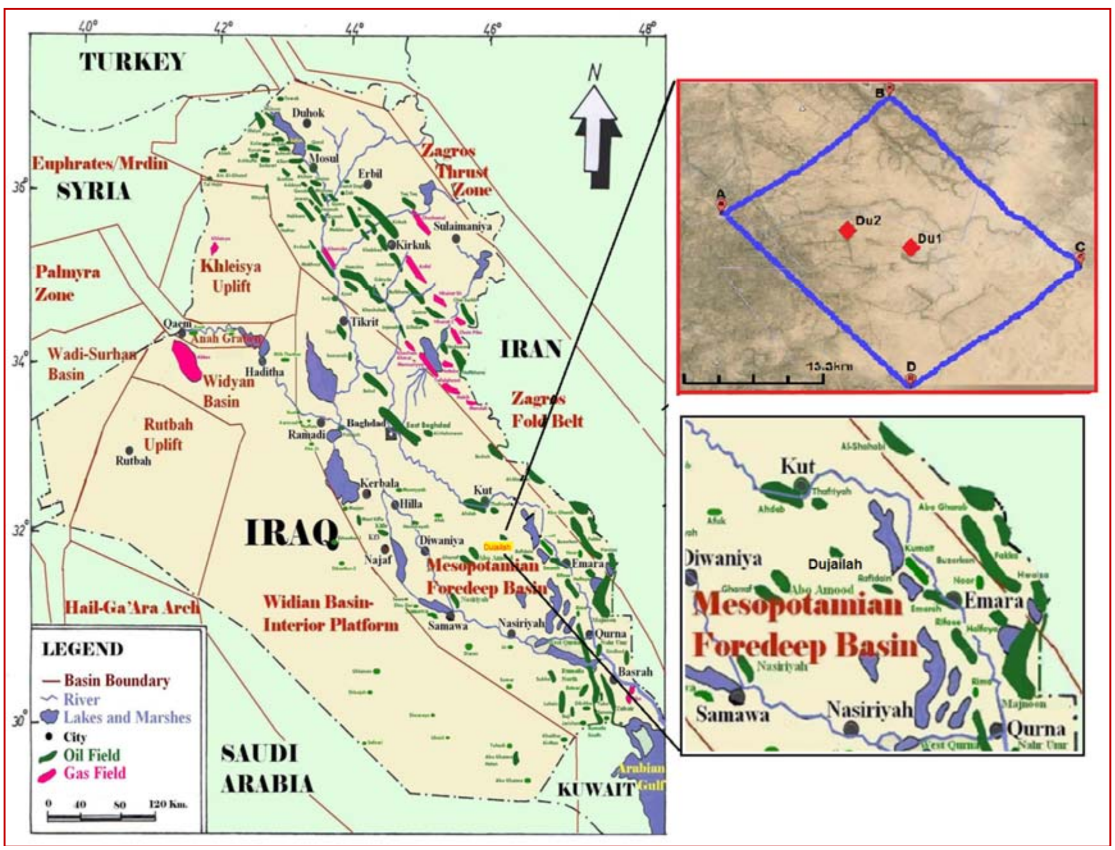

Figure 1- Location map of the study area.

Base Map Preparation

Processed 3D seismic volume are loaded in the interactive workstation of interpretation (GeoFrame 4.5) in SEG-Y format, before starting; special subprograms must be operated to define the required data for loading, 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 number, the first and last cross line number, the separated distance between bin size along inline direction and cross line direction, also includes definition of the geographic coordinates in UTM coordinates system of study area (Figure-2).

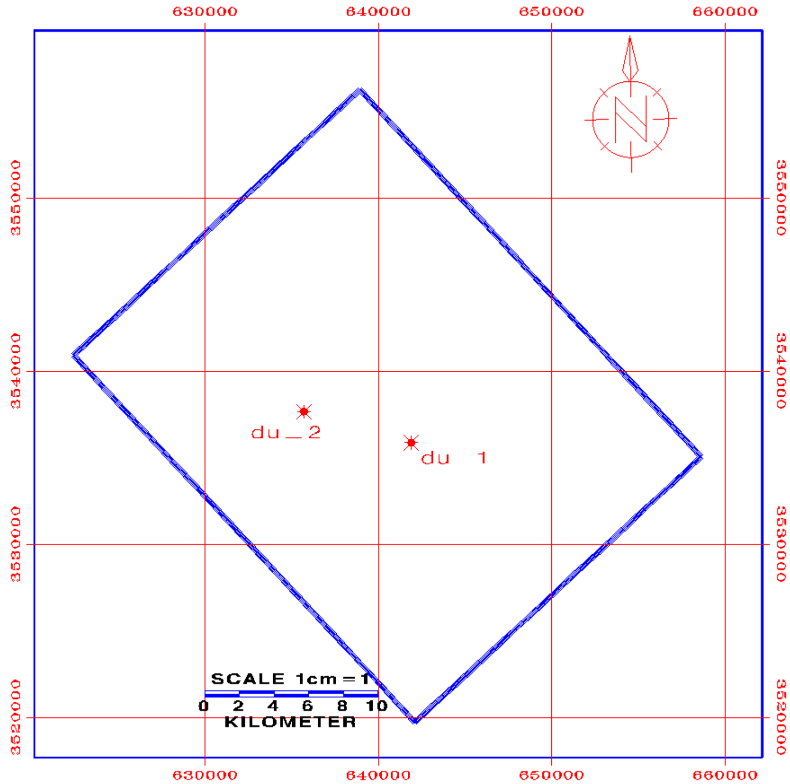

Figure 2-Illustrates a base map of a study area, (3D Dujaila survey).

Generation of Synthetic Seismograms

Synthetic Seismogram was created to know the accurate location of the formation tops of interested horizon then tie it with the seismic section. Synthetic indicates also that if the horizon response is peak or trough [7].

The main steps for generation of the synthetic seismogram are:

1- Computing the acoustic impedance $(z = \rho \times v)$ Where:
  i. v: is seismic velocity.
  ii. ρ: is density measured from log.

2- Computing the reflection coefficients

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

$(\rho i\ , \rho i + 1)$ the density at the interval (i), (i+1)

$(vi\ , vi + 1)$ the velocity at the interval (i), (i+1) [8].

3- Convolution process between the reflection coefficients and experimentally selected wavelet is made to obtain the synthetic seismogram by using either the default of a Ricker wavelet method (which is pretty far from any realistic source) or extract wavelet from the closest seismic inline or crossline method.

Convolution also means replacing each reflection coefficient with the input seismic signal, scaled to the amplitude and polarity of the reflection coefficient Figure-3a. Mathematically is:

I(t) * RC(t) = A(t)

Where:

I(t) = amplitude of the input signal at time t.

* = convolution operator.

RC(t) = amplitude of the reflection coefficient at time t.

A(t) = amplitude of the seismic trace at time t.

Noise adds algebraically to the convolved seismic trace as shown in Figure-3b, mathematically is:

[I(t) * RC(t)] + N(t) = A(t)

Where:

N(t) = amplitude of the noise at time t.

The amplitude and interference patterns (waveforms) observed on seismic traces provide clues to compositions and thicknesses of Earth materials. The seismic energy is reflected when a material of a differing acoustical properties is encountered;

Factors that determine the appearance of an individual seismic trace are:

1- The input seismic signal, dependent on the frequency and phase spectra of the source.
2- Changes in acoustic impedance within the Earth that are encountered by the seismic signal.
3- Noise of many varieties, introduced through the acquisition and processing procedures as well as from cultural and other sources [9].

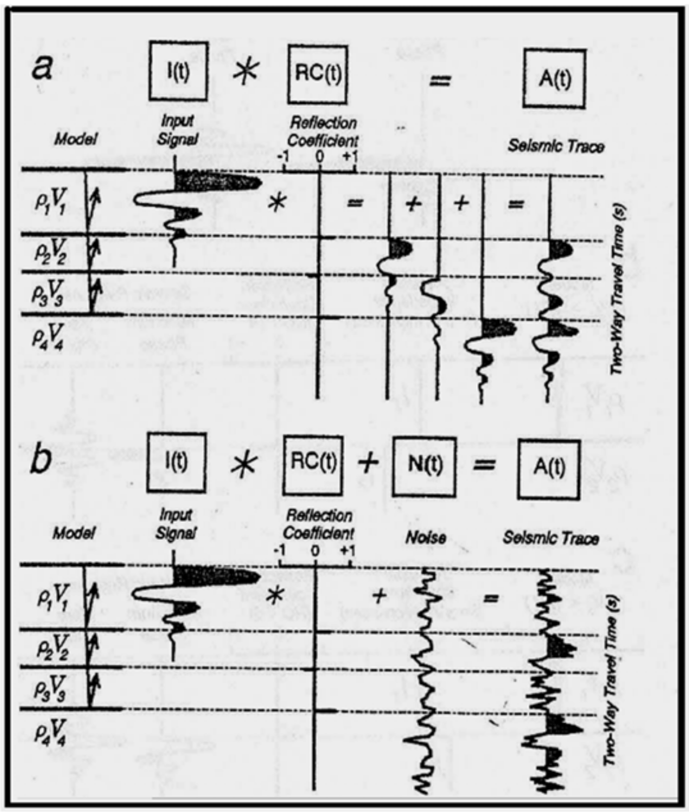

Figure 3- Shows Convolution of reflection coefficients with input signal a) without noise, b) with noise, [9].

The quality of the match between a synthetic seismogram depends on well log quality, seismic data processing quality and the ability to extract a representative wavelet from seismic data [7]. Figures (4a, b) represent the layouts of Synthetic seismograms creation of the Du_1, 2 wells.

Figure-5 represents the arbitrary 3D seismic sections passing through the well locations and synthetic traces of reflectors are displayed. The matching between seismic section and synthetic traces is good. Mishrif reflectors wavelets appeared as peaks on synthetic trace (positive reflection) but in different intensity, then, maps for Mishrif reflectors are drawn over all study area (Dujaila3D survey) as shown in figure-6.

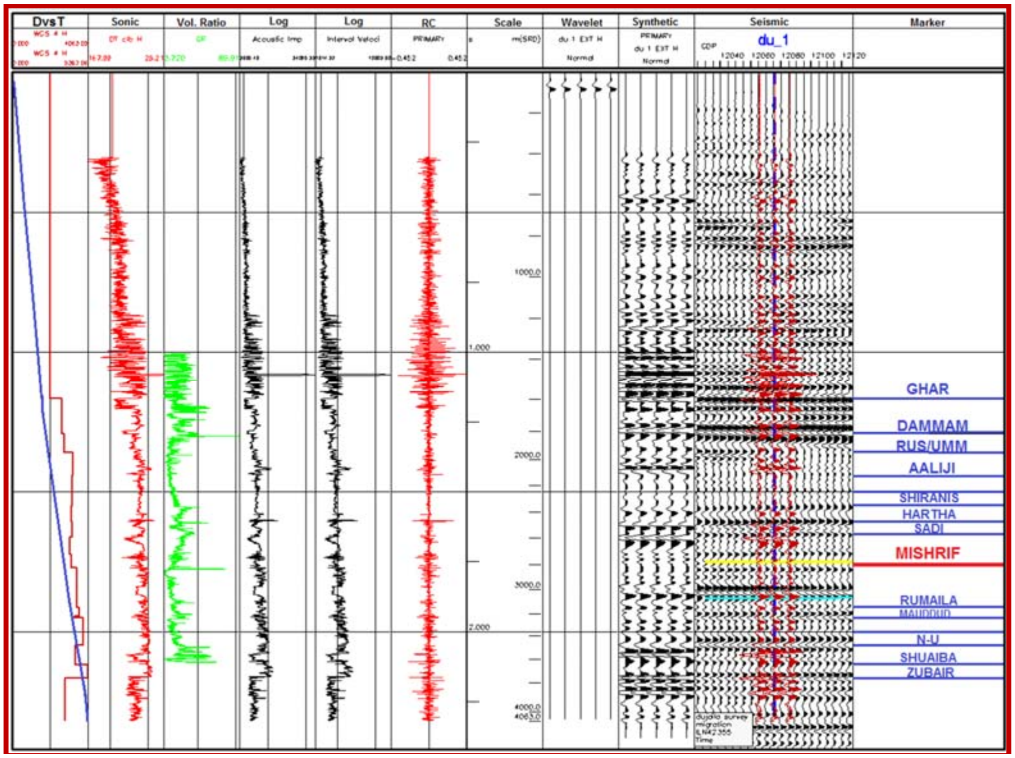

Figure 4a- illustrates the seismic synthetic seismogram of Dujaila_1 well.

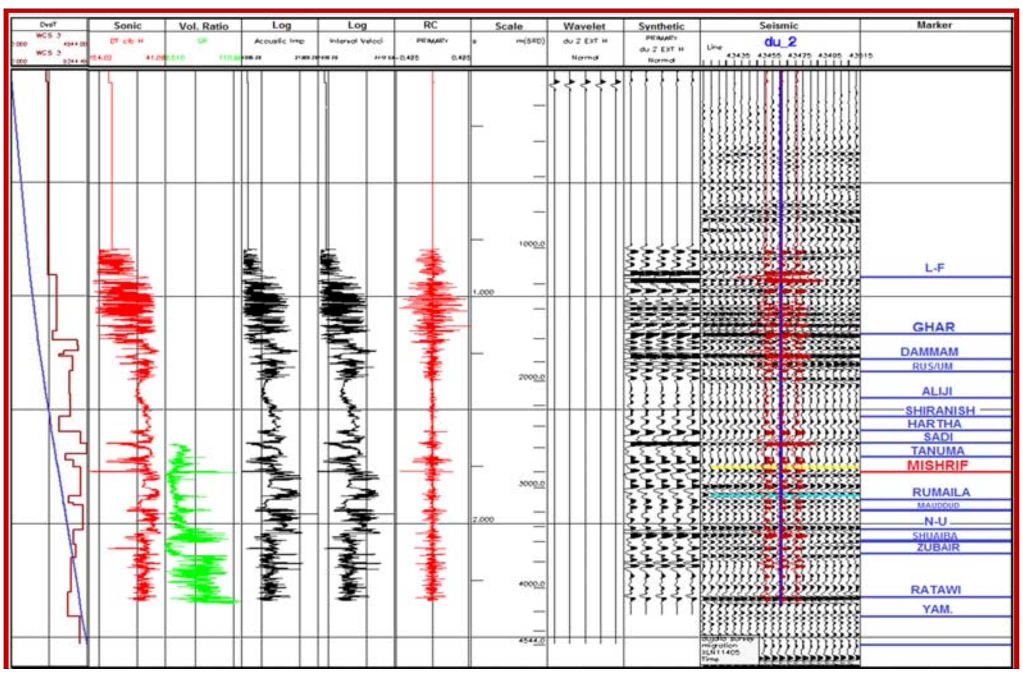

Figure 4b- Illustrates the seismic synthetic seismogram of Dujaila_2 well.

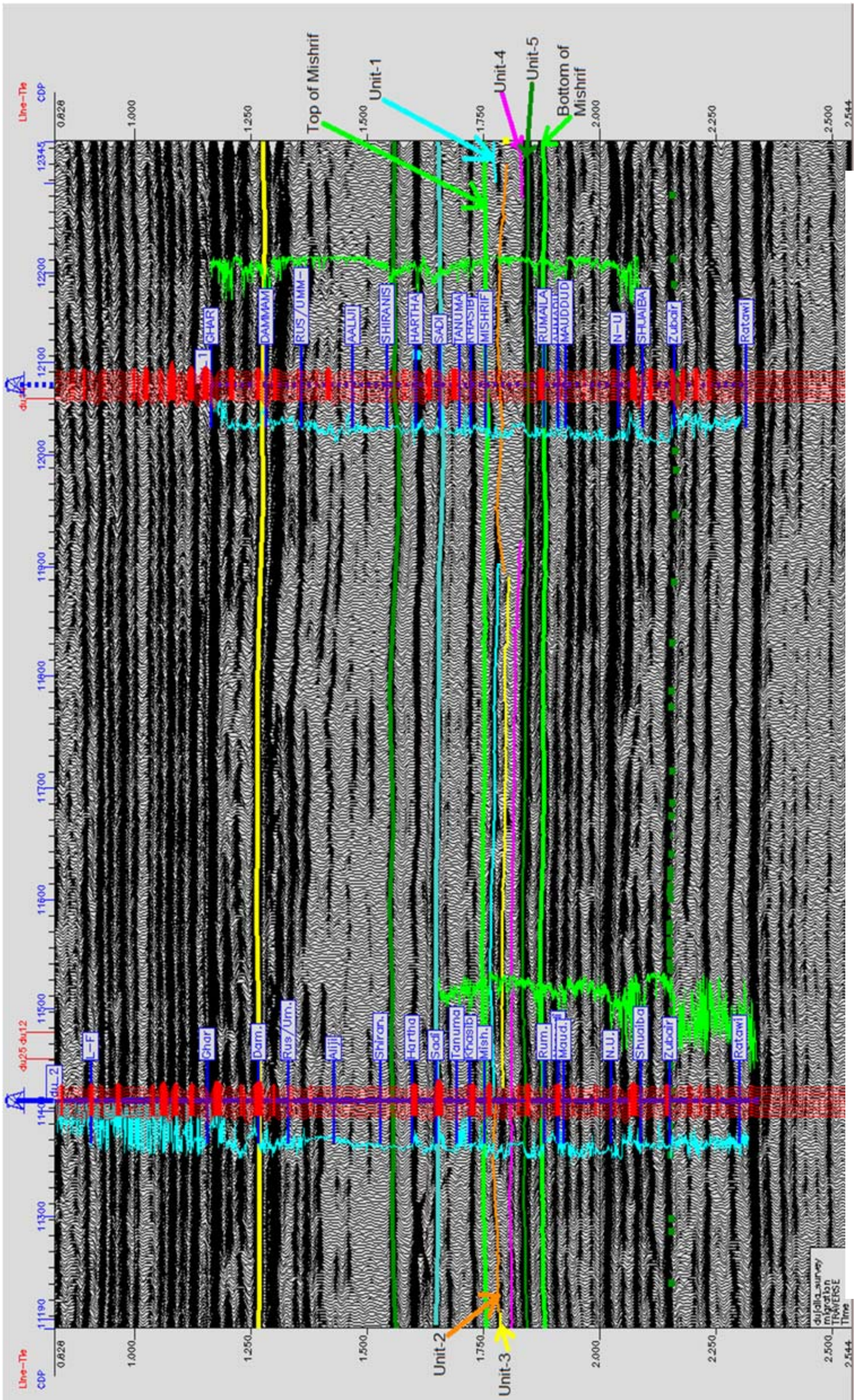

Figure 5 -Represents the arbitrary 3D seismic sections passing through the well locations and synthetic traces of reflectors are displayed

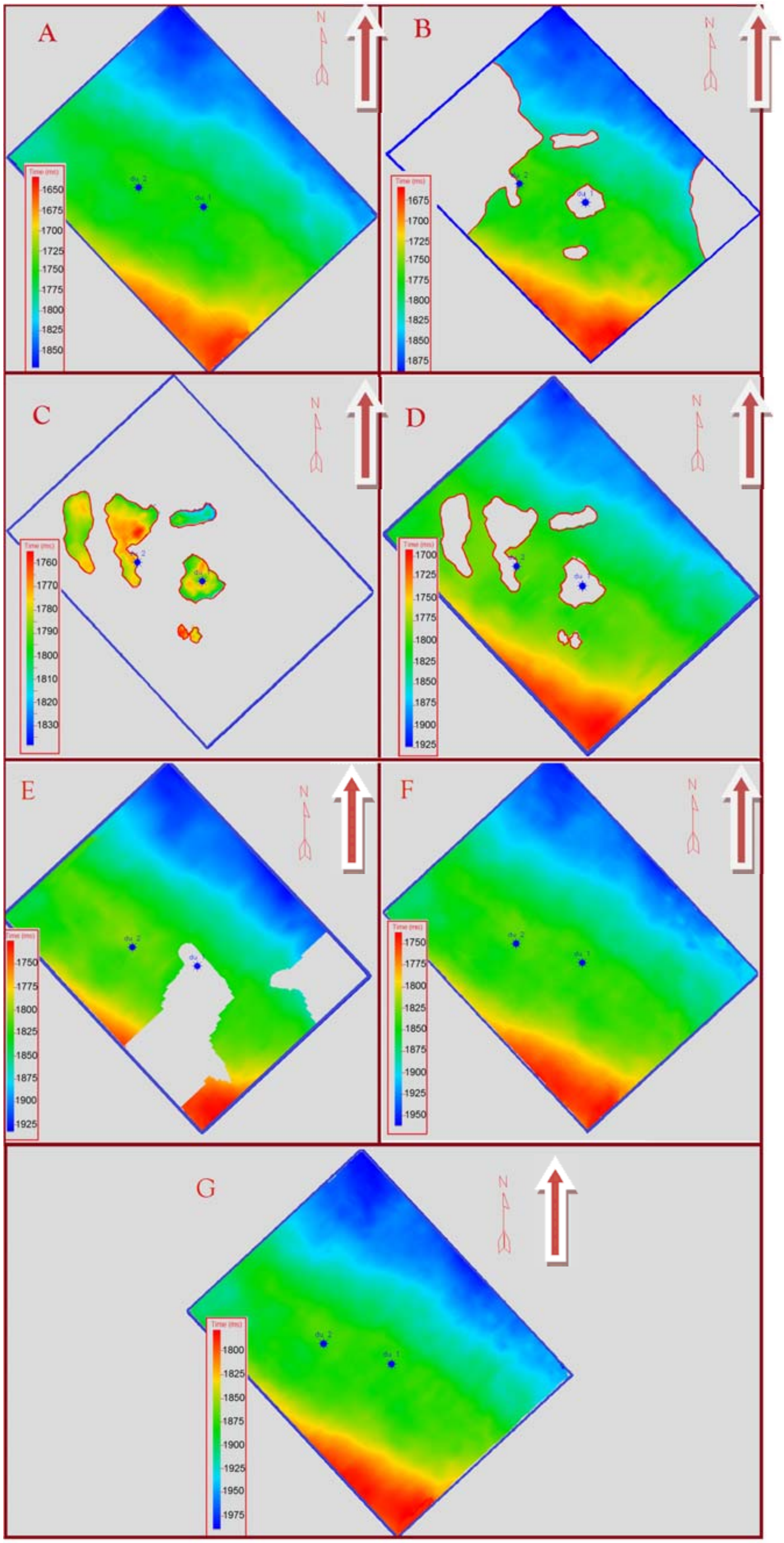

Figure 6- Shows picking maps of Mishrif reflectors in all study area (Dujaila 3D survey).
A) is the picking map of top Mishrif. B) is the picking map of unit-1.
C) is the picking map of unit-2. D) is the picking map of unit-3.
E) is the picking map of unit-4. F) is the picking map of unit-5.
G) is the picking map of bottom Mishrif.

Time Maps

The TWT (two way time) maps for top and bottom of Mishrif Formation are prepared to get the subsurface structural picture, these maps show the general dip of layers tend toward NE, thus, structural domes in the middle of Dujaila Oil Field where two wells (Du-1, Du-2) are found, (Figure-7, 8) represents the TWT maps of the top and bottom Mishrif reflector with contour interval (10ms).

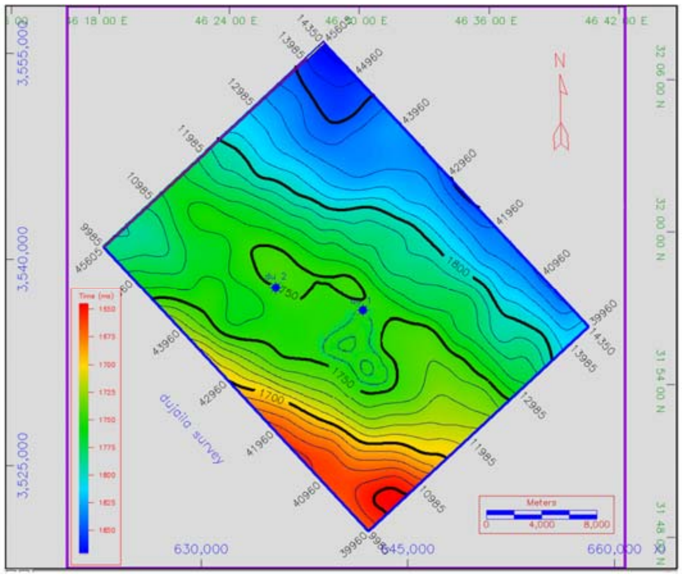

Figure 7 -Shows the top Mishrif TWT map.

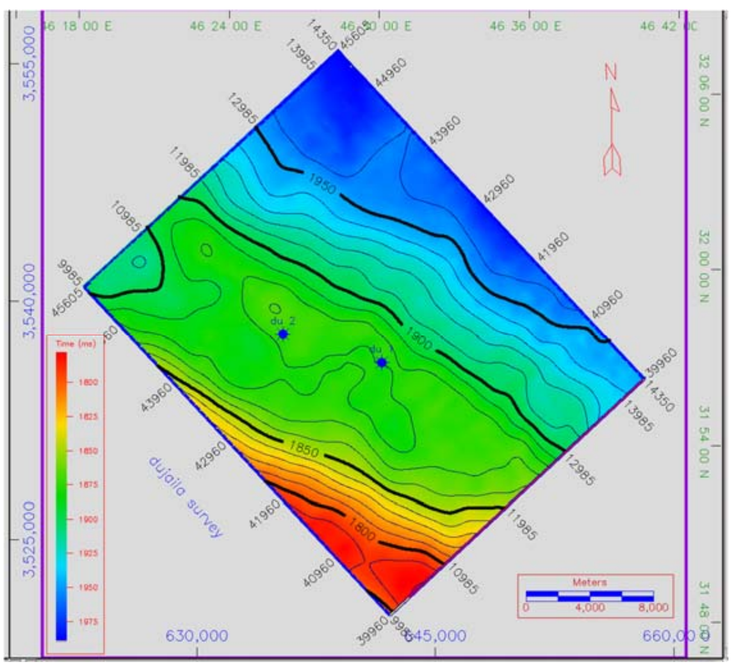

Figure 8- Shows the top Mishrif TWT map.

Depth Maps

The depth map is reflecting the same subsurface picture in time domain. Thus, the shape of depth maps is look like of two way time map, and show the same picture of the studied Formation. It is obtained by using the time map of a given reflector with its velocity map, as follows:

Depth at any point = (velocity × time) at this point.

The RMS (root mean square) velocity cube was loaded to construct the depth maps. The RMS velocity for top and bottom of Mishrif Formation are drawn, then smoothed and correct by using the average velocity of Mishrif Formation that available in check-shot logs of Du_1 and 2 wells. This method is suitable to convert the maps from time to depth domain by combining two types of velocities (RMS & Average), [10].

The structural picture can be described as:

Figures-9, 10 represent the depth maps for the top and bottom of Mishrif Formation with contour interval (10m), and showed these layers covered all study area with general dip toward NE and also showed enclosure domes with NW-SE axis in the middle of Dujaila Field where the two wells (Du_ 1 and 2) are located.

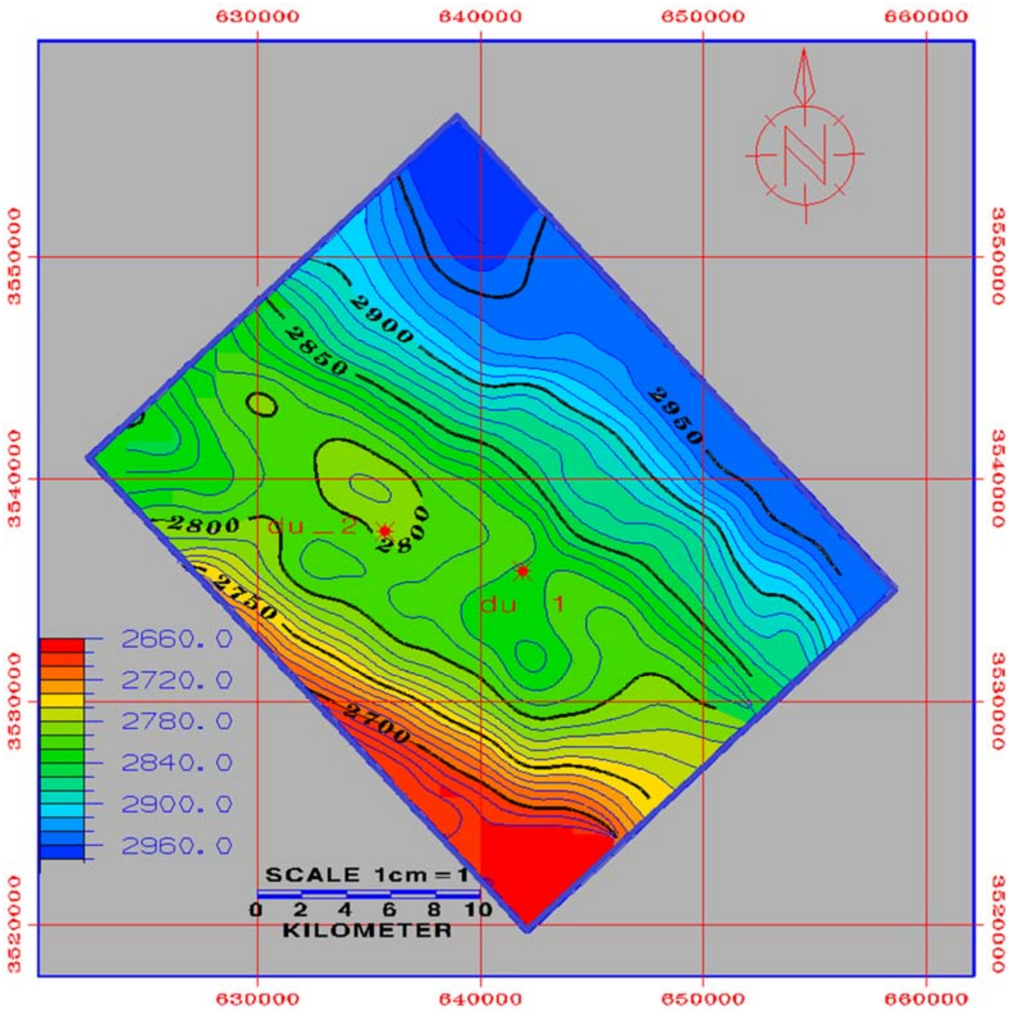

Figure 9-Shows depth map for the top of Mishrif Formation.

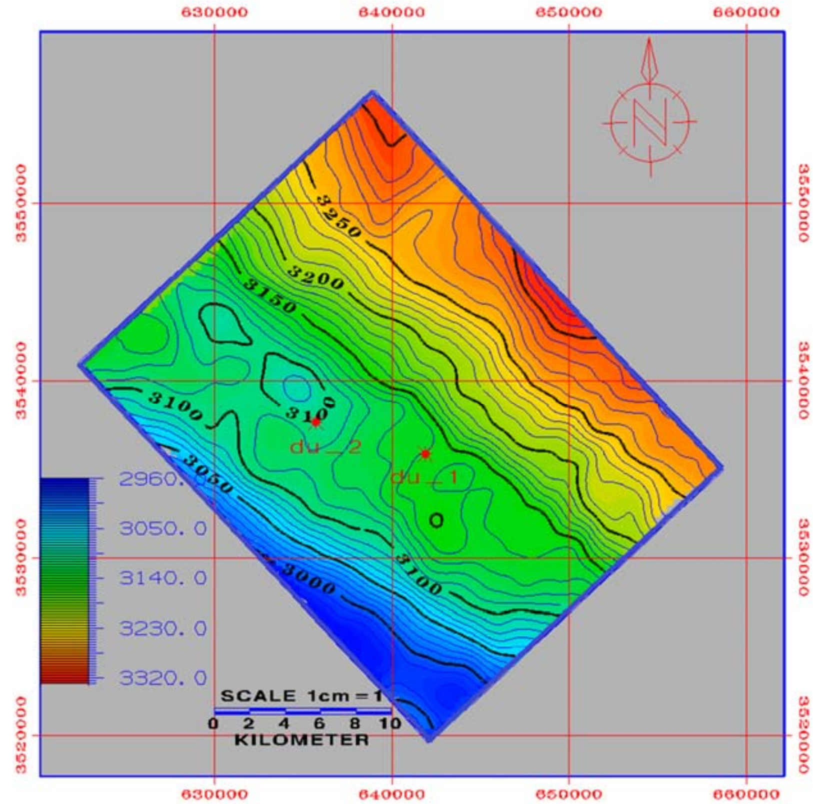

Figure 10 -Shows depth map for the bottom of Mishrif Formation.

Conclusions

1. One formation was studied, representing Mishrif reflector within Cenomanian age. At first, two synthetic seismograms are created for Du-1 and Du-2 based on sonic log, well check shot survey and well markers available for these wells to define and pick reflectors on seismic data. The result proved a good matching between the synthetic seismograms and the seismic section and also good correlation between the two synthetic seismograms. After that, the main two reflectors were picked over the cube that represent top and bottom parts of Mishrif Formation to get the structural picture, then, five reflectors (represent the layers that consist Mishrif Formation) were picked and sampled as Unit_1, 2, 3, 4 and 5 (Unit_2 represents the oil reservoir in Mishrif Formation).
2. Continuity of the picked reflector can be described as follows:
   Top and bottom parts of Mishrif with unit-5 reflectors have a good continuity, while unit_1, 2, 3 and 4 reflectors have medium continuity, it is characterized by the pinch out between each other and this due to the lateral change of facies.
3. In general, there is existence of dis-concordance between different sequences of reflectors along seismic sections. The seismic section of Mishrif reflectors shows that dis-concordance from top to bottom of Mishrif Formation, this due to the presence of the stratigraphic features within Mishrif sequences.
4. In general, the seismic section shows acceptable to good quality of reflectors which represents top and bottom of Mishrif Formation with its layers, this is due to the high signal to noise (S/N) ratio of the recorded signal where the resolution was very good.
5. Time and depth maps for the top and bottom of Mishrif Formation are prepared to get the structural picture. These maps show the general dip of layers tend toward NE, thus, enclosure domes in the middle of Dujaila Oil Field where two wells (Du-1, Du-2) are found.

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