ISSN: 0067-2904

Stratigraphic Study of the Cretaceous-Tertiary Period in Qasab-Jawan Area in Northwestern Iraq by using 2D Seismic Survey

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Received: 30/3/2021 Accepted: 23/6/2021

Abstract
A seismic study was conducted to re-interpret the Qasab and Jawan Oil fields in northwestern Iraq, south of the city of Mosul, by reprocessing many seismic sections of a number of field surveys by using the Petrel software. Two reflectors, represented by the Hartha formation, deposited during the Cretan age, and the Euphrates formation, formed during the Tertiary age, were delineated to stabilize the structural picture of these fields.
The stratigraphic study showed that the Qasab and Jawan fields represent areas of hydrocarbon accumulation. Seismic attribute analysis showed low values of instantaneous frequency in the areas of hydrocarbon accumulation. Instantaneous phase was used to determine the limits of the sequence, the nature of sedimentation, and the type of vanishing, i.e. onlap vs. toplap. Low instantaneous amplitude values were recorded, indicating hydrocarbon reservoirs in the studied area. Various other seismic stratigraphic features were studied , including the distribution mound, flat spot, and channels in the two formations, but they were discontinuous because of the tectonic effects. These activities explain reasonably the distribution of hydrocarbons in the studied area.

Keywords: seismic reflectiin, stratigraphy, Qassab – Jawan, petroleum exploration.

دراسه طباقيه للفتره الطباشيري–الثلاثي في منطقه قصب–جوان شمال غرب العراق بواسطه استخدام المسح الزالزالي ثنائي الابعاد

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الخلاصة
تم اجراء اعادة تفاسير حقل قصب وجاوان النفطي الواقع شمال العراق جنوب مدينة الموصل وذلك من خلال إعادة معالجة وتفسير العديد من المقاطع الزلزالية لعدد من المسوحات الحقلية التي شملت منطقة حقل قصب وجاوان . تم في هذه الدراسة تحديد تكوينين هما الفرات وهارثه تمثل عصري الثلاثي والطباشيري

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لأجل تثبيت الصورة الطبوغرافيه لهذا الحقل . تمت دراسة طباقيه هذه المنطقة ، وكانت هناك تغييرات ملحوظة. تمثل هذه التغييرات منطقة تقدم بحري Transgressive استخدمت تقنيات الملامح الزالزالية منها التردد الاني (Instantaneous Frequency) فقد لوحظ وجود تطابق بين مناطق الترددات الواطئة ومناطق التجمعات الهيدروكاربونية , وكذلك استخدم (instantaneous phase) وهو مهم في تحديد حدود التتابع وطبيعة الترسيب ونوع التلاشي onlap و toplap وذلك لتحديد التجمعات الهيدركاربونية في المقاطع الزالزالية , وأوضح ملامح السعة (amplitude attribute) نقصان في قيمة السعة توضح مناطق محتملة لتجمع الهيدروكاربونات. تعد هذه النتائج مشجعة لاستغلال فترة الطباشيري – الثلاثي للتجمعات النفطية في منطقة الدراسة

Introduction

The history of geophysical exploration of hydrocarbon accumulation extends back to the beginning of the last century, when seismic reflection analysis was first used to detect such accumulation [1]. In terms of cost and number of geophysicists involved, a seismic study is the most effective geophysical approach. Seismic analysis is also considered to be the most applied among other geophysical methods of petrolium expllоration due to several technical factors, including high precision, resolution and, and permeability [2] .

Seismical research is performed to identify seismic components, seismic stratigraphy, and seismic faces in intra-stratigraphic interpretations, which achieve the most accurate picture of the earth's surface and its geological structures [3]. Many seismic studies were conducted to investigate the subsurface geology of many oilfields in Iraq. These studies concluded that the seismic reflection method provides a good image of the stratigraphy and structure of the subsurface, leading to a better understanding of the subsurface geology and the provision of a good evidence of oil accumulation [4-9]. The Qasab and Jawan area which is located in the south of Mosul city, northwestern Iraq, was studied based on data obtained from the Iraqi Oil Exploration Company. This research aims to study the stratigraphic picture of the Createous-Terteary period , as covered by a 2D seismic survey, then suggest the best location of a potential exploration well within the study area. The attribute analysis approach was used to determine the stratigraphic and structural features, which could provide good indicators of hydrocarbon accumulation.

Location of the study area

The study area represents a vast region that extends to the south of Mosul city, northwestern Iraq (Figure 1).

The area is bordered by Sinjar Mountains (anticline), Tela'far city, and Mosul city from the north, Sunaisla lake and Hatra city from the south, Tigris River from the east, and the Syrian borders from the west. The total area of south Sinjar plain which includes the study area is approximately

19714Km^2 . Quaternary Pleistocene and Holocene deposits are covering the region, while Tertiary and Cretaceous deposits Only north of the study area are Tertiary and Cretaceous Terrain Terraces exposed. Sinjar plain area shows the some near surface stratigraphy feature[10]. Sinjar anticline area, located within the Low Folded Zone according to the tectonic map of Iraq, contains outcropping Neogene sedimentary rocks. The cores of the anticlines may expose Eocene limestones or Upper Cretaceous sedimentary rocks [11].

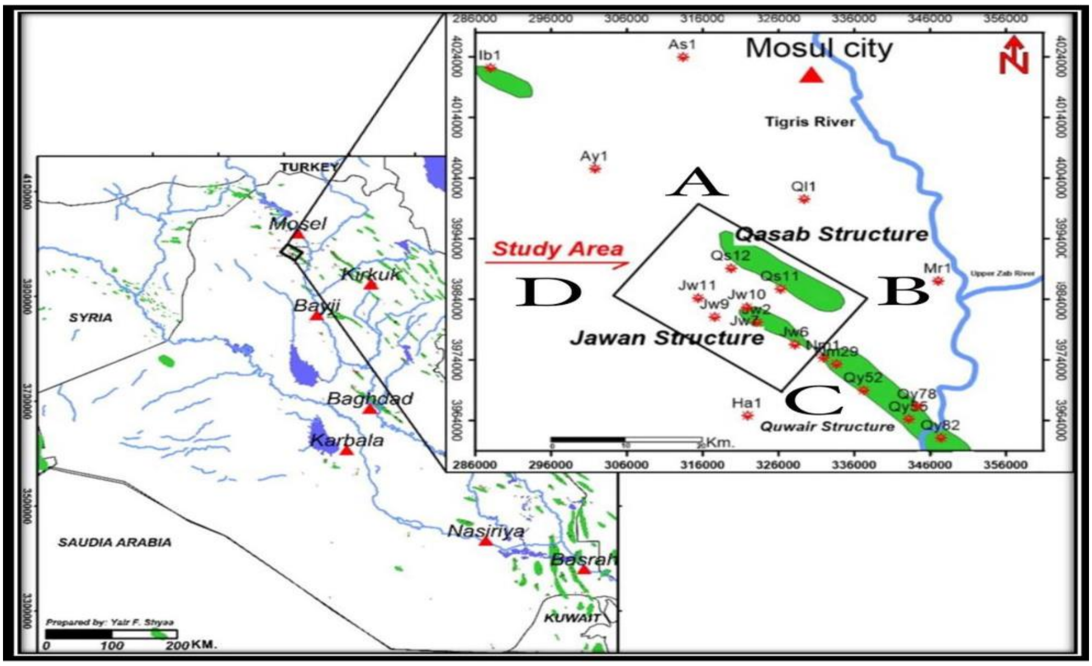

Figure 1- Location map of the Qasab –Jawan area

Methodology

The methodology adopted by the present work included several steps. A base map of seismic lines in the study area was first prepared, followed by creating a synthetic seismogram. The synthetic seismogram was then compared with the seismic section near the well to collect the reflectors of the two studied formations. Interpretation of the above seismic sections was conducted to obtain a stratigraphic image of the study area. Attribute analysis was performed to determine several features that are considered as good indicators of hydrocarbon accumulation.

Processed seismic data (in SEG-Y format) were uploaded, with their coordinates, to the interactive workstation of the Interpretations Department at the Iraqi Oil Exploration Company (O.E.C). Then, the base map of the study area was constructed. Figure 2 shows the two sets of 2D seismic lines.

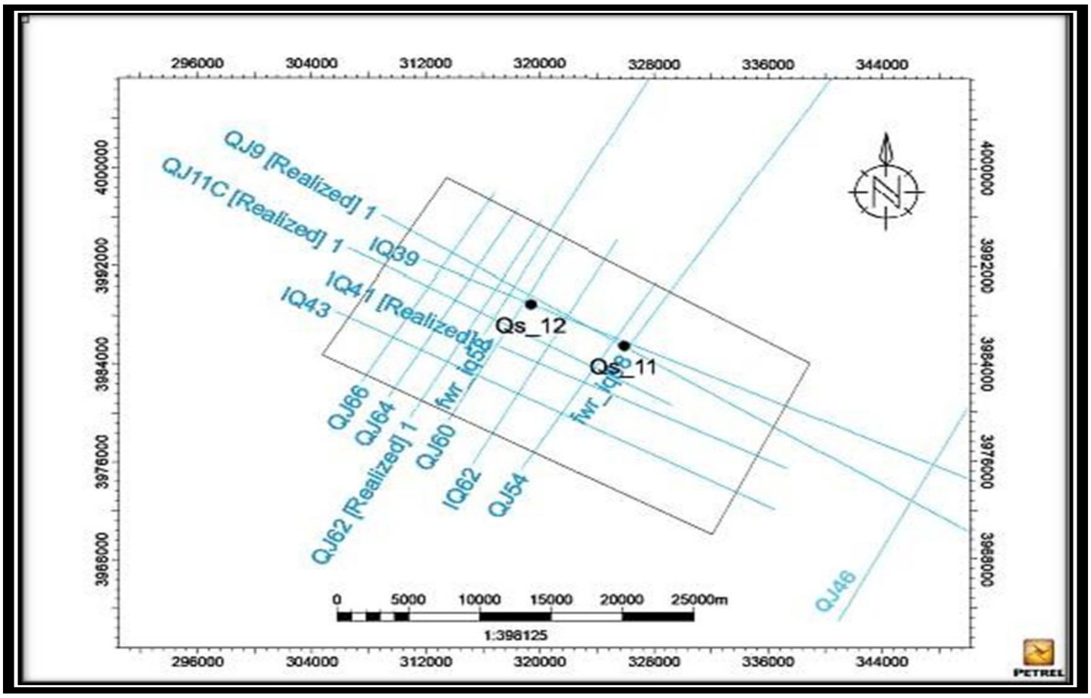

Figure 2- The base map of the Qasab-Jawan area show the seismic line

Generating synthetic seismograms

The seismic section interpretation method was adopted to identify the reflectors representing the studied formations. This was achieved through the comparison of the two-way travel time (TWT) of the seismic section to the synthetic seismogrsms obtained by the sonic log and the velocity survey data of the well [12].

Three main steps were followed for the generation of the synthetic seismogram. First, the acoustic impedance was calculated as $Z = \rho \times v$, where v is the velocity measured from velocity data in the well or from the sonic log, whileρ is the density measured from information of core analysis or from density log. Second, the reflection coefficient was calculated as in the following :

$$R_i = \frac{(\rho_i + 1)(v_i + 1) - \rho_i v_i}{(\rho_i + 1)(v_i + 1) + \rho_i v_i}$$

where (ρi+1, ρi) and (vi+1, vi) are the density and velocity values at the intervals (i+1) and (i), respectively.

The reflection coefficients in the depth domian were converted to reflectivity functions in the time domain [13]. Then, an experimentally wavelet was extracted from the seismic data nearest to the well by using Petrel software. Third, synthatic seismograms were generated for two wells (Qs-11, Qs-12), using the Petral software package, by the convolution of the reflectivity functions and the extracted wavelet (Figures 2 and 3, respectively).

Generally, the accuracy and quality of a synthetic seismogram depends on the ability to extract a suitable wavelet, the quality of sonic log, and the quality of seismic data [13-15].

The comparison of the seismic data with the synthetic seismogram shows acceptable- poor matching between the seismic reflectors. It also shows that the upper contact of Euphrates and Hartha formations occurs in the peak of the wavelet's amplitude, due to the fact that the reflection coeffeicent is positive.

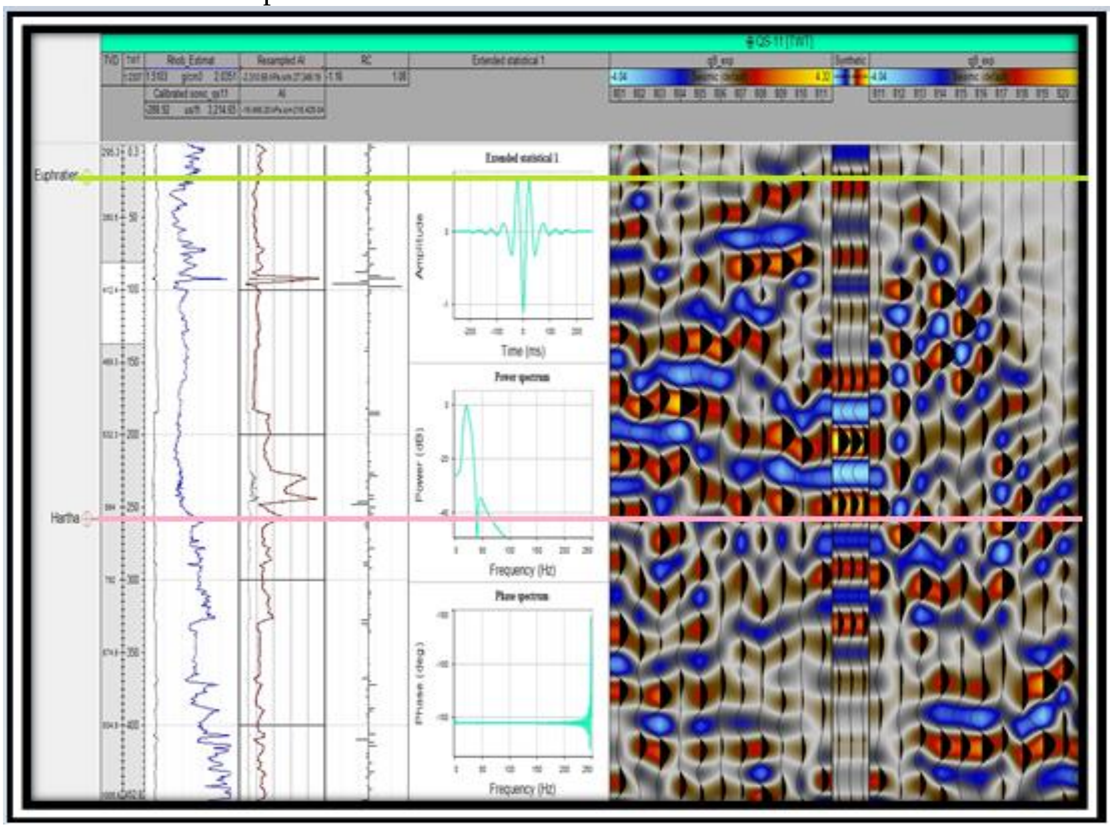

Figure 3- The synthetic seismogram of the Qs-11 well in Qasab-Jawan area

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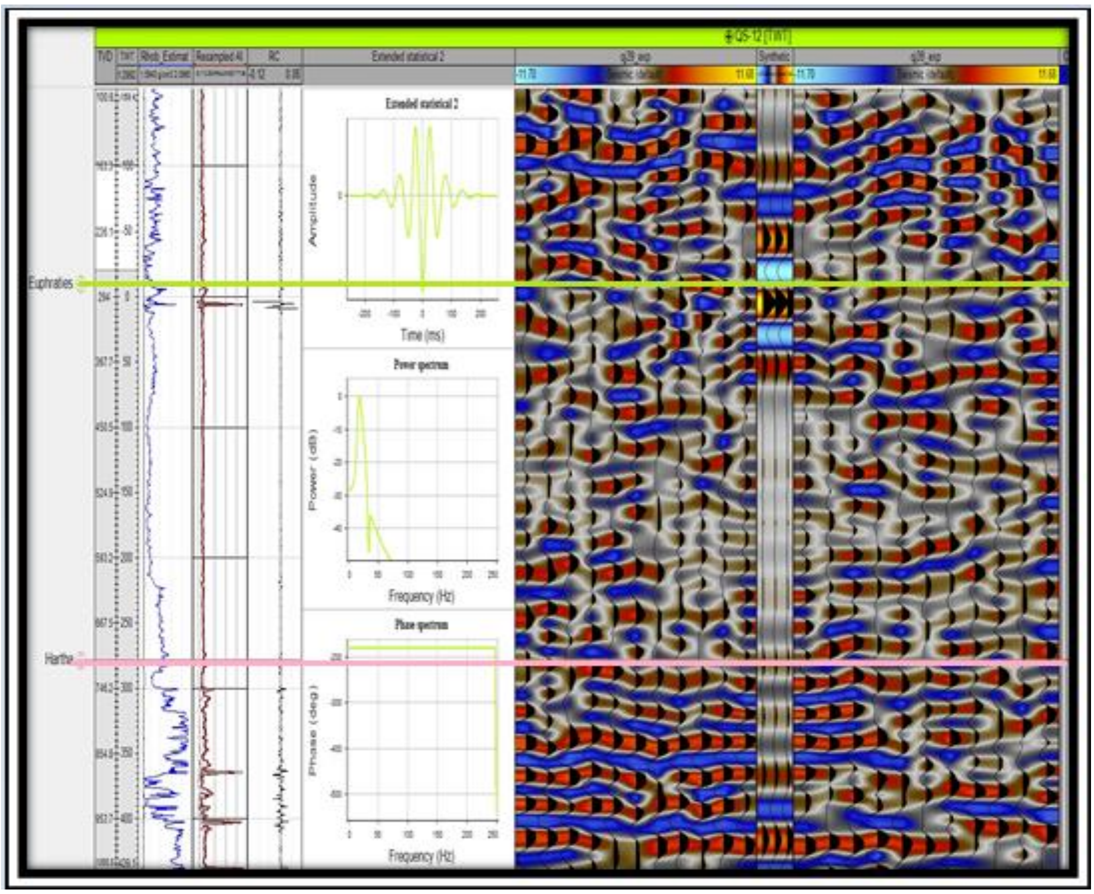

Figure 4- The synthetic seismogram of the Qs-12 well in Qasab-Jawan area .

Seismic reflectors

To study the Cretaceous-Tertiary period, two reflectors were recognized. These are the top Euphrates (Tertiary) and the top Hartha (Upper Cretaceous) (Figure 5). The general specifications of seismic reflectors in the 2D seismic volume are described as follows .

These reflectors were diagnosed on the seismic sections after connecting these sections with the wells available in the study area. The seismic line (IQ-39) was considered as a basis for the interpretation of the remainder of the area's lines, due to its passage through the well (Qasab-11) and (Qasab12). The reflectors definition based on three factors.

The first factor is the quantity, for which two reflectors were selected. The first represents Euphrates Formation(Teriary) and the second represents Hartha Formation (Cretaceous).

The second factor is the continuity of the reflectors, for which two reflectors were selected; the Euphrates reflector which showed a moderate continuity and Hartha reflector which showed a good continuity.

The third factor is the quality of the reflectors, used in order to present the same specifications and show the lack of change in interface time between the studied reflectors. The seismic sections showed in general a good match throughout the study area.

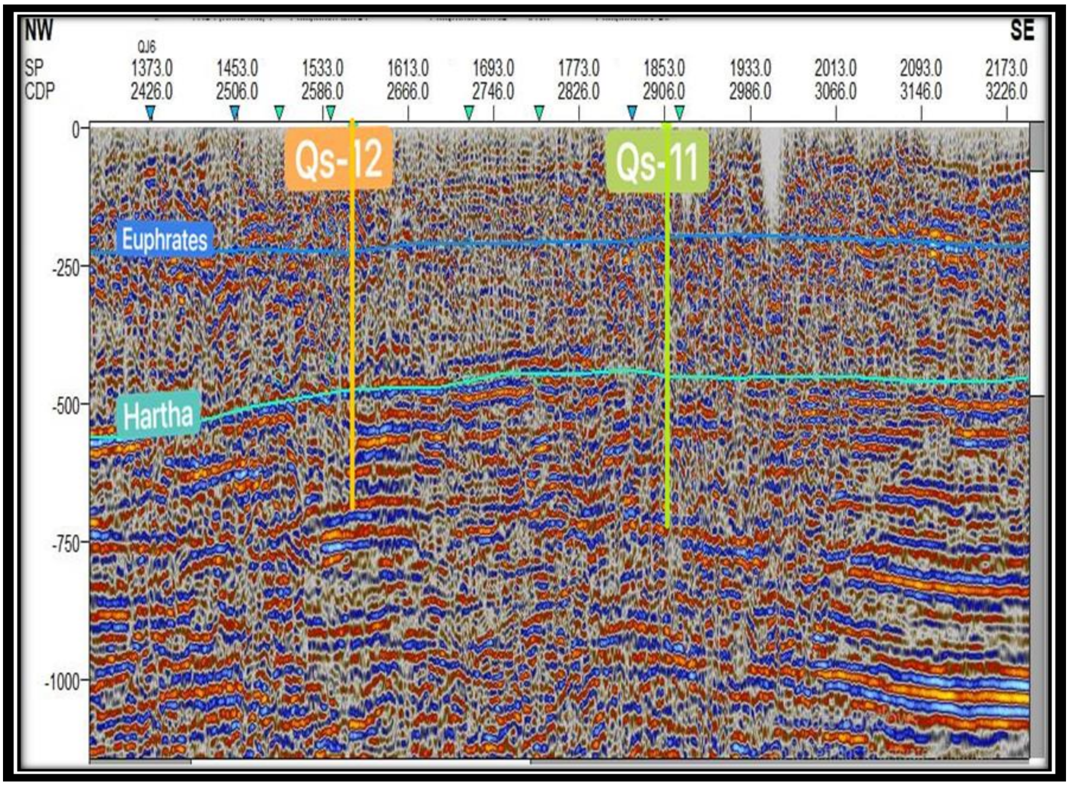

Figure 5- The Euphrates and Hartha seismic reflectors in Qasab-Jawan area .

Seismic Data Interpretation

Seismic interpretation is an important step that forms the last phase of the seismic exploration project. This involves the transfer of the processed seismic data into similar geological information [15, 16].

The interpretation stage initially involved identifying and selecting the reflectors of Euphrates and Hartha on all seismic lines that cover the study area. This was followed by the determination of the stratigraphic features between these reflectors. Finally, a stratigraphic image was created and the environment of deposition was identified.

Stratigraphy of the Studied Formations

The study area contains sediments from the Miocene age. Most of these deposits are. Also, most of these deposits were covered with Quaternary deposits. The stratigraphic analysis revealed the following components.

1- Euphrates Formation

It is composed of porous, brown-dark brown, medium-hard, fine crystalline, dolomitic, vuggy, brittle in some places, anhydrite, olitic limestone with heavy oil appearances. The fauna identified include Miliolids, Rotalia, and shell fragments.

2- Serikani Formation

It is composed of brownish gray-gray, soft-medium hard, fine crystalline, dolomitic, pyritic, partially silty, marly limestone with slight bitumen.

3- Basal Anhydrite

This is a streak of white, mediam-hard, micro crystalline anhydrite.

4- Kirkuk group

It is composed of hard, fine-medium crystalline, dolomitic, pyritic, white-light gray, soft, marly limestone, with traces of dead oil. Fauna included globigerina and rotelids.

4- Jaddala Formation

It is composed of light gray-gray, soft-medium hard, fine crystalline, , dolomitic, partially silty , glauconitic marly limestone**.** Fauna included globigerina, textularia, nodosaria, and rotelids.

5- Aaliji Formation

It is composed of light gray-dark gray, soft-medium hard, fine crystalline, partially shaly, silty, pyritic limestone with marl. Fauna included globigerina, nodosaria, and globorotalia.

6- Shiranish Formation

It is composed of light gray-dark gray, soft-mediam hard, fine crystalline, partially shaly, silty, glauconitic, pyritic limeston**.** Fauna included globigerina and globorotalia.

7- Hartha Formation

It is composed of partially porous, white-beige, soft-medium hard, fine crystalline, dolomitic, recrystallized, pyritic, slightly vuggy, partially pelletal limestone with pure calcite and anhydrite in some parts along with calcite filling micro fracture and gas appearance. Fauna include monolepidorbis, rotalids, echinoid, and undifferentiated fossil fragments (in well Qasab12).

Seismic Stratigraphic Interpretation

Seismic stratigraphy is a stratigraphical data analysis method derived from seismic data. Changes in the type of rock cause fundamental changes in the reflectivity, influencing the shape of the wave in seismic information and inferring stratigraphical changes based on seismic information [17].

Stratigraphic seismic data analysis involves good data quality and needs both art and research. In a good record area, the effects of structural problems will outweigh the effects of stratigraphic changes. Seismic stratigraphic research can provide useful geological information and help to understand hydrocarbon deposition zones, aggregation and trapping processes, and deposition conditions [18].

By integrating lithological data and logs with the seismic analysis, stacking patterns may be inferred fore Euphrates and Hartha sequence observed from stratigraphy phenomenon which is thought as carbonate platform fore reef towards the Continental shelf. depositional sequence represents by maximum flooding surface (MFS) and system tract of formations which is represents High stand system tract , Transegrressive system tract and low stand system tract .

This cycle is considered as the highest flooding surface in the basin facades. The high-level system tract is defined by a comprehensive progression of the reef facies and their related reef facades over the front of the reef facies of the middle ramp. Because of its limited length, the low-level system tract is less developed. It is reflected by the sea shift from the facies belt, followed by the local erosion of the high part of the reef (Figures 6, 7, 8).

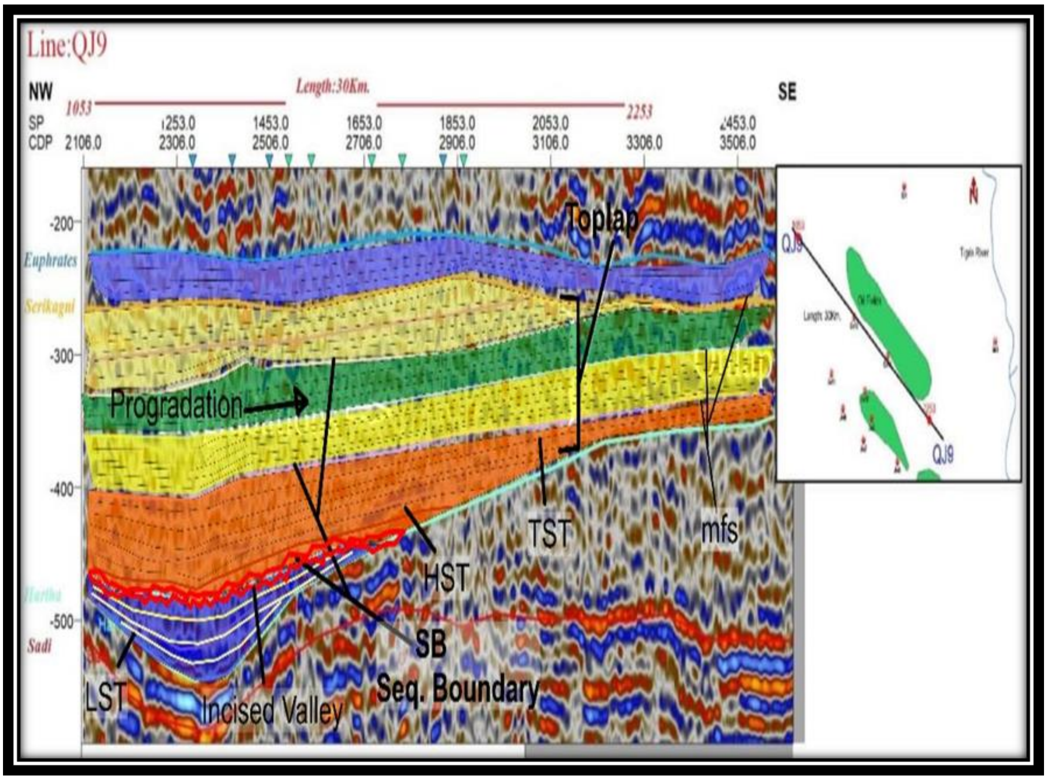

Figure 6- Depositional sequence and system tracts of Euphrates and Hartha formations (line QJ-9).

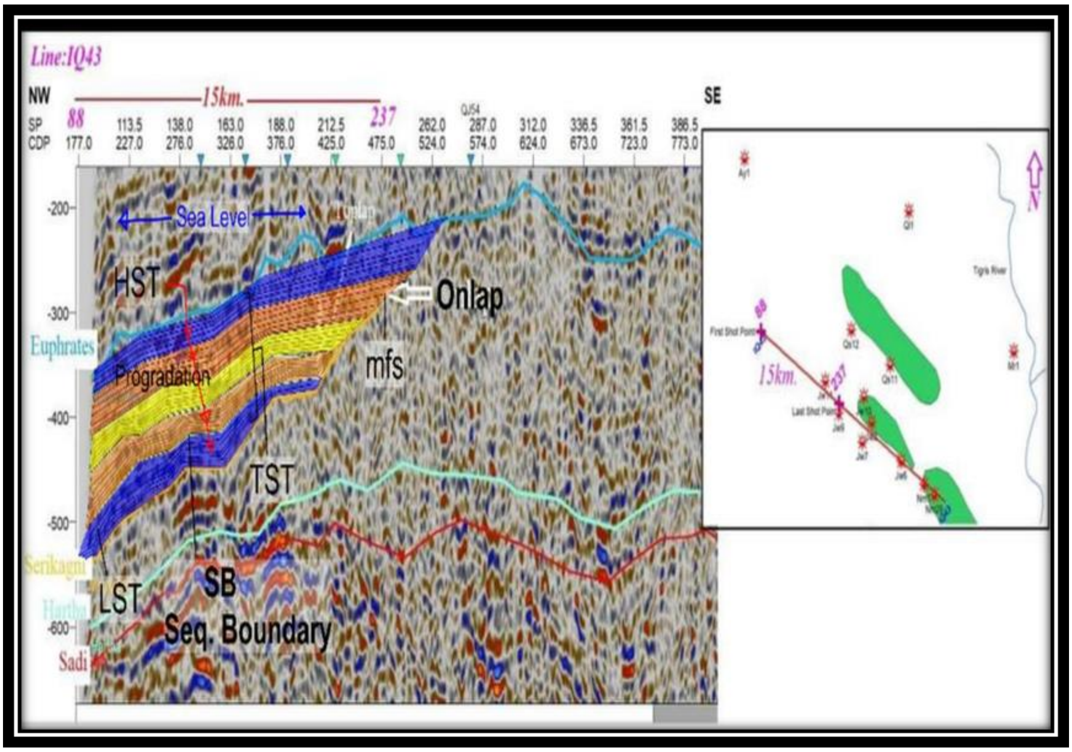

Figure7 - Depositional sequence and system tracts of Euphrates and Hartha formations (line IQ-43).

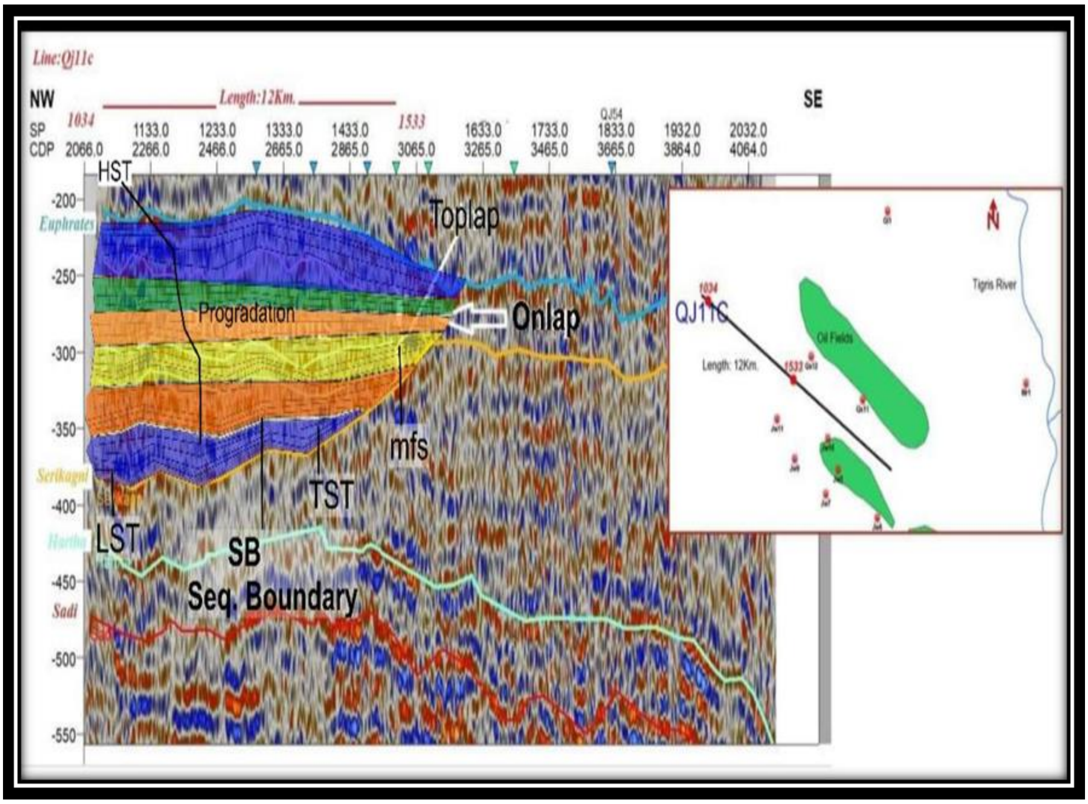

Figure 8- Depositional sequence and system tracts of Euphrates and Hartha formations (line QJ-11C).

Seismic Attribute Section

In the seismic part of the study, seismic attributes were applied to diagnose the extension of changes in facies and classify the direct hydrocarbon indicators of the (DHI) of traps. We also interpreted the seismic area by converting the data on seismic attributes. The types of attributes found are described below.

Instantaneous Amplitude Sections

Depending on the difference in velocity and density between the rocks layers above the reflection and the one below, seismic reflections are described as high or low [18]. The time-measured attribute mainly visualizes regional features such as form, sequence limits, width, and lithological variations. In certain cases, phenomenon of light and dim points are related to gas build-ups. In the research area, in the area of possible hydrocarbon reservoirs, low amplitude values are observed (Figure 9).

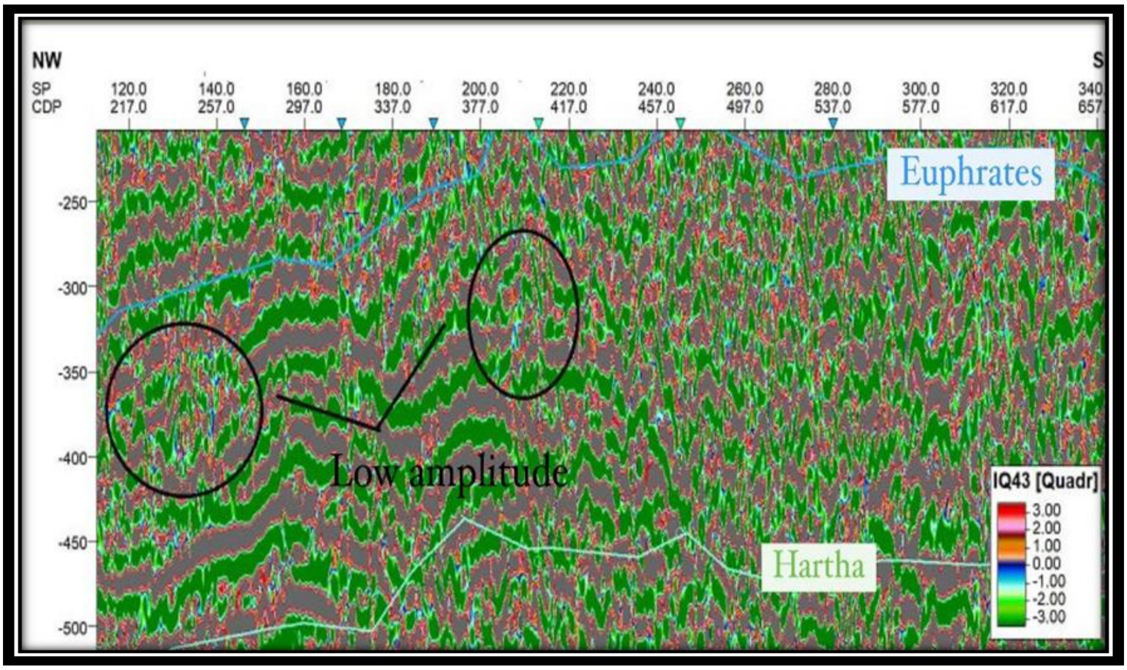

Figure 9- Instantaneous amplitude (line IQ-43)

Instantaneous Frequency Sections

Jumping to onlap, downlap, or toplap seismic reflectors is a common problem when it comes to monitoring regional sequence borders. Sequence limits can be separated from reflectors which end up on them due to the lack of high frequency tuning away from the contact region.

The results of the application of attribute assist to determine sites changes Instantaneous frequency and their relationship to changes in petro-physical qualities, is linked frequencies of low-lying areas to zones communities of hydrocarbon [19].

Low frequency signals were noticed within this section which indicates of hydrocarbon accumulation , high frequency which indicate weak probability of hydrocarbon accumulation (Figure10) .the low frequency areas may be reflect an isolated rudist reef mound that act stratigraphic trap .

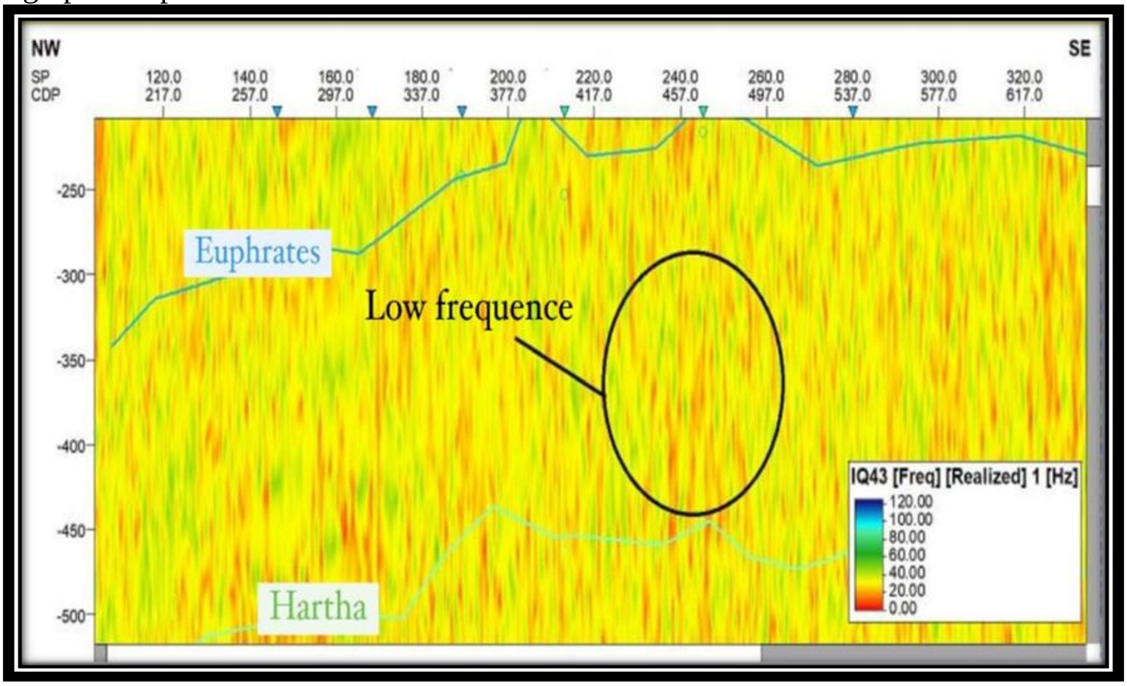

Figure 10-Instantaneous frequency (line IQ-43)

Instantaneous phase

Change in instantaneous phase means change in lithology or/and in the form of fluid material. Figure 11 shows a part of the QJ-43 is a part of seismic line QJ-43 shows transegrressive system observed in study area, which is probably the area of hydrocarbon reservoirs. This figure shows many seismic phase features. An example is the discontinuity in the Hartha reflection, indicating the presence of a discontinuous surface, which marked the end of the transgression depositional cycle.

Mound shape, flat spot, and polarity reversals can be noticed, which are related to the lateral change

in lithology, confirming the presence of the reef build-up in the region to the left part of the section.

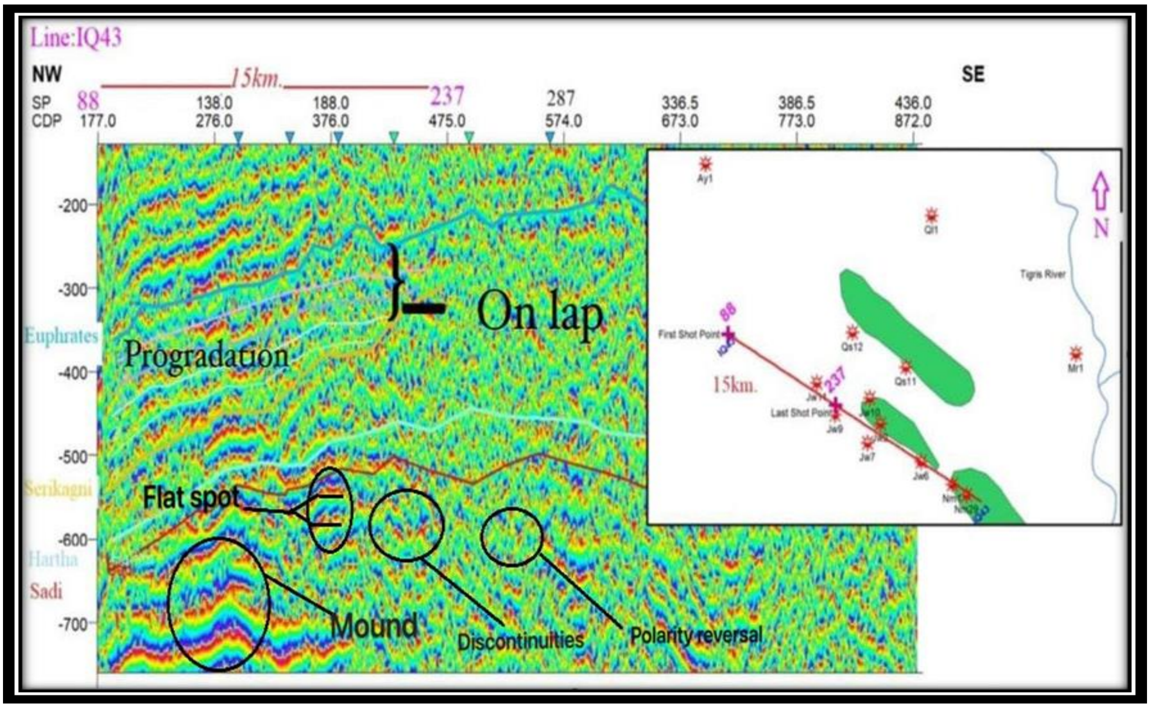

Figure11-Instantaneous phase of seismic (line IQ-43)

Conclusions

The upper Cretaceous-Teriary is interpreted as three depositional sequences, the base of which is a low stand system tract and the top represents high system tracts and transgressive system tracts. Seismic attributes, such as the instantaneous phase, showed stratigraphic features, such as mound and flat spot, suggesting accumulations of hydrocarbons. Instant frequency showed low values in hydrocarbon accumulation areas. Instantaneous amplitude showed low values in the hydrocarbon reservoir area. In light of the results of our study, we suggest the drilling of evaluation wells in the discovered reservoirs within the Tertiary and Cretaceous periods.

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