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Delineation of a Subsurface Stratigraphic Setting Using 2D Seismic Data in Buzurgan and Abu Gharp Oil Fields, South Iraq

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Abstract

This study focused on determining the stratigraphic phenomena of the sequences of the Kirkuk group, within the Tertiary age, in the study area at the Buzurgan oil field within the Maysan governorate. In addition to various seismic lines from the completed seismic survey of the study region, data from the Buzurgan oil field wells was utilized. The stratigraphic interpretation results showed that the seismic sections of the Kirkuk Group formations are deposited in the form of a sigmoid configuration through the continuous deposition of shallow-shelf carbonates. Periodic rises in sea level led to episodes of deeper-water sedimentation, including shelf and shelf margin facies. Clastic (sandstone) was deposited as the sea receded from the Ghar formation, which represents the alluvial fan in the outer-shelf basin (slop and basin fan), through periods of sea-level (LST) and in a shallow-marine environment, leading to an overlap between sediments and the presence of sand lenses, onlap, and down lap. The current study shows the phase change in reflectors and perfect hydrocarbon indexes. The study detected a stratigraphic trap in the formation's eastern part and a large lens in the Southeast parts of the study area.

Keywords: stratigraphic interpretation; Kirkuk group; Buzurgan oil field; southern Iraq, Seismic attributes.

تحديد الضواهر الطباقية التحت سطحيه باستخدام البيات الزلزالية ثنائيه الابعاد في حقول بزركان وابو غرب جنوب العراق

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الخلاصة

ركزت هذه الدراسه على تحديد الظواهر الطباقيه لتتابعات مجموعه كركوك، ضمن عمر العصر الثلاثي، لمنطقة الدراسة في حقل بزركان النفطي ضمن محافظة ميسان. تم استخدام بيانات ابار حقل بزركان النفطي اضافه الى عدد من الخطوط الزلزالية من المسوحات الزلزالية الذي تم تنفيذه لمنطقة الدراسه. تم استخدام عدد من المقاطع الزلزالية خلال المنطقة لبيان وتفسير الضواهر الطباقيه. تم تحديد وتفسير المصائد الطباقية وهي من نوع تقدم بحري بالاضافه الى وجود عدد من العدسات الرملية. تم تحديد منطقة التجهيز الرسوبي لرمال

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مجموعة كركوك. تم استخدام تقنيه التوابع الزلزالية والتي اثبتت الصفات المكمنية العالمية لمنطقة الدراسه والمساعدة في تفسير الضواهر الطباقية خصوصا ضاهره العدسات الرملية وضواهرالمصائد الطباقية من نوع البنج اوت وغيرها.

Introduction

Sequencing stratigraphy concepts have been published since 1977 by Exxon in the American Society for Petroleum Geology and, since the 1970s, have become an intrinsic part of sedimentary geology. Sequencing stratigraphy is defined as the study of the relationship of rocks in terms of the temporal stratigraphy of layers with a single inherent relationship that determines the surfaces of erosion or non-sedimentation [1]. The Kirkuk field dominates the Tertiary play system, and any field will likely be able to reach this in the future. However, considerable potential still exists within the Tertiary succession. Additional fields may still be found producing from platform-margin carbonates. The majority of these reservoirs are located at depths of under 2 km. The Mesopotamian basin is about 350 km southeast of Baghdad and approximately 175 km to the north-northeast of Basra. It includes three main production oilfields: Buzurgan, Fauqi and Abu Ghirab [2].

Tertiary reservoirs account for 23.9 % of the petroleum resources in the southern part of the Mesopotamian Basin [3]. Several previous geological, structural and stratigraphic studies have been conducted on the oilfields in the study area by the Iraqi Oil Exploration Company and other researchers [4] & [5] & [6]. All these studies contributed to understanding the structural and stratigraphic geological situation and identifying reservoir characteristics of the fields of this region and the surrounding regions. The research aims to study the rocks of the Tertiary Period in the southeastern part of Iraq and to determine the lateral and vertical stratigraphic and sedimentary extensions of the Fatha, U-Kirkuk, Jaddala, and Aaliji Formations.

Location of the study area

The study area is located in the southeast of Iraq within the Maysan Governorate. as shown in Figure 1.

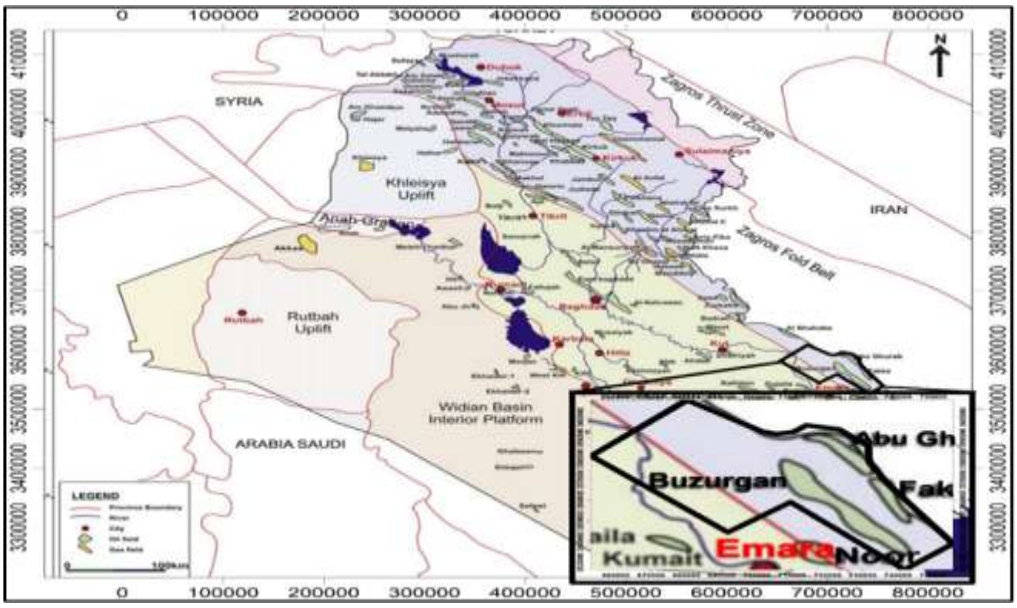

Figure 1: location map of the study area [7]

Stratigraphic and Geological setting of the study area

The deposition of the Kirkuk Group formation in the Mesopotamian Zone in Iraq became asymmetrical and formed a complex reef system. The main Oligocene basin in Iraq trends

NW-SE and contains 150-350 m of sediments [2]. The Kirkuk Group (Maysan) was deposited in the fore-reef and basin of the southwestern margin of the Oligocene basin (Figure 4), a mixture of carbonate and clastic sediments through periods of the sea-level low stand. Deposition showed lateral differentiation of Carbonate narrow shelves that developed along the margin of the basin. The clastic (sandstone) sedimentation included within the Kirkuk Group has been identified by wells in southeastern Iraq, which is related to the Ghar formation during the Oligocene age, and unconformity occurs along the Zagros basin margin [8]. The study area is located in southeastern Iraq within Maysan Governorate; the site is generally flat and gradually rising towards the northeast. The elevations in the study area range between several meters in most parts of it and between 100 meters in the far east of the study area. The area covers modern clay, alluvial, and fluvial sand sediments, and marsh deposits, mostly with river water bodies and marshes, while the far northeast of the region is covered by Bai Hassan and Muqdadiya sediments (Pleistocene and Upper Miocene), as shown in (Figure 2). The study area, according to the tectonic map [9] located within an unstable shelf, where part of it (the northeastern part) is situated in the low folded zone of (the Hemrin belt) and the other part (most parts of the study area) within the Mesopotamian (Tikrit- Amara belt) (Figure 3)

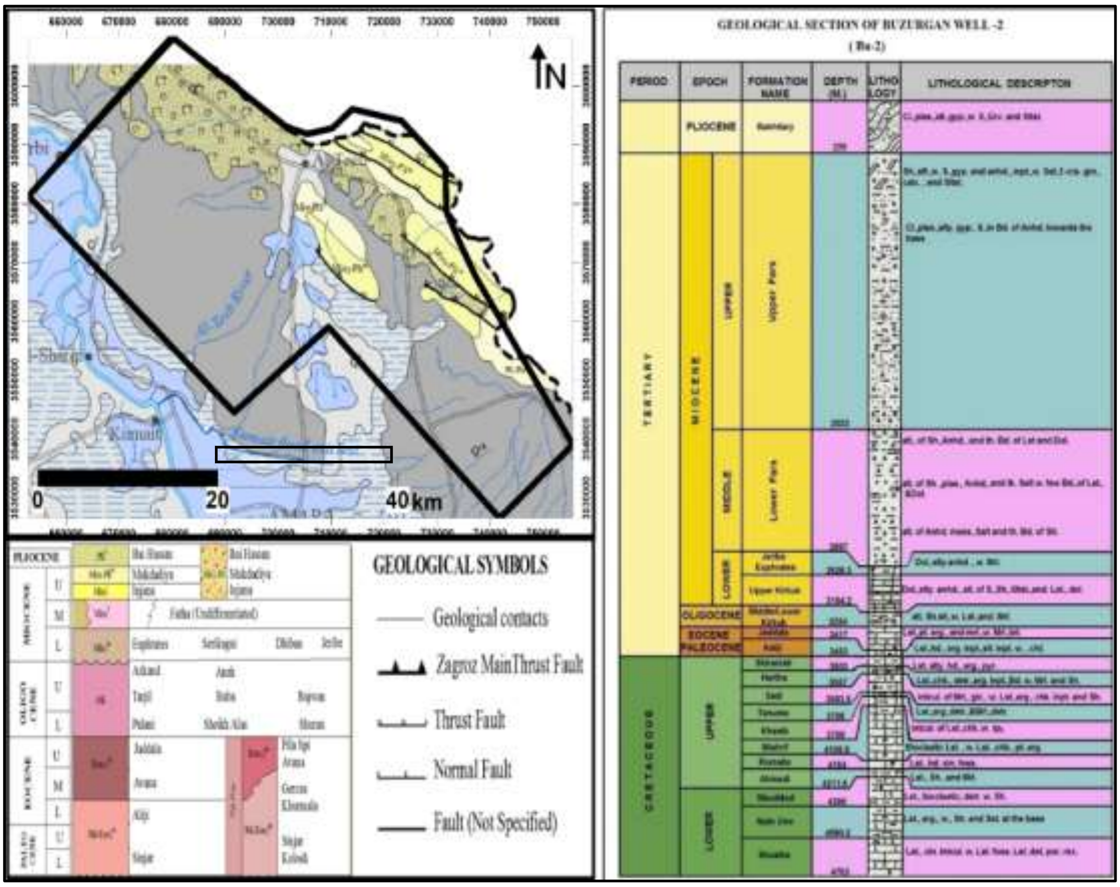

Figure 2: Rock sequence of the Tertiary period of the BU-2 well

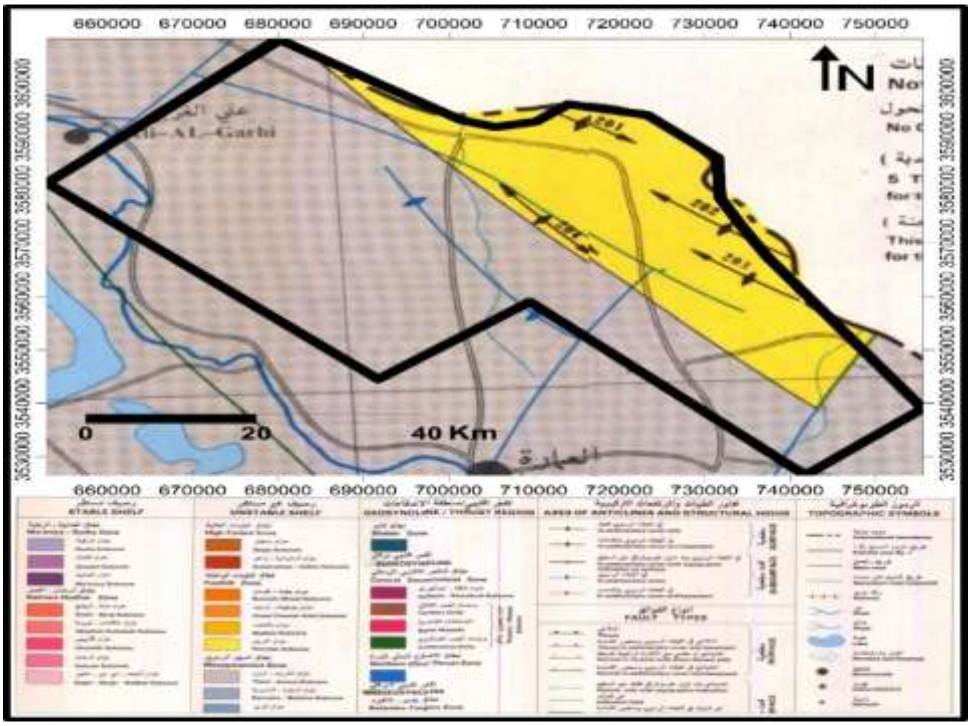

Figure 3: tectonic features in study area [9]

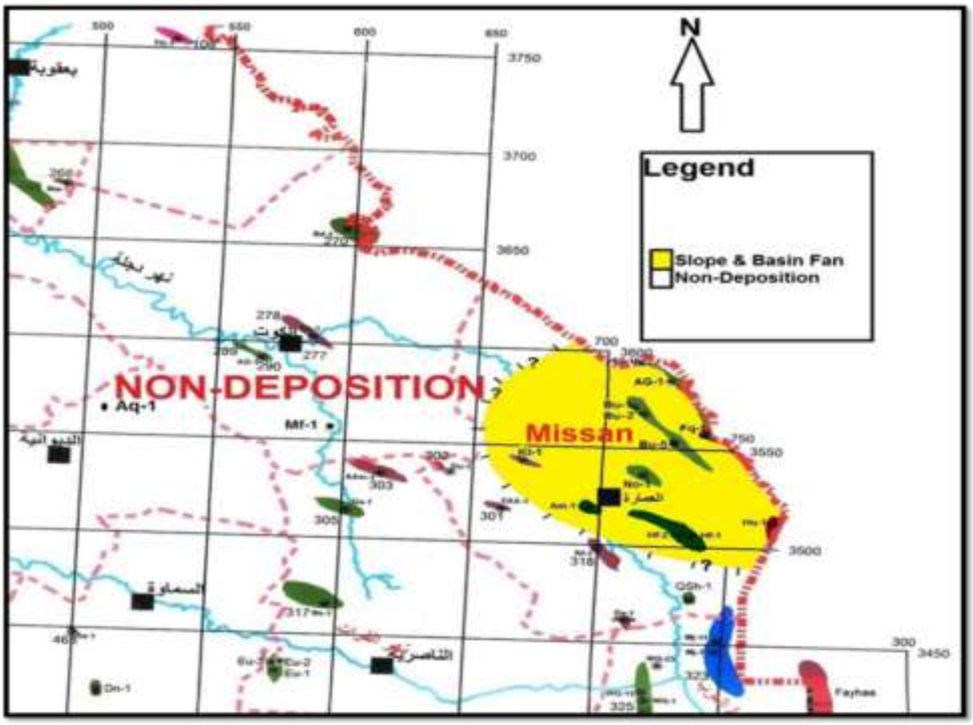

Figure 4 : The distribution of the sandstone of the Kirkuk Group and the facies (sandstone) [10].

Materials and Methods

After completing the synthetic seismogram procedure, reflectors represent the L-Fars, U-Kirkuk, Jaddala, and Aalijii Formations were selected. The synthetic seismogram has been developed for Bu1 and Bu2 wells. The study area consists of (662) seismic 2D lines named (B, WB, and BR). The Buzurgan oil field includes 11 oil wells, but wells 1 and 2 were relied upon in creating the synthetic seismogram and definition of the reflectors. Three software are used to complete this study, which are GeoFrame, petrel, and surfer11. These interactive workstations available in OEC are utilized to create the interpretation. The reflectors representing the top L-Fars, U-Kirkuk, Jaddala, and Aaliji Formations are built or depicted using these applications for seismic interpretation. This application has several icons, and each one stands out for reasons unique from the rest. Used to build a grid (surface appears as contour interval lines) by converting velocity to depth. According to the function, Average velocity = [depth / (1-way time)], the velocity model was created. Created time contour map by the two-way grid time data imported from geoFrame workstation and made depth contour map by multiplying the grid two-way time maps by the average velocity map via surfer11 software. The serfer11 program created the base map (Figure 5) by downloading the coordinates of the two-dimensional seismic lines of the seismic surveys that cover the study area, which are the Buzurgan (B) Survey, the Ali Al-Ghrbi (BR) Survey, and the Western Buzurgan (WB) Survey. The materials and methods of work included some steps, including building synthetic models and making sections from which evidence of the structural state is extracted. A number of the following steps will be clarified to show the selection of seismic areas that are useful in determining stratigraphic phenomena.

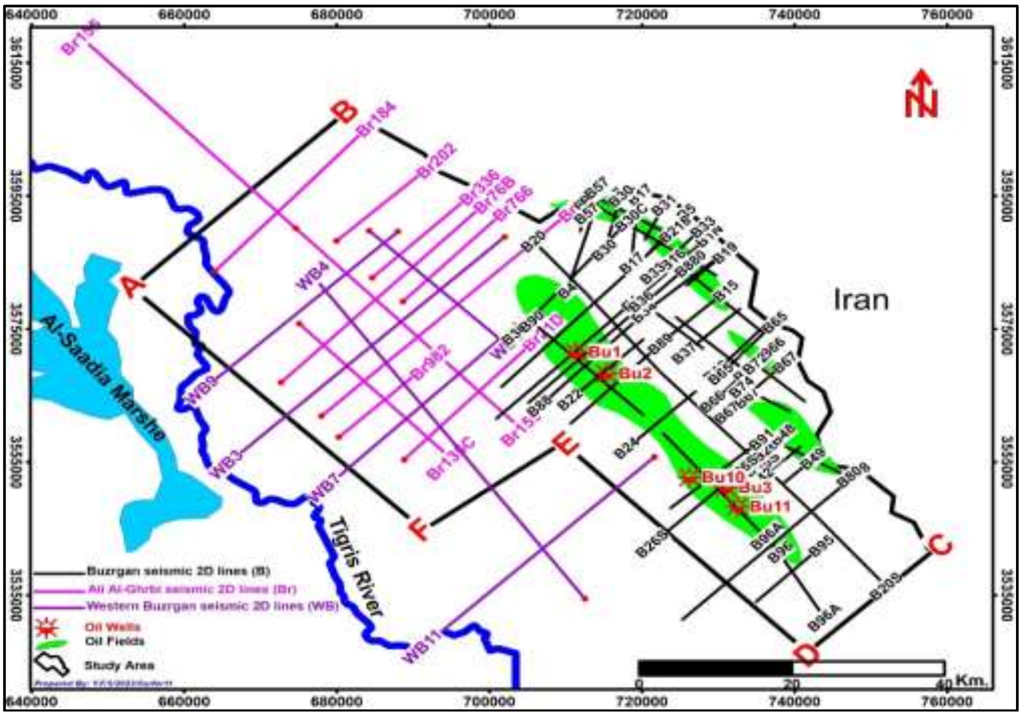

Figure 5: The base map for seismic lines of the studied area

Seismic Stratigraphic Interpretation and Results

Seismic Reflection Configuration

Seismic stratigraphy makes an effort to analyze seismic data using geological knowledge to understand the depositional settings better. Understanding the many sorts of traps, how hydrocarbons build up, and how migration systems work is all part of this. The configuration of reflections provides the best guide to interpreting the seismic carbonate facies. The Kirkuk Group reflector has a high to moderate amplitude and high continuity. Reflection configurations of (upper and lower) reflectors indicate a wide, relatively uniform lateral extent in a sedimentary basin. Depositional angles in a sigmoid progradation design are typically smaller (less than 1°). As the strata terminate or become too thin to be discernible on seismic lines, the lower (bottom set) strata segments approach the lower surface of the facies unit at shallow angles, and the seismic reflections reveal actual or apparent down-lap terminations.

This conjecture suggests relatively little sediment supply and a quick rise in sea level to allow for the deposition and preservation of the top set units. The sedimentary regime is interpreted as having a low energy level. The bottom set portions frequently match source rocks (Figures 6 and 7).

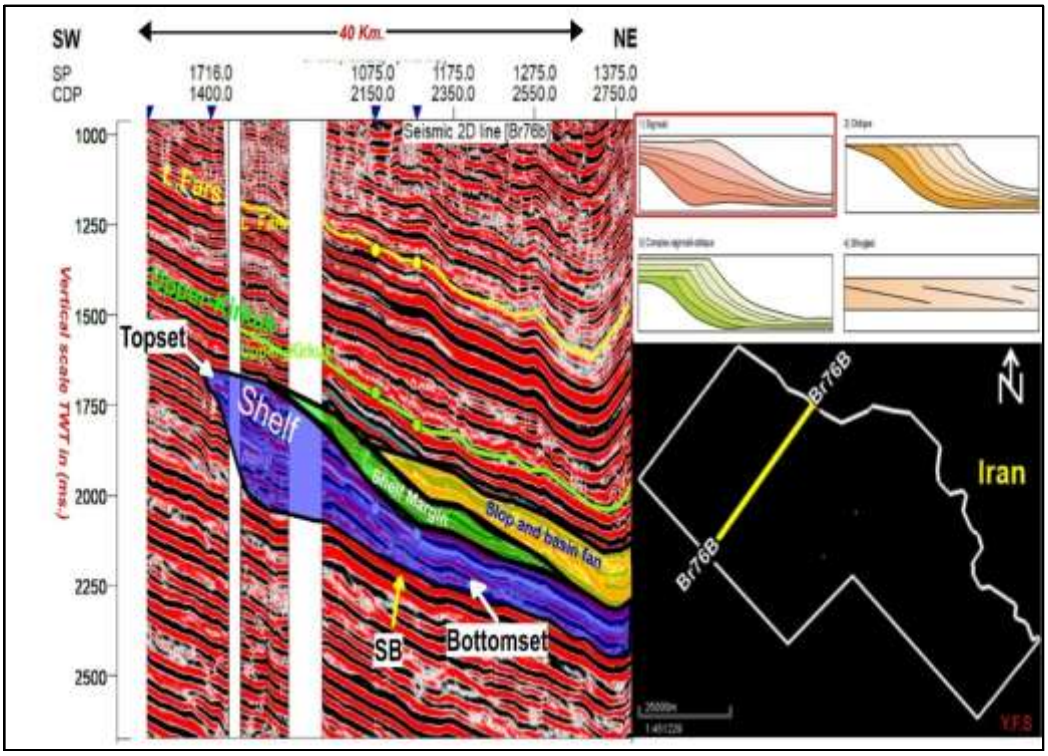

Figure 6: The sigmoid model Configuration in the Kirkuk Group formation in the seismic section Br76B

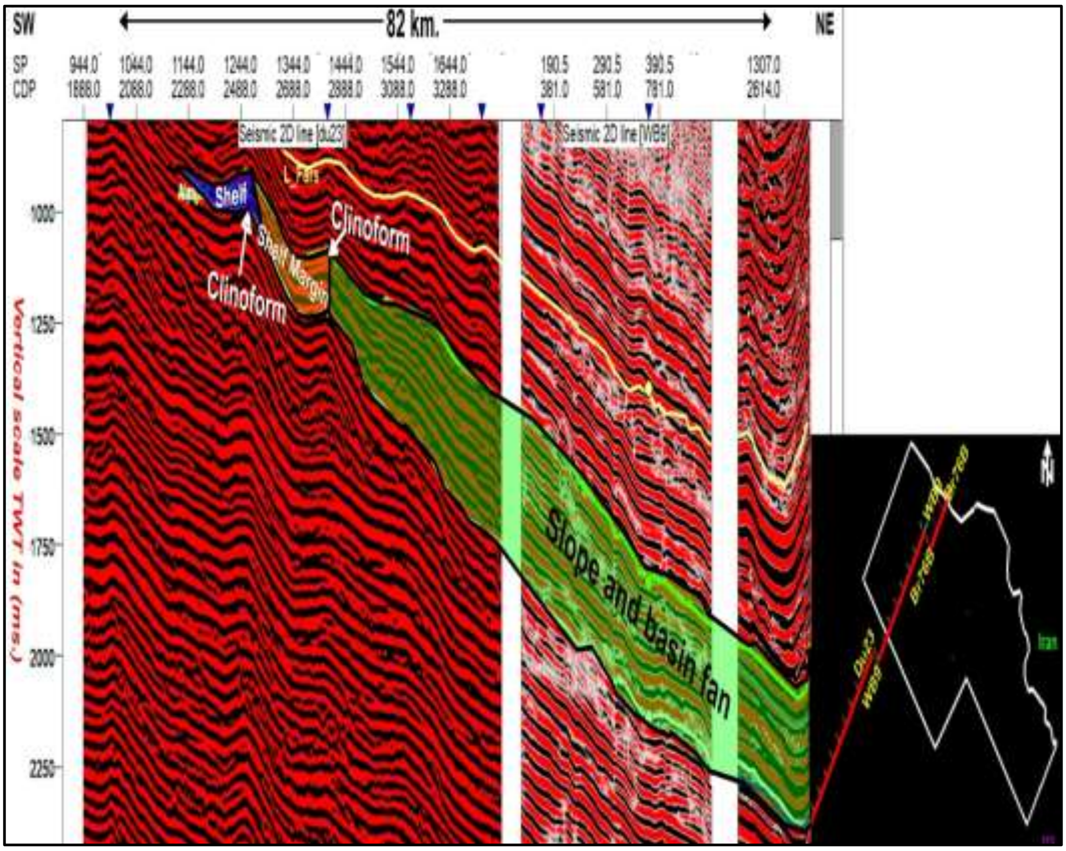

Figure 7: Composite section of the two lines (Du23 and WB9) showing the sandstone sediments represented by the basin fan and slope.

Geological Model

The stratigraphic geological model is a broad overview of a specific depositional system, including numerous instances of recent sediments and ancient rocks. Sedimentary processes in particular regions of the depositional settings regulate the formation of facies. Therefore, observing facies aids in understanding syn-depositional processes. Recreating paleo-depositional environments requires an understanding of facies connections. Such reconstructions, in turn, are crucial in understanding how to interpret the sequence of stratigraphic surfaces. The model makes the shape and development of a depositional environment predictable by assuming "typical" vertical profiles and lateral facies modifications. As shown in (Figure 8), it represents a geological model for the Kirkuk Group formation. It shows the presence of clastic sediments in slope and basin fans and through periods of sea-level low-stand systems tract (LST). It comprises stacked fining-upward cycles of alluvial-fan sandstone in a shallow-marine environment.

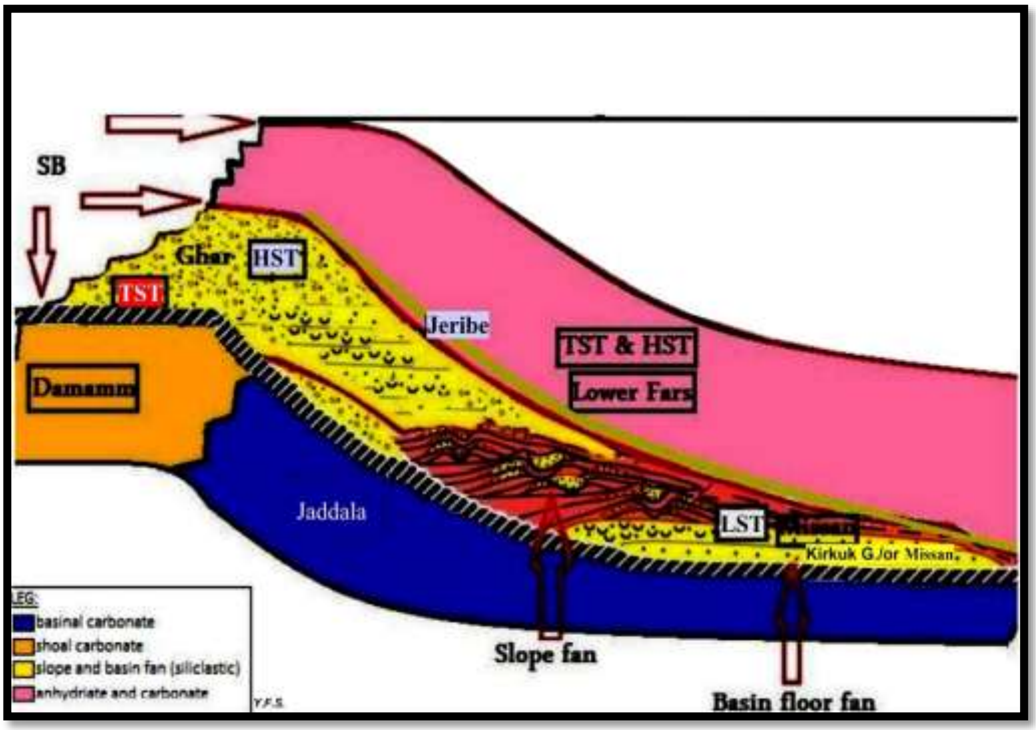

Figure 8: A geological model represents the Kirkuk Group or Missan Formation proposed by OEC

Seismic Attribute Interpretation

Seismic attribute techniques were applied to the 2D seismic data for the formation of the study area, including instantaneous phase and frequency attributes, which had been chosen as good indicators for hydrocarbon accumulations. The acoustic impedance indicates a lateral change in the porosity within the same reflector on the seismic sections.

Instantaneous phase

The instantaneous phase effectively indicates faults, pinch-outs, bed interfaces, sequence boundaries, and on-lap pattern regions. The Cosine of the instantaneous phase is generally used due to the amplitude-invariant nature of the attribute. The 2D seismic data phase attribute view was used for the seismic signal in the time domain to explain the lateral variations in lithology and the fluid content type of phase for Kirkuk Group reflectors, as presented in (Figure 9). The phase shows the event's continuity and discontinuity and evident bedding, the strongest indicator of lateral continuity and a helpful tool for identifying sequence boundaries. The phase represents a change in the petrophysical properties in lateral distribution due to deposition conditions; this phenomenon is called pinch-out. The phenomenon of pinch-outs has also been identified in the lower layers of the L.Fars Formation (Figure 9). Sand-covered layers frequently pinch out to form bodies that resemble lenses. Oil and natural gas can move into the lenses of sand and will be trapped by the impermeable rocks if the rocks surrounding them are impermeable and deformation has generated inclined strata. This kind of trap demands subterranean investigation tools and is challenging to find from the surface. (Figure 10).

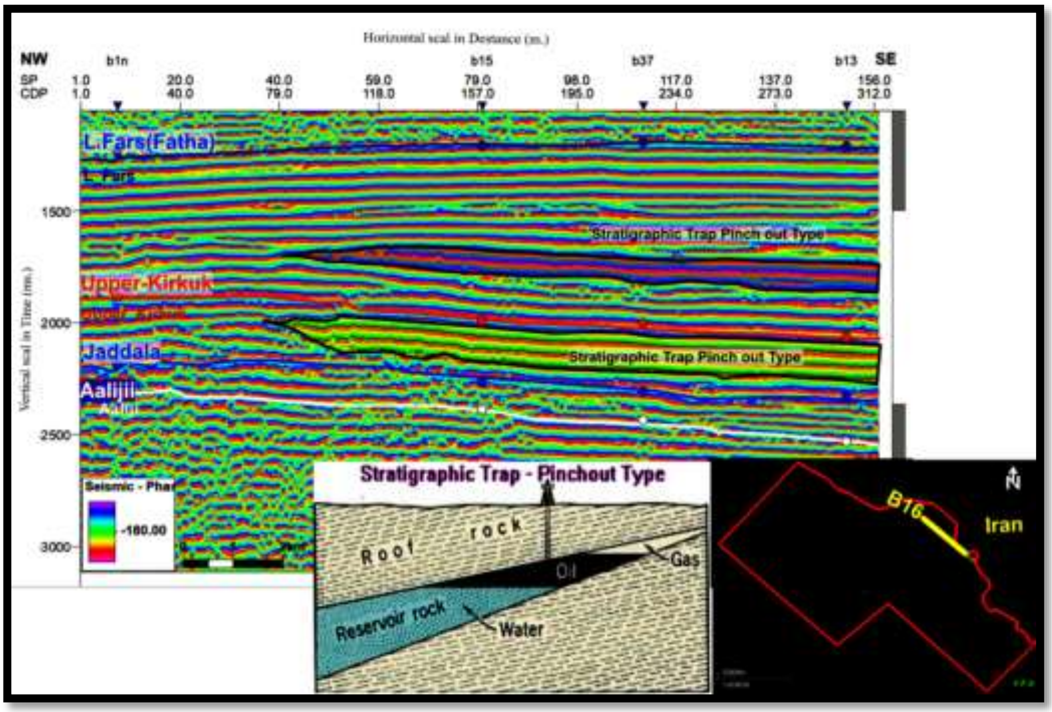

Figure 9: The instantaneous phase of the seismic line B16 illustrates Stratigraphic Trap Pinch out Type

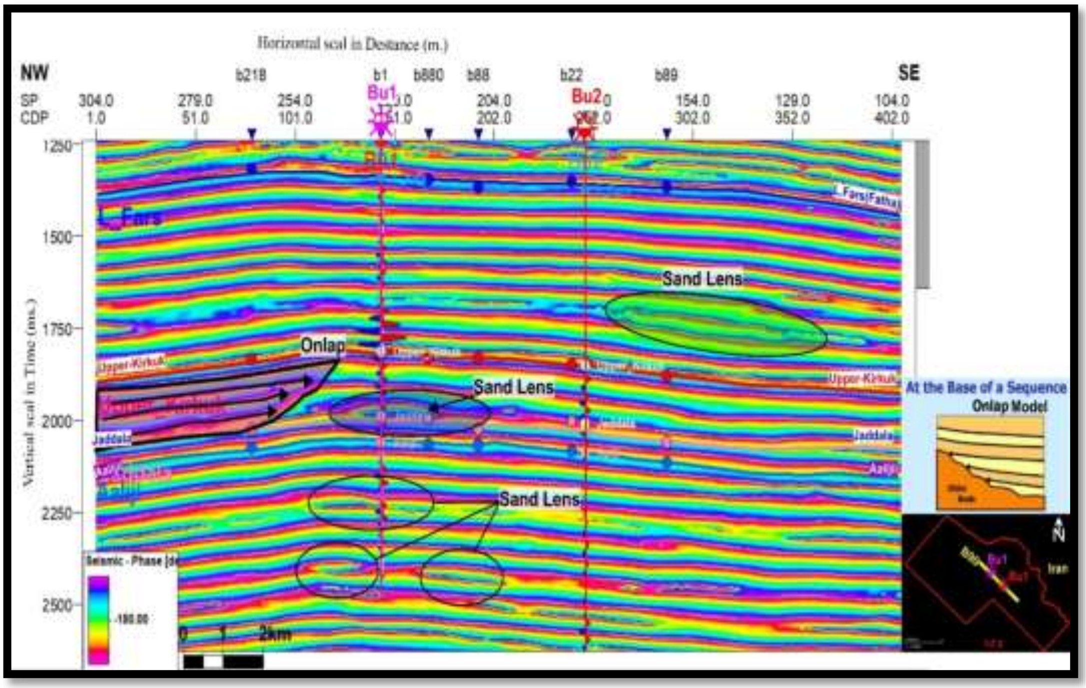

Figure 10: The instantaneous phase of the seismic line B90 illustrates Onlap and sand lens.

Instantaneous Frequency

This attribute helps geological intervals cyclicity, and it can be helpful for cross-correlating across faults. The time derivative of phase, w=d(phase)/dt. The time derivative of instantaneous frequency is often referred to as 'Phase Acceleration'. It is calculated using the instantaneous phases' temporal rate of change. (Its a time derivative). Instantaneous Frequency is not the same as, and not to be mistaken with the wavelet's frequency. It is frequently employed to compute seismic attenuation. High-frequency components typically decrease near oil and gas deposits. It can be helpful for cross-correlation across faults and determining the cyclicity of geological intervals. Additionally, it may spot any gas-water or gas-oil connections. In the presence of noise, instantaneous frequency is frequently variable and occasionally challenging to discern. The seismic data in the time domain is converted to frequency seismic attributes. The findings of applying attribute assistance to pinpoint site alterations' instantaneous frequency and connection to petrophysical quality changes are related to how frequently low-lying places are home to hydrocarbon-rich zone populations. (Figures 11,12,13) depict a progradation pattern; a similarity between the low-frequency region and carbonate buildup, which symbolizes hydrocarbon accumulation, is also apparent.

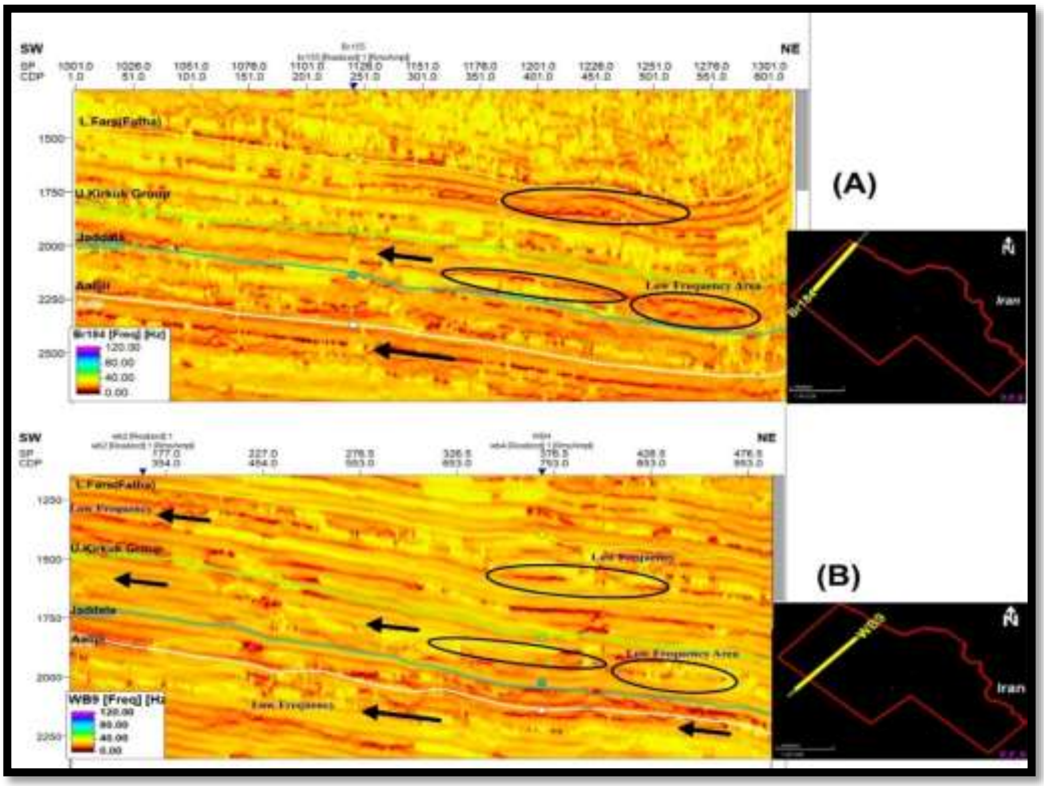

Figure 11: The Instantaneous frequency attribute on the 2D seismic section of the study area for seismic lines A-(Br184), B-(WB9).

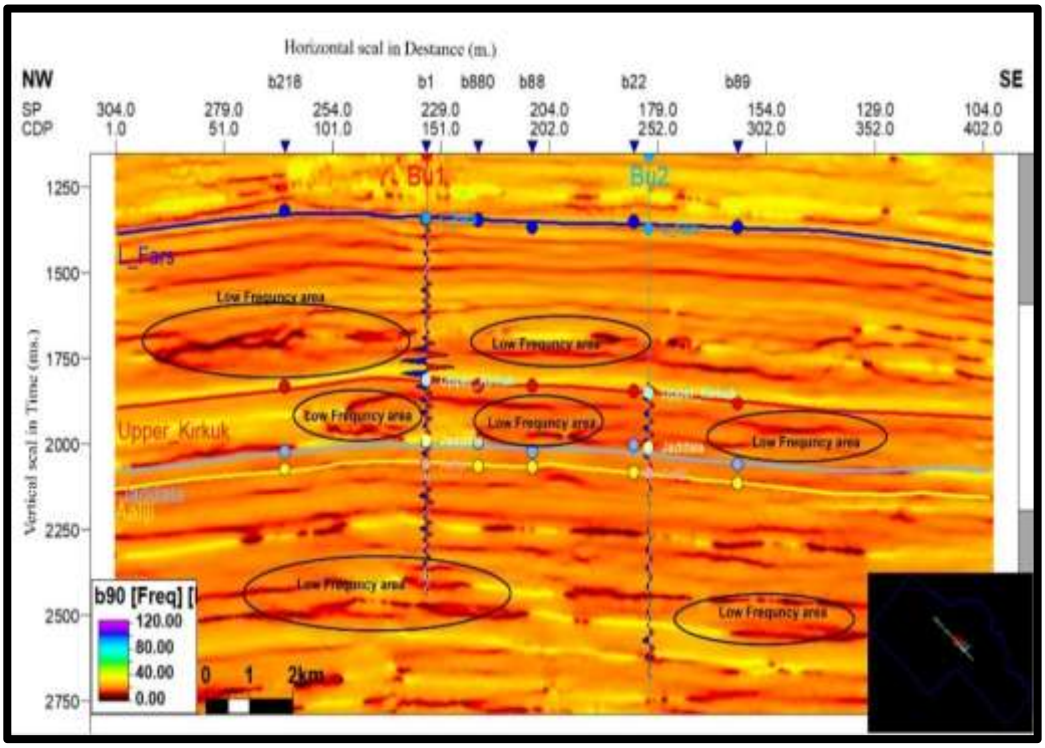

Figure 12: The Instantaneous frequency attribute on the 2D seismic section of the study area for seismic lines (B90).

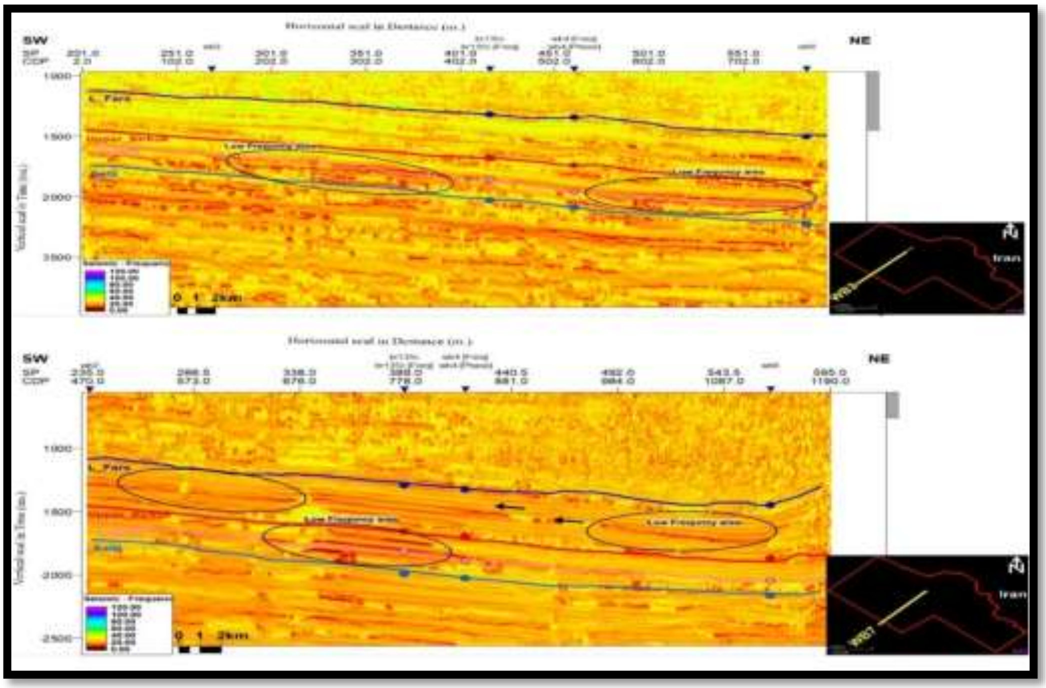

Figure 13: The Instantaneous frequency attribute on the 2D seismic section of the study area for seismic lines (WB3), (WB7).

Conclusion

The stratigraphic interpretation concluded that shallow-shelf carbonate accretion is still taking place while the seismic sections of the Kirkuk Group formation are being deposited in the shape of a sigmoid configuration. Epochs of deeper-water sedimentation were caused by periodic sea level rise. They included shelf and shelf margin facies. Clastic (sandstone) was deposited as the sea receded from the Ghar formation, which represents the alluvial fan in the outer-shelf basin (slop and basin fan), through periods of sea-level (LST) and in a shallow-marine environment, leading to an overlap between sediments and the presence of sand lenses, onlap, and down lap. The current study shows the phase change in reflectors and perfect hydrocarbon indexes. The study detected a stratigraphic trap in the formation's eastern part and a large lens in the southeast.

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