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Subsurface Investigation of Tuba Oil Field Depending on 2D Seismic Reflection South Iraq

Salman Z. Khorshd, Dlal F. Almarsoomy*
Department of Geology, College of Science, University of Baghdad, Baghdad, Iraq

Abstract

This study deals with the seismic reflection interpretation of Cretaceous Formations in Tuba oil field, southern Iraq, including structural and stratigraphic techniques. The study achieved by using Geofram , Geolog and Petrel software. The interpretation process, of 2-D seismic data and well logs have been used. Based on well logs and synthetic traces two horizons were identified and picked which are the tops of Mishrif and Zubair Formations. These horizons were followed over all the area in order to obtain their structural setting. Structural interpretation indicates that the Tuba oil field is an anticline structure as well as the presence of normal fault near Mishrif Formation trending NE-SW. Information from the wells appeared Mishrif Formation deposited on shelf areas with no basinal sites, the nature of the Mishrif Formation in the study area deposits (MB1, MB2and MA) represents the highstand system tract (HST) shallow facies deposited in high-energy. Amplitude geometry of reflections within the reservoir units for Mishrif and Zubair Formations are moderate to high amplitude which is the presence of lateral variations in the geologic facies. Reflection continuity in Mishrif Formation (SF1) and (SF2) between parallel to subparallel which indicates some uniform in sediment, divergent reflection configuration (SF3) is found in Zubair Formation that indicates wedge shaped also, subparallel reflection configuration (SF4) in Zubair Formation has relatively uniform strata where delta depositions. Stratigraphic interpretation of seismic facies indicated that the Mishrif Formation represents progradational seismic facies (mounded), uniformity Mishrif indicated deposit in stable environment while Zubair Formation represents aggredation and progrodation seismic facies (shingled) that was deposited in delta environment.

Keywords: seismic structural interpretation, seismic stratigraphy

دراسه تحت سطحية لحقل طوبه جنوب العراق باستخدام المعلومات الزالزالية ثنائية الابعاد

سلمان زين العابدين خورشيد، دلال فالح المرسومي*
قسم علم الارض، كلية العلوم، جامعة بغداد، بغداد، العراق

الخلاصة

ان هذا البحث يتعلق بالتفاسير الزلزالية الانعكاسية التركيبية والطباقية لتكاوين االطباشيري لحقل طوبه النفطي، جنوب العراق. وقد انجزت هذه الدراسة باستخدام البرامج Geolog،Geofram و Petral. اذ تم التفسير باستخدام المعلومات الزلزالية ثنائية الابعاد وكذلك مجسات الابار. لقد تم تعريف عاكسي اعلى تكوين المشرف و الزبير من مجسات الابار والاثار المصنعة .ومن ثم متابعتهما على مستوى المنطقة وذلك لمعرفة الوضع التركيبي. التفسير التركيبي يبين وجود طية محدبة ووجود فالق اعتيادي عند مستوى تكوين المشرف باتجاه شمال شرق– جنوب غرب .اظهرت معلومات الابار أن تكوين المشرف ترسب في منطقة shelf، أن طبيعة رواسب تكوين المشرف في المنطقة (MB1,MB2,MA) ضمن نظام سطح البحر العالي المتمثل بأقصى طغيان بحري (HST) حيث الضحالة المناسبة والطاقة العالية. تم دراسة سعة العاكس للوحدات المكمنية لتكويني المشرف والزبير حيث كانت بين المتوسطة الى العالية وسبب هذا الاختلاف هو وجود

*Email:dlalfalh0@gmail.com

تغايرات سحنية جانبية. تم دراسة استمرارية العاكس SF1 و SF2 حيث كانت بين متوازية وشبه متوازية لتكوين المشرف ممايدل على الانتظامية اثناء الترسيب ,اما استمرارية عاكس الزبير (SF3) كانت من نوع (divergent) مما يدل على وجود وتد رملي ، كذلك اظهر الزبير(SF4) استمرارية من نوع شبه متوازية حيث الانتظامية اثناء الترسيب في بيئة دلتاوية. اما التفسير الطباقي فقد تم تحديد السحنات الزالزاليه في تكوين المشرف وهي سحنه تقدمية progradational من نوع (المقببه) تدل على ان تكوين المشرف ترسب في بيئات مستقره بينما تكوين الزبير تمثل بالسحنة الزالزالية progrodation and aggredation من نوع المتقدم (shingled) حيث كان ترسبه في بيئات دلتاوية.

Introduction

Seismic surveys had been used widely for different important fields in order to identify the geology of the layers [1].The Tuba oil field is one of the most oil field in the Mesopotamian basin, which is discovered in 1960. The main carbonates reservoir in Tuba is Mishrif Formation which forms about 65% of the rate of oil extraction, followed by the clastic of Zubair Formation as a production of oil [2].The main purpose of this paper is interpretation of the structural setting of Tuba oil field using the data of seismic 2D as well as the well logs.

Description of Study Area:

The study area is located at about (40 km) south west of Basra governorate, southern Iraq, between the Zubair oil field in the east and the Rumaila oil field in the west Figure-1. It occurs at (5km) from Zubair field, and (2km) from Rumaila oil field. Gravity survey was carried out in 1950 by Basra oil Company for most southern areas of Iraq including study area. In addition, magnetic survey carried out in 1974, by French Company (CGG). The results of interpretations of both survey showed that there are folds that have the same direction and hydrocarbon potential in other area of the southern Iraq. The first exploratory seismic reflection survey for Tuba oil field was carried out in 1960 which was conducted in Tuba area tying to other survey of Rumaila and Zubair, and according to the results of the survy Tu-1 well had been drilled and reached depth 3639.3m which penetrated Ratawi Formation in 1960. In 1977 deep seismic survey has been done in Tu-2 and Tu-3 wells which had been drilled between (1977-1978) according to results of interpretation.

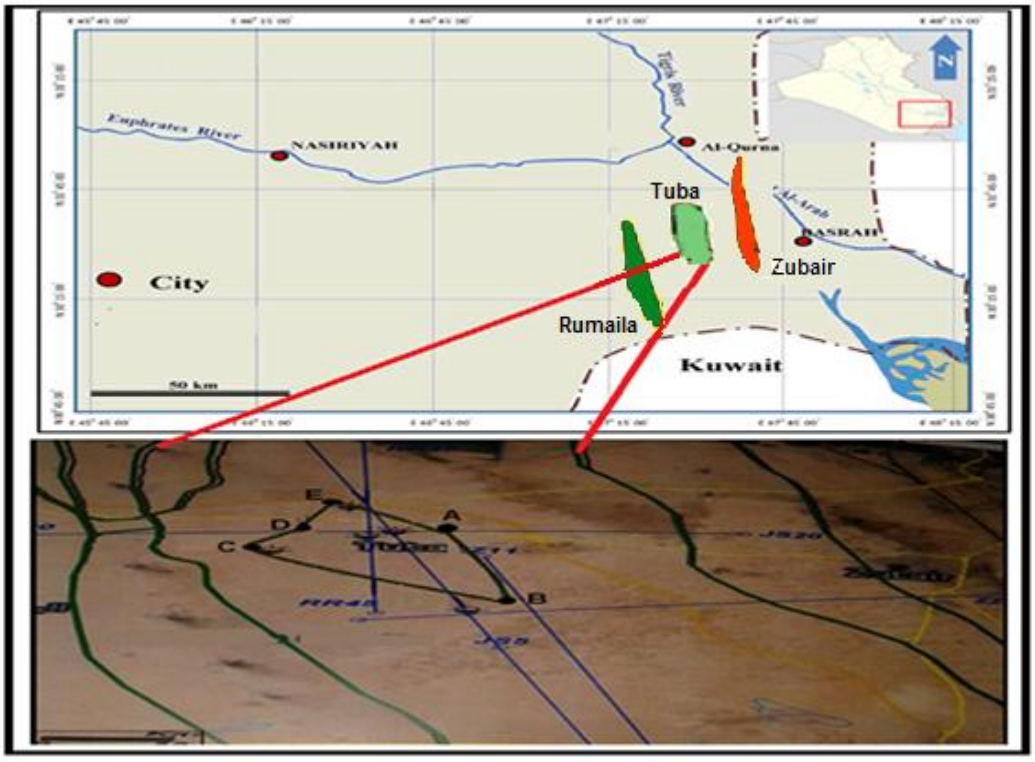


Figure 1- Shows location map of the study area (modified from the hydrocarbon potential map of Iraq [3]).

Geological Setting

Surface Geology:

The study area is flat and semi desert, gradually reduced in high toward the south direction to be at sea level, and the highest level is about (12m) above the sea level [3]. So it was located in unstable zone of Mesopotamian under Zubair subzone.

Subsurface Geology:

Tectonically the study area is located in unstable platform of Mesopotamian zone under Zubair subzone [4].The structural element of Tuba is an anticline with a flat dome area. The Tuba dome is asymmetrical anticline, with 1.27° of the eastern limb, while the western limb gives inclination of 0.9°.

Such a contradiction may be a clue for vertical movements [5]. Formations of Tuba oil field originated in the shallow sea that formed after a series of regression and transgression in seawater due to tectonic movements composed of several depositional cycles separated from each other by periods of non-depositional and erosional cycles. The results of water oscillation have been characterized by cyclic model of deposition and subsequently a number of unconformities (tectonic events and loads). The complex cyclicity controlled the pattern of vertical lithological alternation [6].Through the regional stratigraphic correlation, the effect of tectonic activities during the Cretaceous period reflected on the deposits as a three regional unconformity surfaces, with another one occurred during the late Aptian age [7].

Methodology

To achieve the aim of the study and updating the surface image of Mishrif and Zubair reservoir is to know the structural picture of the formations and reservoirs in the field and make a stratigraphic analysis of the sequences in the field, which is the main interested formation. The following steps were applied:

1. Determine the depth of each unit from well tie to seismic record or trace.
2. Create of the seismic section as well as seismic map also getting the velocity map and depth map, then interpretation of these maps structurally.
3. Make a stratigraphic analysis for the sequences in the field and correlating well logs in sections to illustrate the variation in reservoir thickness.
4. Analysis change of seismic facies in Mishrif and Zubair Formations.
5. Application of seismic attributes like amplitude, Cosine of Instantaneous Phase that disposed within the new software interpretation system (GeoFrame), to predict the hydrocarbon accumulations that may present in Mishrif and Zubair Formations.

Data Base

The base map of the study area is constructed using the processed seismic data which were loaded in the interactive workstation of interpretation in SEG-Y format. Two types of perpendicular lines are assigned which are termed strike lines and dip lines Figure-2. Acquired and processed by Iraqi National Exploration Company [8].

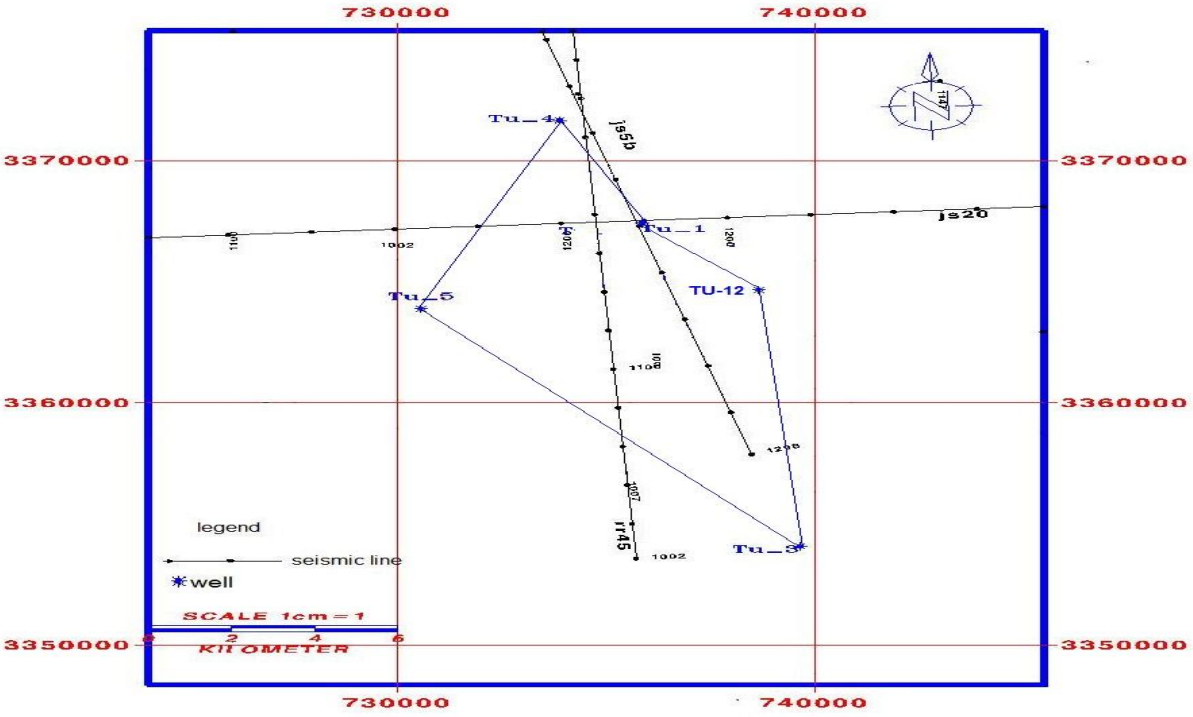


Figure 2- Base map of the study area.

Synthetic Seismogram

Synthetic seismogram studies have spanned many decades from the earlier days of 1-D modeling as described by [9] to the more recent descriptions of finite-difference anisotropic viscoelastic modeling as described [10]. By comparing marker beds or other correlation points picked on well logs with major reflections on the seismic section, Interpretations of the data can be improved. 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 .The acoustic log is generally calibrated with check-shot before combining with the density log to produce acoustic impedance. The synthetic seismograms for the Tuba-1well Figure-3 illustrates the strong reflection coefficients that were predicted for the top and base of the Mishrif and Zubair levels with weaker reflection coefficients at the Lowe Fars (Fatha) and top Gar levels. These should correspond to events on the seismic data. The embedded wavelet was estimated from the seismic over a window from 500 ms to 3000 ms and achieved an excellent tie.

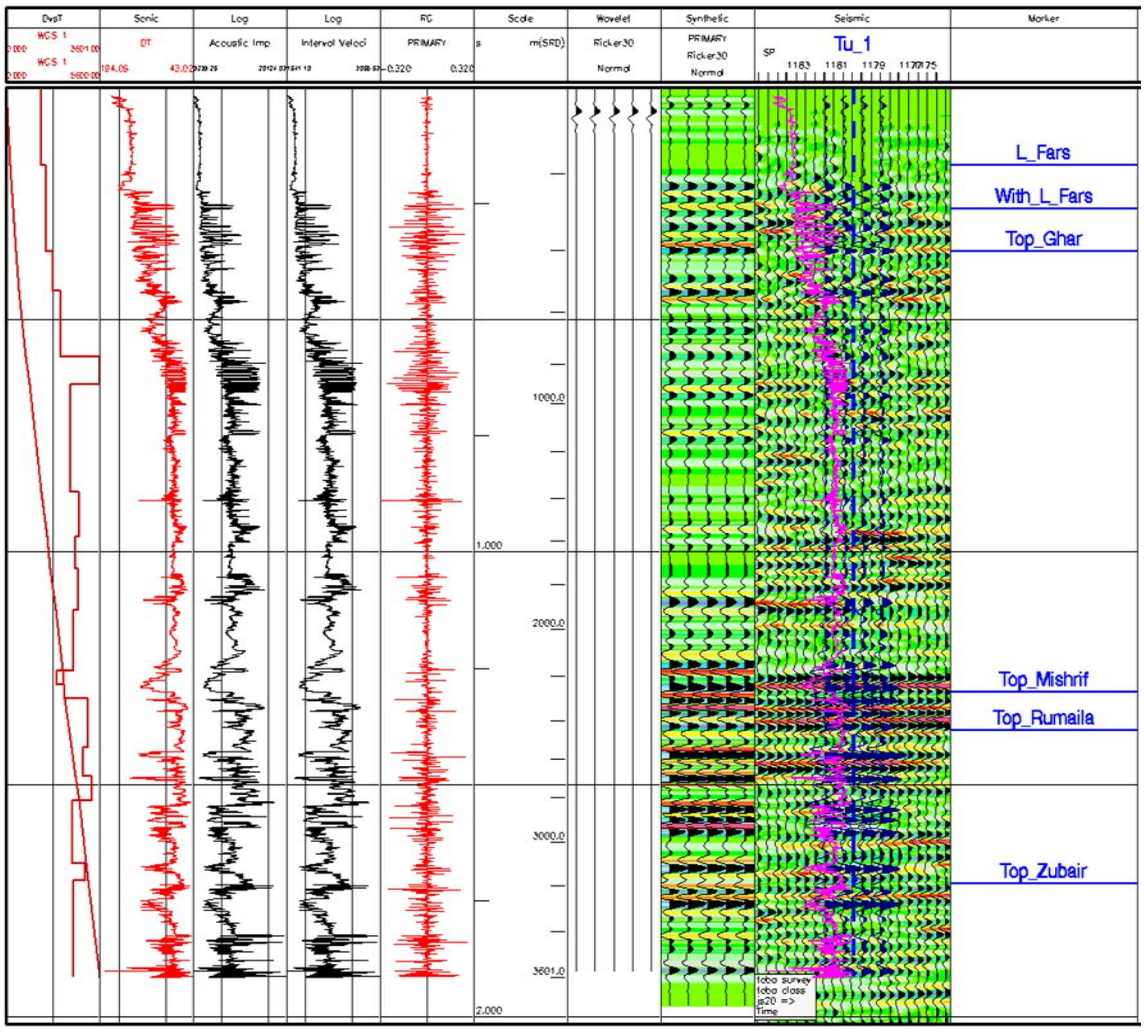


Figure 3- Shows synthetic seismogram of Tuba well-1

Data Interpretation

The primary aim of qualitative geophysical data interpretation in this study to map the geological setting qualitatively and estimating the best geological model, Geofram, Petral, Geolog are software used to interpreted seismic and well logs in the current study.

Structural Interpretation

The initial interpretation shows that the reflections are good for anticline structure Figure-4; it is gentle enough to be easily seen on a section where the reflections dip down both ways from a high point, it is form a good reservoir for accumulation of hydrocarbon.

The existence of fault at Mishrif Formation was a normal fault extended (NE-SW) direction, the fault were picked in all the area along each inline and cross lines. Each inline was used because it was parallel to the general dip direction of reflectors. Thus, the fault is more distinct along the inline sections.

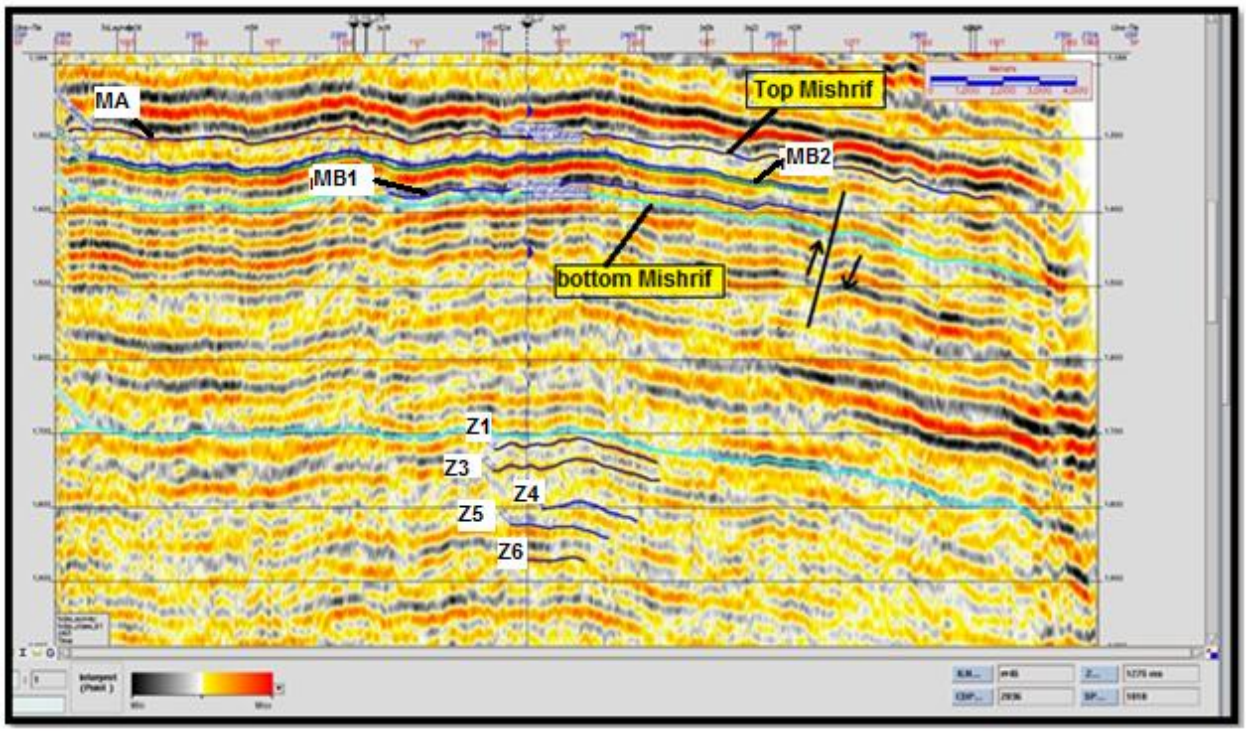


Figure 4 - Shows normal fault near Mishrif Formation line 5sb.

Sequence Stratigraphic Analysis of Mishrif Formation

The sequence stratigraphy depends on Eustatic sea level changes and tectonism primarily defined the sites of platform development that complicated the architectural heterogeneity of the depositional sequences [11]. Information from the wells showed that Mishrif Formation was deposit on shelf areas with no basinal sites included; low stand system tract (LST) deposits are not encountered and would be assigned as type 2 sequence boundary [12].

The nature of the Mishrif Formation in the study area carbonate deposited within the HST system (MB1, MB2) that the basin configuration, as well as sedimentary limestone systems point to subsidence, which led to increased thickness of MB. MA unit deposited through high stand system tract (HST) in open and restricted lagoon environment where sea level decline The Mishrif Formation is represented as Rudist and algal which indicates that they formed near the detached platform through HST where suitable shallow environment, high water energy, high organic activity, in combination leads to the formation of depositional patterns of a stratigraphic traps [13].

We were able to determine transgrassive systems tract (TST) through increased in density log function on the conditions of deepening upward. Gamma log indicators used for shallowing/deepening whereas high gamma is noticed by base level rises (termed as maximum flooding surface: MFS) [14] Figure-5.

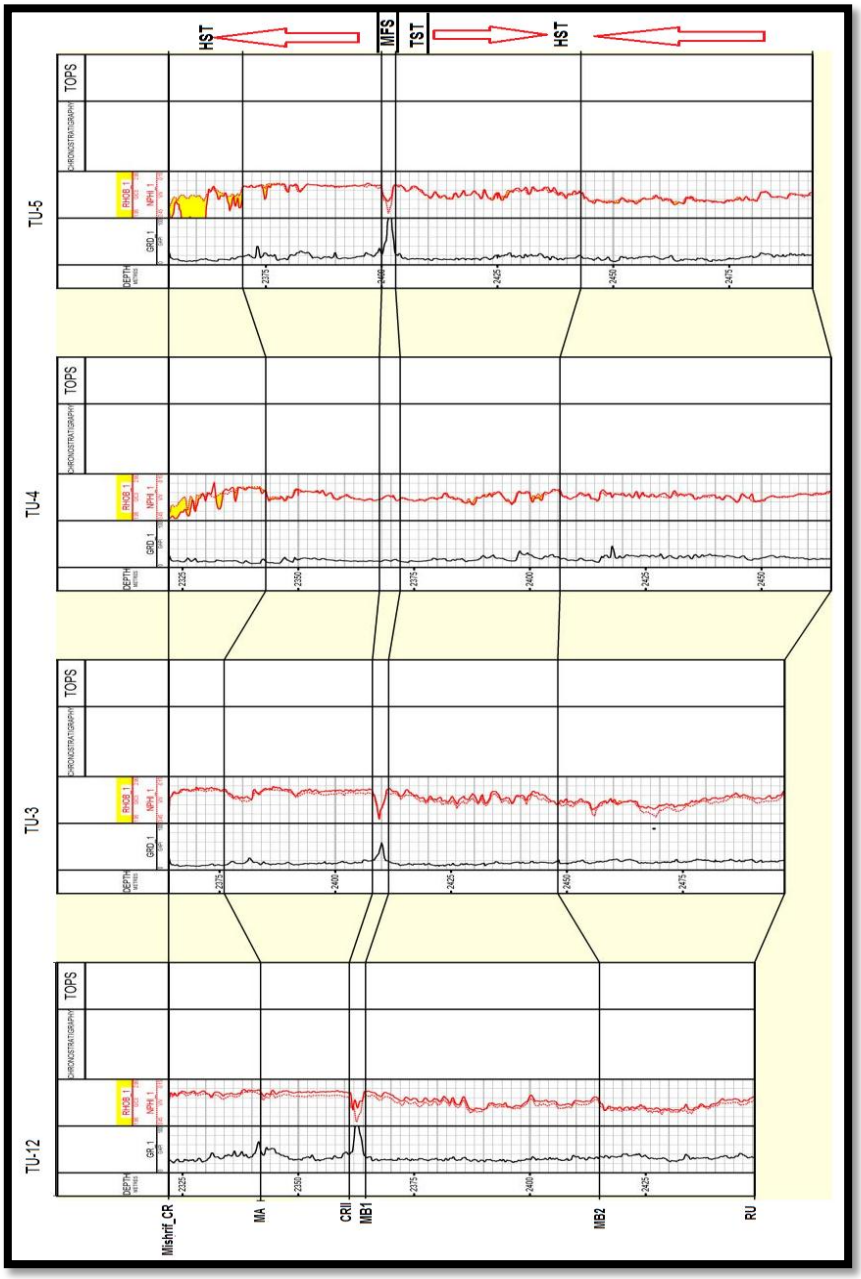


Figure 5- Shows systemic tract of Mishrif Formation and variation in reservoir thickness by using Geolog software.

Stratigraphic Interpretation Works

Basically, seismic stratigraphy can add important geological information and enhance the understanding of the depositional environments, which may help in the understanding the origin, accumulation, and trapping mechanisms of the hydrocarbon deposits [15]. For this reason, this interpretation technique in the actual study is used which includes the following:

Reflection Continuity and amplitude (geometry of reflections)

Seismic facies (SF) analysis is the description and interpretation of seismic reflection parameters, such as configuration, continuity, amplitude within the stratigraphic framework of a depositional sequence [16].The reflection continuity gives information on lateral continuity of strata (uniformity of deposition) while amplitude gives information on lithological variation [17]. Figure-6 shows amplitude variation within the reservoir units for Mishrif (MB1, MB2, MA) and Zubair (Z1, Z2, Z4, Z5, Z6) Formations the variation is moderate to high in amplitude. It may be the reason for this difference at the reservoir units that is the presence of lateral variations in the geologic facies. Parallel and Subparallel continuity appeared in Mishrif Formation (SF1), (SF2) indicated some uniform in sediment deposition. Divergent reflection configuration (SF3) in Zubair Formation indicates presence of wedge shaped sediment bodies. Sub parallel reflection configuration (SF4) in Zubair Formation and relatively uniform strata where delta deposited near the coast.

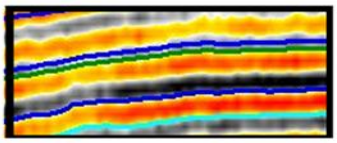
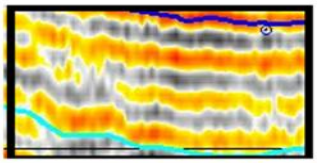
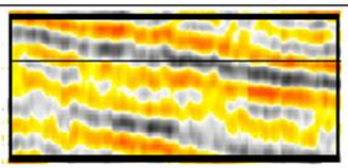
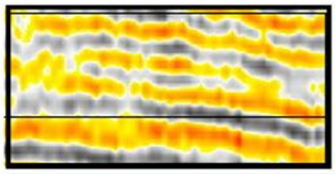
Seismic facies	Reflection continuity	Description continuity	Amplitude	Example (Vertical bars 100 ms)
SF1	Parallel	uniform sources and subsidence	High amplitude	
SF2	Sub parallel	uniform sources and subsidence	Medium amplitude	
SF3	Divergent	source and subsidence variation	High amplitude	
SF4	Sub parallel	uniform sources and subsidence	Medium amplitude	

Figure 6- Shows Reflection Continuity and Amplitude of Mishrif and Zubair Formation

Seismic Reflection Configuration and Terminations

Configuration of reflections provides the best guide to interpret seismic facies. Mishrif Formation deposition on a shallow-shelf carbonate platform, inner-shelf environments [18] .Progradational reflection configuration showed in Mshrif Formation sequences which offer the main potential for hydrocarbon generation and accumulation. The mounded configuration is obviously associated with reefal buildups Figure-7. Parallel reflections characterize some shallow-water shelf environments.

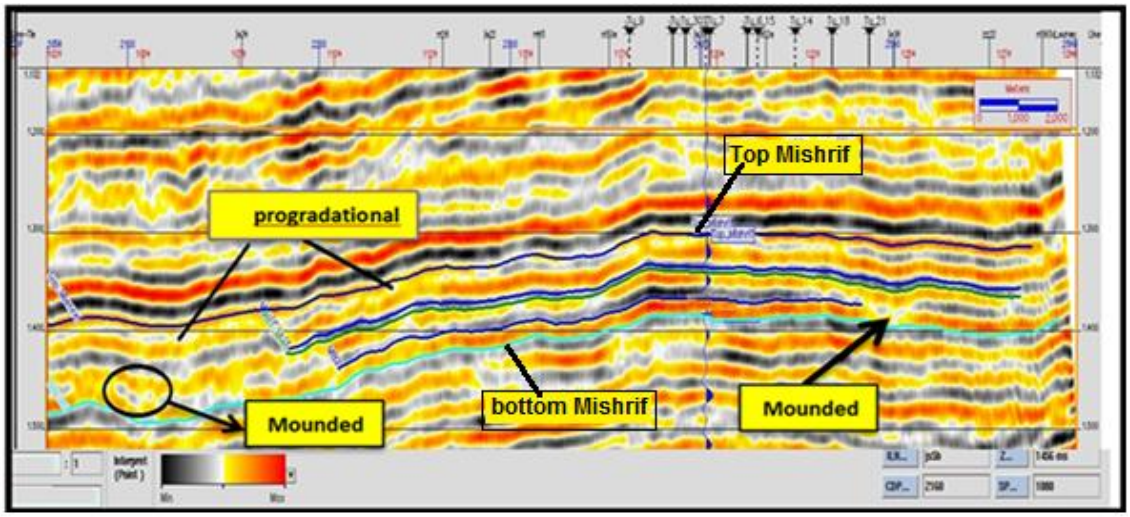


Figure 7- Shows Seismic section of the Mishrif progradation carbonate platform and mounded seismic reflection configuration line js20.

Zubair facies are deposited on delta platform consisting of shallow-water, high energy [19]. The interpretation of geometries from Zubair reflectors in seismic section depicts an aggradational phase represented by mounded geometry and progradtional phase represented by shingled and mounded geometries that prograde mainly to the west Figure-8. Shingled progradational reflection configuration is a thin prograding seismic pattern, commonly with parallel upper and lower boundaries, and with gently dipping parallel oblique internal reflectors that terminate by apparent toplap. Shingled reflection pattern associated sand wedge shaped feature is interpreted to have formed during the fairly slow, early, intermediate part of the relative rise of sea level [20].

Sands associated with channels often make good reservoirs for hydrocarbons. Mounded reflection configurations are interpreted as strata-forming elevations rising above the general level of the surrounding strata Figure-9.Most mounds in the clastic rocks (Zubair Formation) are deposited on slope or basins, while mound in the carbonate rocks (Mishrif Formation) are deposited in shelf plateform it's associated with reefal buildups.

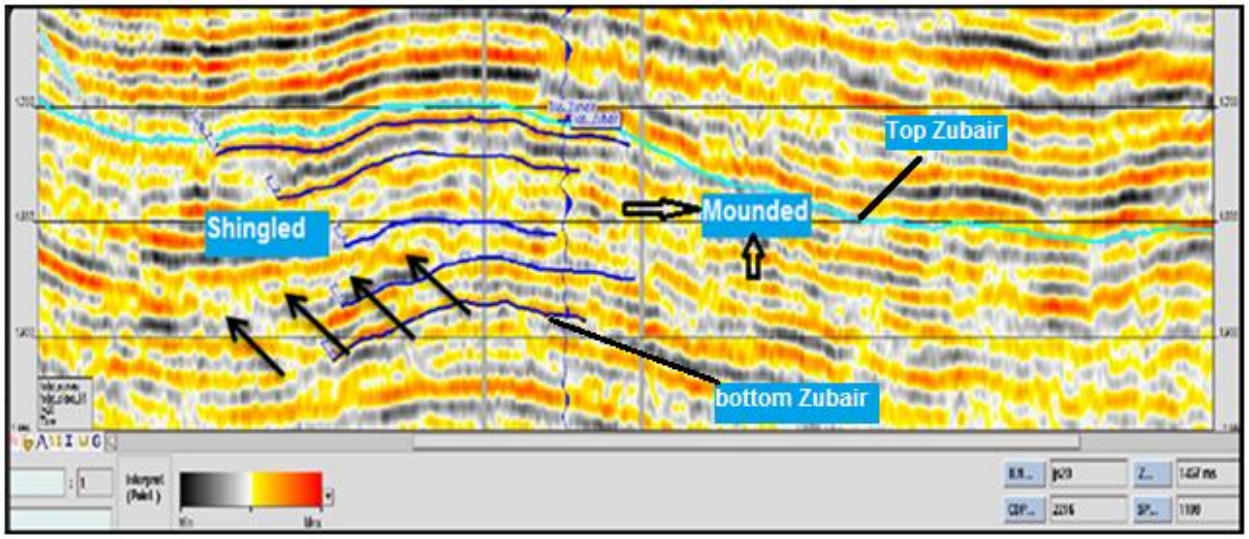


Figure 8- Seismic section showing shingled and mounded in Zubair Formation line js20.

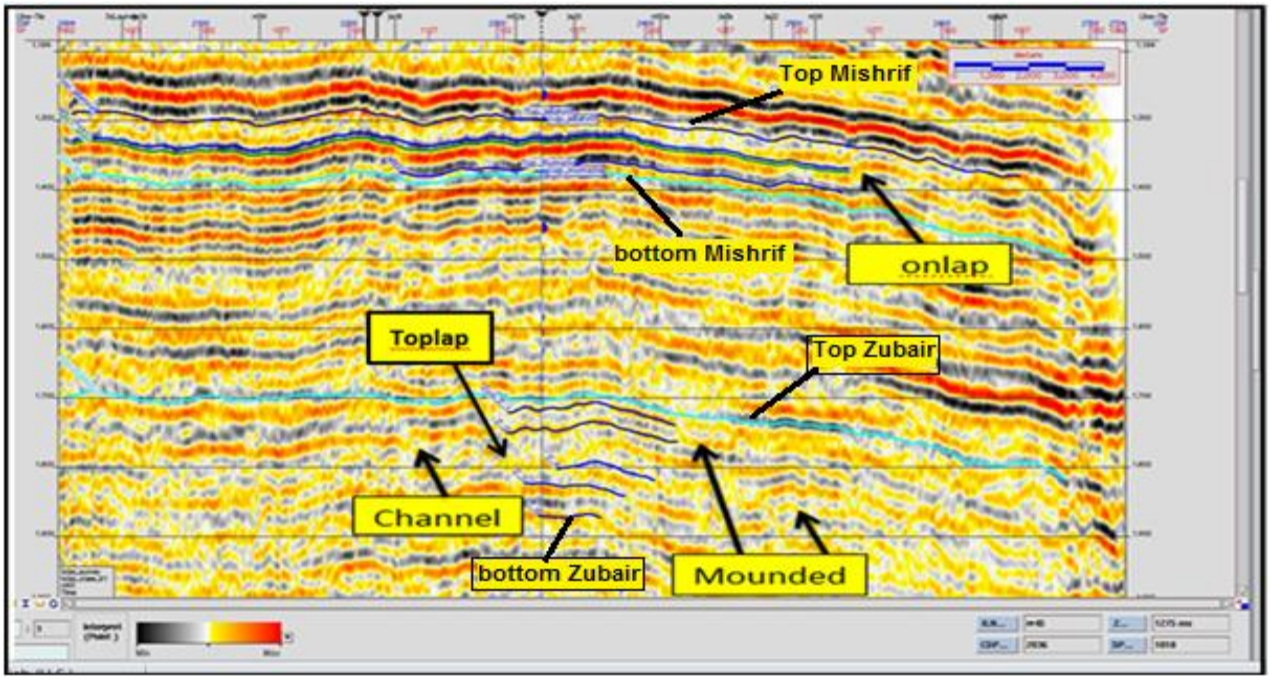


Figure 9- Seismic section reflection shows termination and external forms line rr45.

Amplitude Attribute

Variations in amplitude along a reflector should indicate changes in the properties of the formations [21]. Low amplitude at level of Zubair Formation are probably the area of hydrocarbon reservoirs. Mishrif Formation was seen on the reflection of low amplitude zone (dim spot), which is indicative of hydrocarbon presence; the dim spot is a decrease in amplitude of reflections over a short distance. They are produced as a result of the contrast between the acoustic impedance of the embedding medium (shale) and that of the reservoir, decrease in amplitude of the top reservoir reflection is indicative for a change in pore fill. The Flat spot is a horizontal reflection that is reflected from fluid to fluid interphases (fluid contact), which is oil-gas contact; the flat spot is easily identified by its flatness [22] Figure-10.

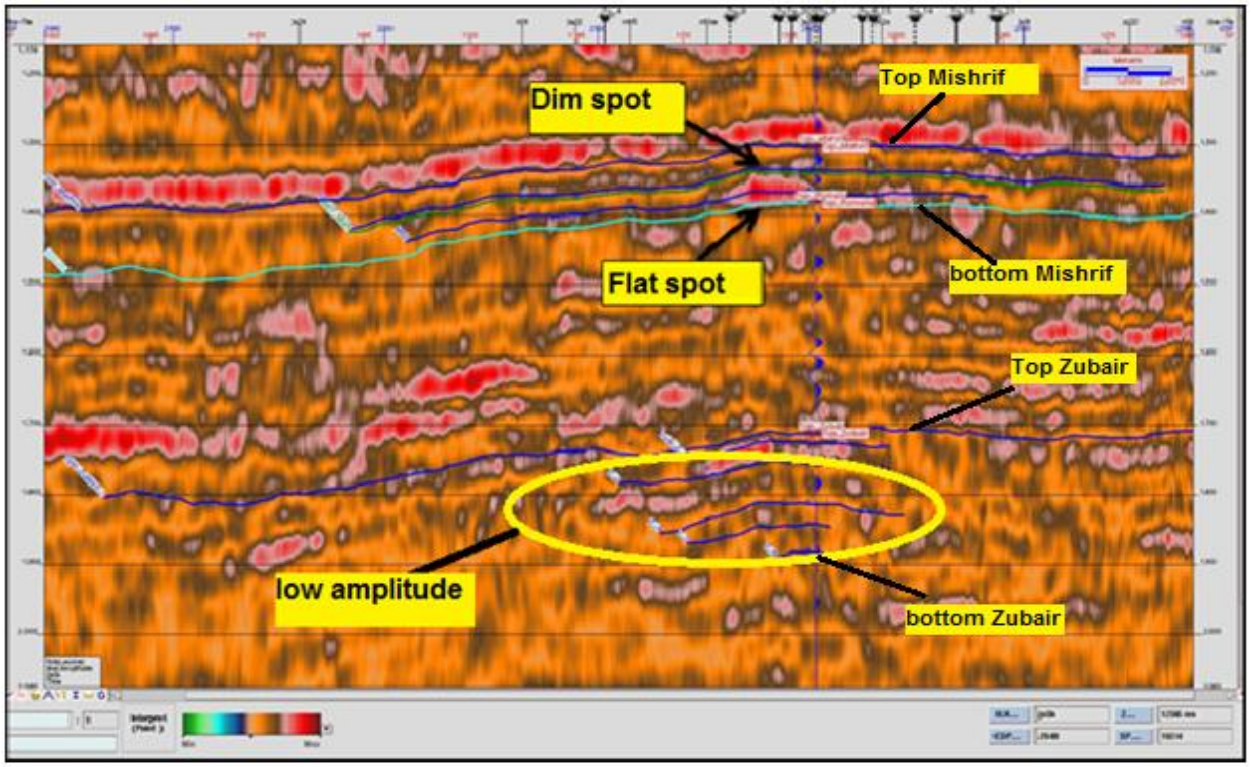


Figure 10- Composite reflection strength amplitude section of the studied package ties the well Tu-1 line js20.

Cosine of Instantaneous Phase ($C(t) = \cos(\emptyset(t))$

The cosine instantaneous phase makes strong events clearer and is effective at highlights discontinuities, pinch-outs, angularities, and bed interfaces. Seismic sequence boundaries, sedimentary layer patterns and regions of onlap/offlap patterns often exhibit extra clarity [23]. Mishrif Formation represents sequences boundary where deposited in carbonate platform, this formation unconformities are produced by subaerial erosion associated with a drop of relative sea level [24]. Different amounts of time may be associated with these surfaces conformably and gradationally in Khasib Formation, and occurred at Mishrif unit onlap termination strata. Zubair Formation showed that it formed by trasgressions and regressions during their deposition time (progradtion and aggradation), toplap termination of strata when delta deposits Figure-11.

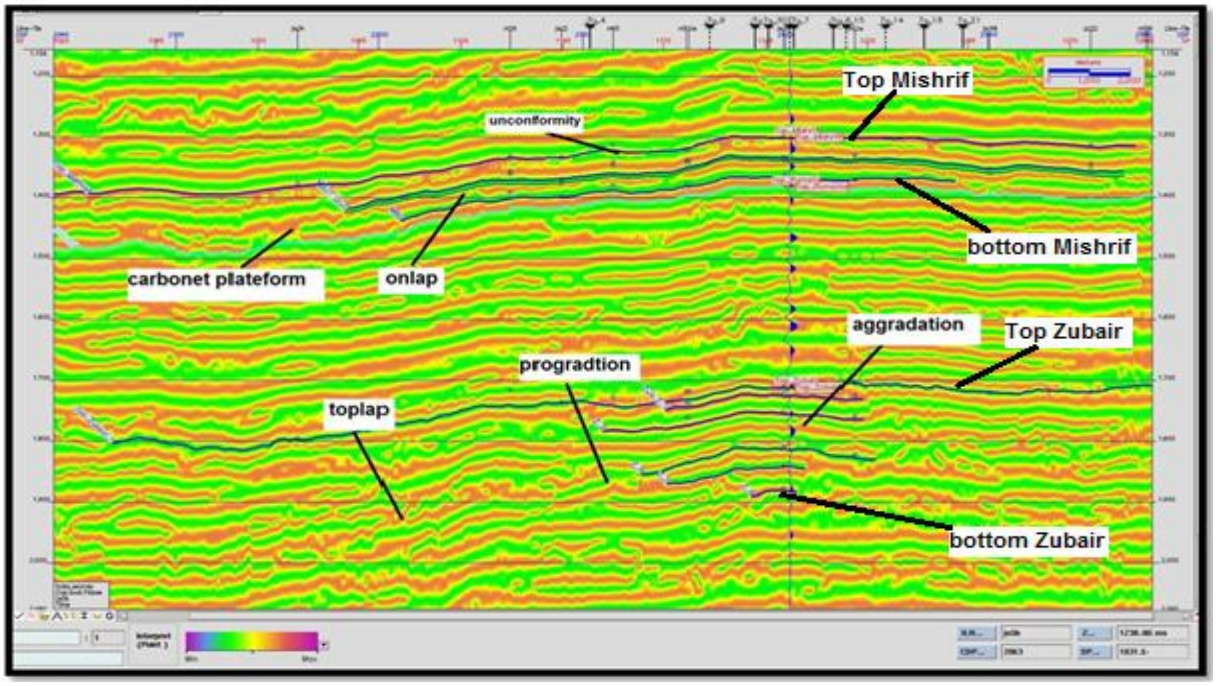


Figure 11- Shows cosine instantaneous phase of studied in Tuba line js20

Conclusions and Recommendations

Tuba oil field represents common trap (structure and stratigraphic). Stratigraphic traps noticeably organic bulidups (reefs,mounds) and structure traps closure is created by folding and faulting. Mishrif Formation represents type 2 sequence boundary. The nature of Mishrif Formation in the study area was deposited within the HST system (MB1, MB2) these units sequences are displayed onlap. While MA unit was deposited through high stand systems tract (HST) in open and restricted lagoon environment where sea level declines. This pattern is called progradeitional parasequences set. Mishrif reflector display parallel configuration which leads to conclusion that the Mishrif facies (mounded) is obviously associated with reefal buildups that deposited on a broad relatively stable shelf, while Zubair reflector displayed mounded deposited in slope and progradtional represents shingle facies indicated sand wedge shaped feature which was interpreted as formed during the fairly slow, early, intermediate part of the relative rise of sea level as result ,the Zubair Formation represents delta platform facies. Cosine instantaneous phase attribute detected seismic sequence boundaries, sedimentary layer patterns and regions of onlap and toplap patterns. Amplitude attribute showed that Mishrif Formation has low amplitude zone (dim spot) which is indicative of hydrocarbon presence and flat spots is indication of oil-gas contact. For future work the 3D surveys are necessary because they are needed to clarify the stratigraphic feature and hydrocarbon accumulations.

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