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3D- Seismic Analysis of Paleocene Carbonate Succession in Nafoora Area, Southeast Sirt Basin, Libya

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الملخص:

هذه الورقة سلّطت الضوء على التفسير السيزمي للتتابع الباليوسيني في منطقة النافورة، السرود المجمعة واختبارات السرعة وسرود الصوت للعديد من الابار في امتياز 51 الغربي استخدمت في هذه الدراسة، هذا البحث تضمن خرائط الوقت ثنائي المسار لكل وحدة وذلك لإيضاح توزيعها في منطقة الدراسة وكذلك لتقييم العلاقة بين الوضع الطبقي والتركيبي لصدع النافورة. هذه الخرائط تم انشائها لكل من عضوي عريش وحراش وذلك بناءً على تفسير معلومات سيزمية ثلاثية الابعاد وقمم التكوينات. وتبين ان الاختلاف الصخري وتكوين الصدوع التي عملت على قطع العواكس في الغالب كانت تتحكم في تواصل الاحداث السيزمية. اشكال الصدوع بينت ان اغلبها نوع عادي وباتجاه الشمال الغربي الى الجنوب الشرقي. ولوحظ ان هذه الصدوع عامة تطابقت مع الشكل التركيبي العام في شرق حوض سرت. هذه الدراسة أعطت فرصة للتحقق من الترسيب والطبقية لحافة المصطبة الكربونية لبحر التيشي خلال العصر الباليوسيني. هذا العمل من الممكن ان يكون له اهمية اقتصادية للصناعة النفطية بأن يساعد في تحديد مناطق للاستكشاف في المستقبل.

الكلمات المفتاحية:

سيزمي، باليوسين، عضو عريش، عضو حراش، منطقة نافورة، حوض سرت.

Abstract

This paper focuses on seismic interpretation of Paleocene sequence in Nafoora area. Composite logs, check shots and sonic logs for many wells in the block 51W have been used herein. The paper aimed to i) present time structural maps for each unit to demonstrate their lateral distribution throughout the area of study, ii) and to evaluate the relation between the stratigraphy and structural setting across the Nafoora Fault. The maps are generated for Arish and Harach horizons on basis of 3D seismic data, and formation tops. Variations in lithology, and the development of faults, which introduce discontinuities in the reflectors mostly control the continuity of the seismic events. The fault patterns show that most of faults are of normal type with a NW-SE strike trend, these faults generally coincide with the major regional structural features in the eastern Sirt Basin. However, this study provides an opportunity to examine deposition and the stratigraphy of the carbonate platform on the southern margin of Tethys during the Paleocene. Furthermore, the work may have economic benefits to the petroleum industry in form of a predictive tool for future locations of hydrocarbon prospectivity.

Keywords: Seismic, Paleocene, Arish Member, Harash Member, Nafoora area, Sirt Basin.

1. INTRODUCTION

The area of study is regionally located on Nafoora area in the southeastern part of Sirt Basin (Fig. 1). It is located on western part of Concession 51, which encompasses approximately 8400 km2 (Fig. 2). The Sirt Basin is one of the youngest sedimentary basins of Libya and covers an area of 600,000 km2 in the central Libya. The basin consists of complex northwest-southeast–trending Cretaceous to Eocene rift structures, forming a system of horsts and grabens that began to develop in the latest Jurassic [(1)]. The objective of the seismic interpretation in this study is to evaluate the structural and stratigraphic setting of the Paleocene sequence in the southeastern Sirt Basin. An additional aim is to identify and map seismic facies to form a chronostratigraphic framework for the Paleocene interval .

Many authors such as [(2, 3, 4)] have described the stratigraphy and structural setting of the Sirt Basin. Ankettle [(5)] who proposed a different phases for the structural evolution of the Sirt Basin and Adjacent areas, has reported a detail work on structure in the onshore regions of the Sirt Basin. The stratigraphic subdivsions of the Basin were established by Barr and Weegar [(6)]. The Tertiary rocks in the Sirt Basin has been studied and defined by Berggren [(7, 8)] who divided the sequence into some stratigraphic units.

El-Shari [(9)] studied the relationship between the stratigraphy and structural setting at the northeastern part of the basin. The Mesozoic and Cenozoic sedimentary succession in the Sirt Basin rests on a Precambrian basement and Cambro-Ordovician clastic sediments. The succession consists of Upper Cretaceous continental-marine clastics, overlain by Upper Cretaceous fine marine clastics and carbonates, and Paleocene to Eocene carbonates and evaporates. The Cenozoic sequences is capped by Eocene to Miocene mixed carbonates and siliciclastic deposits [(1)] (Fig. 3). The rock sequence in the study area generally consists of carbonate with some shales ranging in age from late Cretaceous to middle Eocene.

The geophysical and geological databases used in this study mainly consist of well log data, well reports, and seismic reflection sections. In this study, the identification of the seismic events was based on the ties to the many boreholes that had well velocity surveys, then correlated and interpreted throughout the seismic data. The seismic data used herein are composed of 3-D seismic survey which covers a total area of

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about 170 km2. (Survey 2000; Fig. 2). The 3-D seismic survey was acquired in 2000 and covers a total area of about 170 km2 (Fig. 2). It consist of N-S-oriented inline and E-W oriented cross lines which is orthogonal to the main structural features.

Generally, there appears to be a high signal to noise ratio over the area. The quality of the seismic data is generally moderate to good. The best seismic marker in this sequence is the Sirt upper Cretaceous Shale horizon.

It has excellent acoustic impedance and provides a good control for deeper and shallower horizons. However, there are some portions of the deeper data are relatively poor.

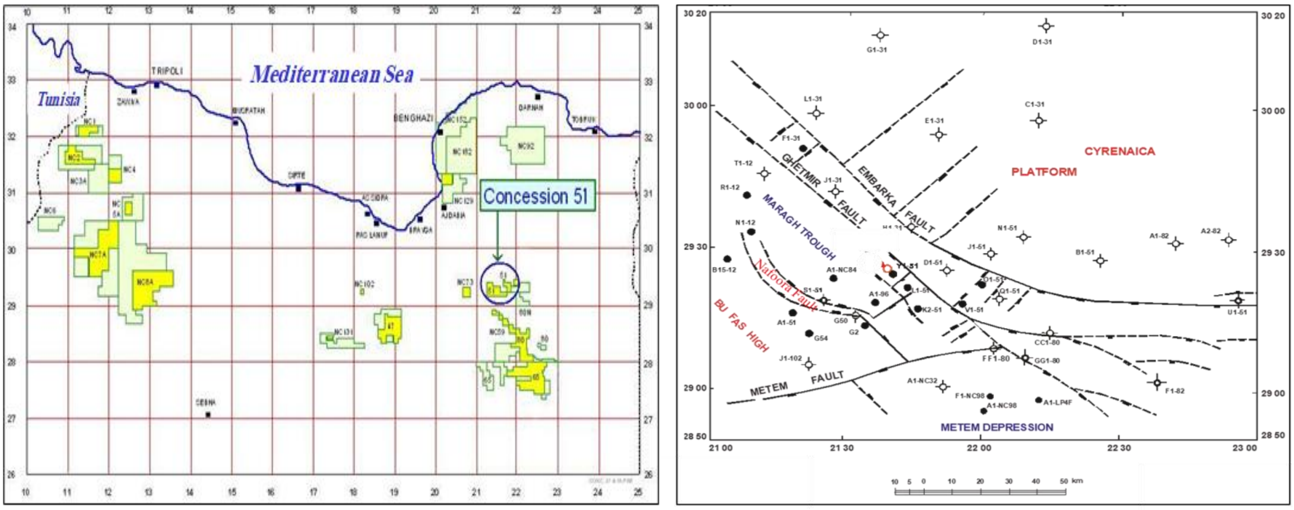

Figure 1. Location maps of the study area (Concession 51).

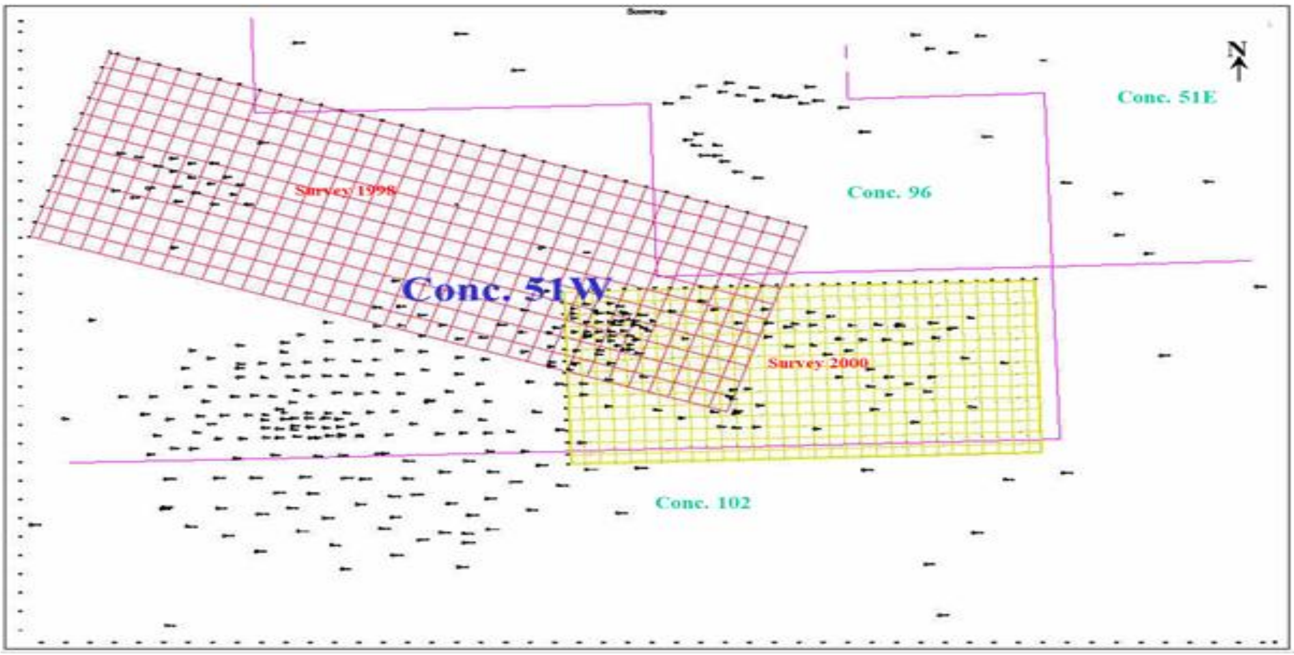

Figure 2. The shotpoint location map of the seismic profiles used in the study (Names of wells and seismic data are not mentioned for confidentiality reasons).

2. REGIONAL SETTING

The study area is regionally situated within the eastern margin of Sirt Basin. The structural framework of the basin includes two major structural elements, which show different geological conditions. The southern part (Bufas High), generally represents the upthrown block of the NW-SE trending Nafoora Fault, while the northeastern part (El-Khatt Graben) represents the downthrown block of this fault (Fig. 1). Bufas High is an old granitic basement body which extends from Nafoora/Augila area in the southeast to the Amal Field in the northwest. El khattt Graben (the down thrown block) however is an important structural feature where a thick stratigraphic section of sandstone and shales of pre-Upper Cretaceous is preserved.

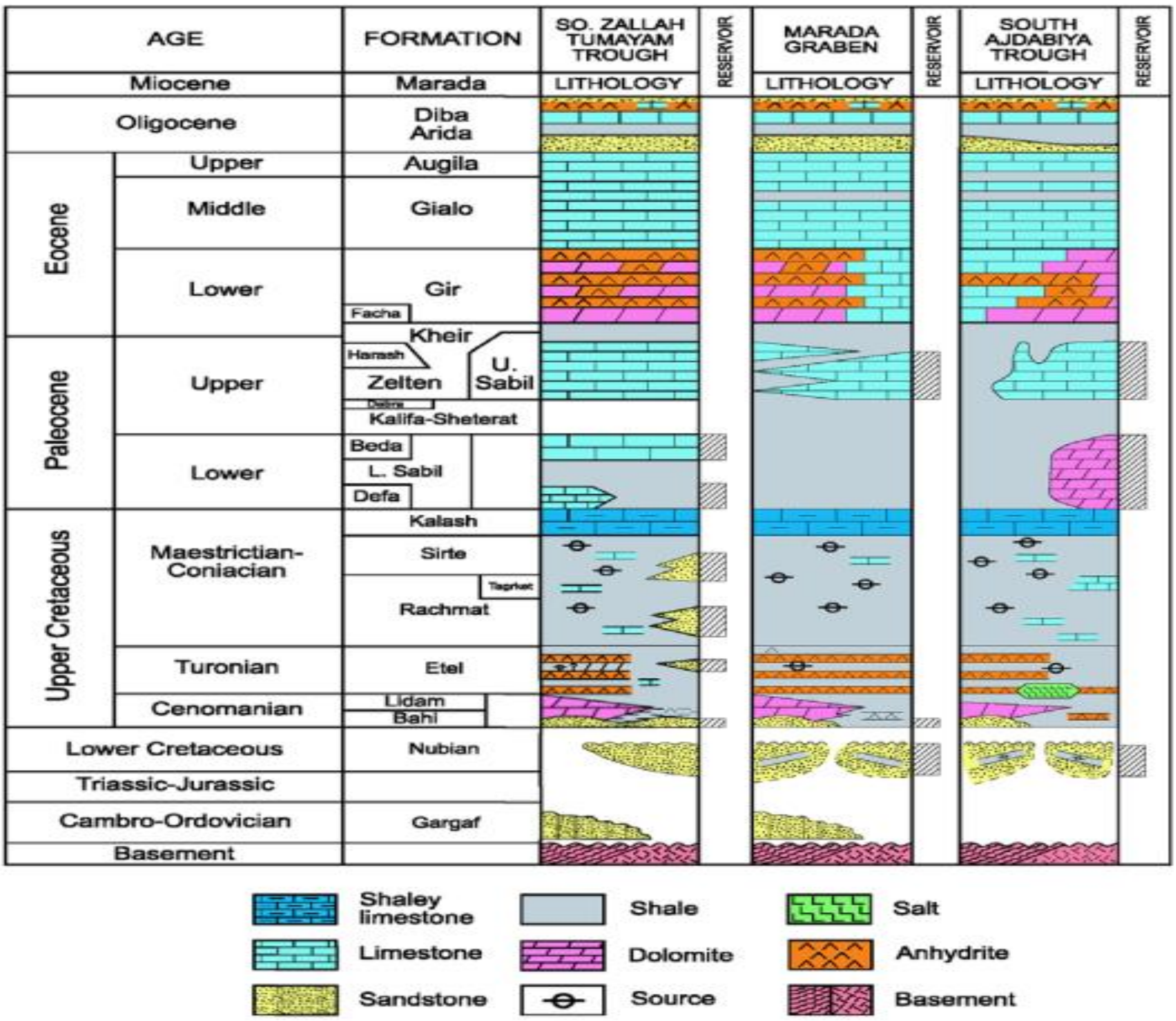

Figure 3. Generalized correlation chart for the Sirt Basin [10]

The basement is penetrated by wells on the Naforea filed only, on the up-thrown side of the faults south of the 51W. The pre-Upper Cretaceous sedimentary rock sequence is present only in the El-Khatt Graben area, while is completely missing in the upthrwon block of the fault. Bahi Formation (Upper Cretaceous) is a basal clastic unit of late Cretaceous age (Fig. 3). In general, the total thickness of this section increases towards the north and northeast The Paleocene facies distribution in the Sirt Basin, have been studied by Conley [11], Brady *at el.* [12], and Bezan [13]. An extensive marine transgression, followed thermally-driven basin wide subsidence, can be seen in the basin from the Paleocene to Oligocene time. Along major horsts, carbonate banks and reefs developed under open marine conditions. This carbonate / shale interplay in some places, is reflecting transgressive and regressive sedimentary cycles. The Paleocene reservoirs contain the huge amounts of hydrocarbon accumulations in the Sirt Basin. In the eastern part of the basin as example, the bioclastic coral-rich boundstones and grainstones of the upper Sabil Formation, form the main reservoir [14].

Paleocene section in the study area is represented by Najah Formation, which is divided into two sections, the upper section (Harash Member) and the lower section (Arish Member). The Harash Member consists mainly of dolomite facies changed laterally into microcrystalline limestone with poor porosity. The underlying Arish Member consists of sucrosic dolomite interbedded with thin beds of anhydrite. The limestone section of the middle Eocene in the area lies within the Gialo and El-Giza Member. Nafoora Member of Upper Eocene is calcarenitic to micritic limestone facies.

3. SEISMIC INTERPRETATION

This study focuses on 3D seismic reflection interpretation of the Paleocene sedimentary succession in the southerneast Sirt Basin, where two seismic reflectors are traced and contoured. Five horizons have been interpreted across the study area. Only two key horizons have been mapped in details and their TWT structural maps were produced. These horizons are Paleocene Arish and Harash members of Najah Formation (Figs, 4, 5). Seismic horizons were identified according to the relationship of the boreholes to seismic data, together with the evaluation of the seismic boundary condition built on the principles of seismic stratigraphy. However, correlation procedure between the reflectors in this study clearly follows major structural changes and identifies apparent features, such as dip and faults trends.

A large number of NW-SE faults clearly dissect the interpreted horizons, which are mostly normal faults, where most of them are down-thrown towards the north and northeast (Figs. 4, 5).

These are generally steep with a common apparent dip ranging from 70 degrees to about 80 degrees. Maximum vertical displacement on the faults is about 30 ms. Within the interpreted area planar normal faults are the common type. Generally, major faults have stratigraphic sequences that are similar thickness on both the hanging-wall blocks and the foot-wall blocks. Therefore the vertical displacement of these faults is likely to occur after sedimentation in the area.

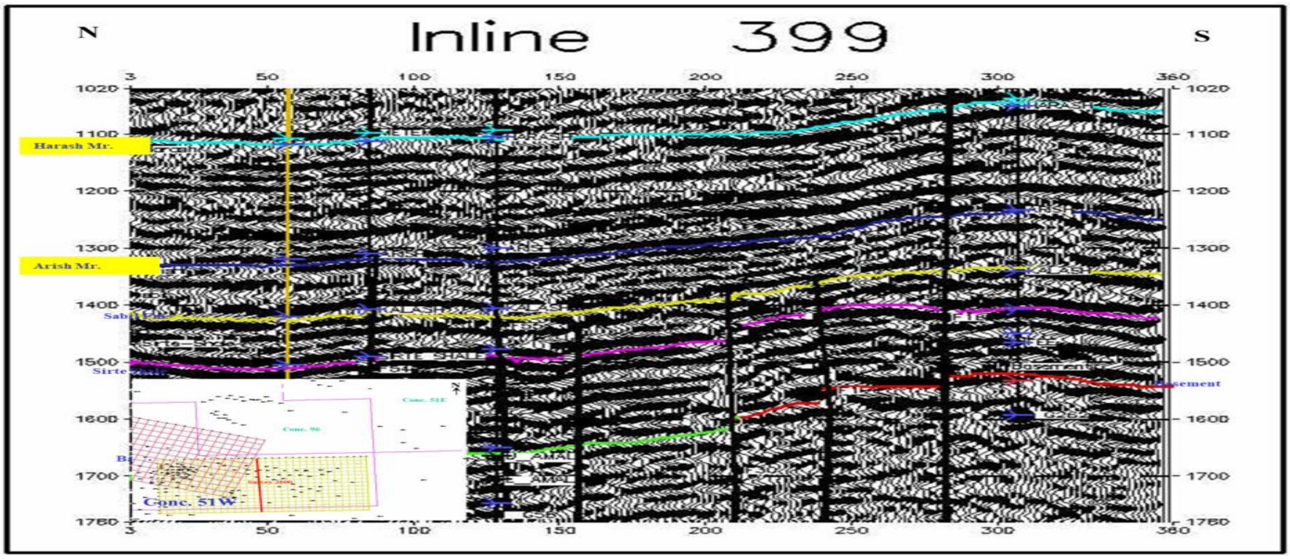

Figure 4. Interpreted inline seismic profile showing the tops of both Arish and Harash horizons in the study area.

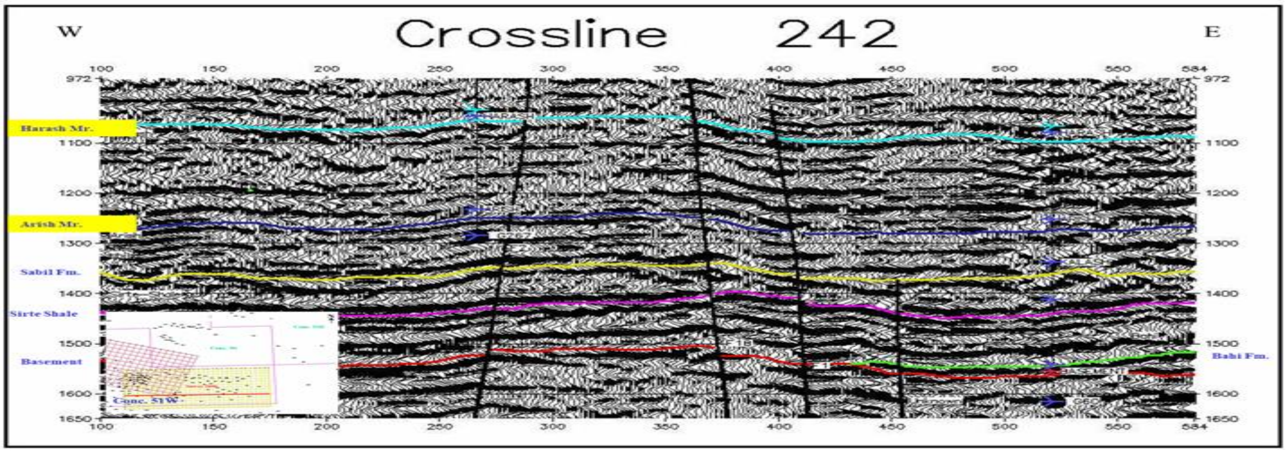

Figure 5. Interpreted crossline seismic profile showing the tops of both Arish and Harash horizons in the study area.

3.1 Arish Member:

The reflector of the Arish horizon is considered the lower part of Najah Formation (Figs. 4, 5). The reflection quality associated with this horizon shows good lateral continuity with only local discordances. The horizon reflectivity is relatively good on the northwest, while on the southeast the reflector is relatively much stronger. However, in some parts the reflector can hardly be followed throughout the study area due to discontinuity related to structural disturbances, which makes correlation quite poor. Furthermore, the paleocene sequence are carbonate dominated and this may caused a greater degree of attenuation which caused the poor data quality.

The TWT contour map shows the structural situation on the top of Arish Member in the study area (Fig. 6). The map generally represents a dipping surface towards the north and northeast. The minimum TWT contour value is 1220 ms and the maximum contour is 1300 ms. Close contour spacing in the map indicates an increase in dip gradient towards the southwest

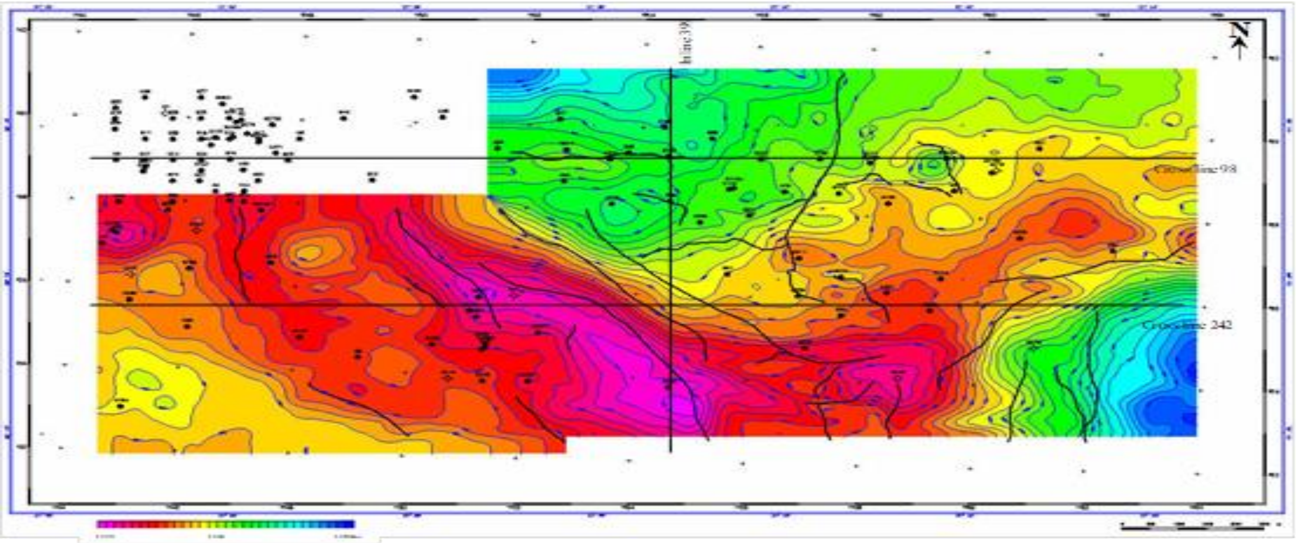

Figure 6. TWT structure contour map shows the top of Arish Members in the study area.

This map indicates that the crest of the structure is in general at the centric part of Nafoora /Augila Field. The structure of the horizon appears moderately smooth with some scattered high positive. A number of extensional normal faults are identified on this surface of NW-SE general trend. These faults represent the major structure trend that bounded by the Nafoor Fault on the south. Figure (7) represents a time slice at 1250 ms through seismic volume which reveals clearly the Nafoora Fault zone of NW-SE trend. However, there are some minor faults of approximately N-S general trend.

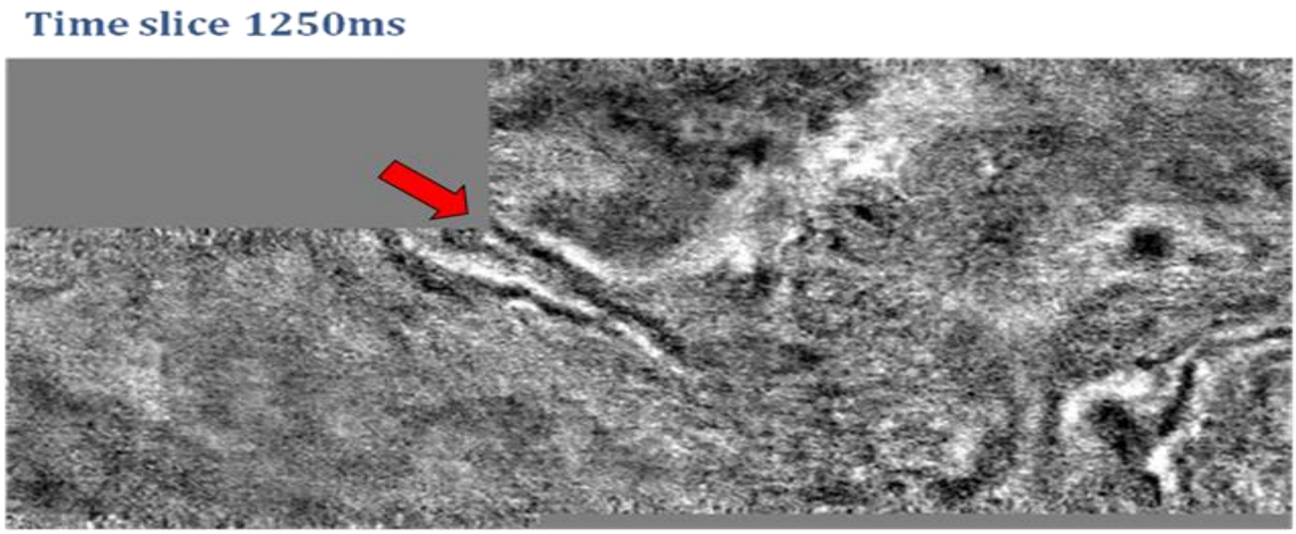

Figure 7. Ttime slice at 1250 ms through seismic volume, the red arrow indicates a fault zone of NW-SE trend.

3.2 Harash Member:

The Harash Member represents the upper part of the Paleocene sequence. This reflector exhibits strong amplitude and high continuity (Figs. 4, 5). In the west and southwest, reflection quality associated with the horizon is good, and characterised by continuous and strong amplitudes. No disturbance of the reflector was noticed, but it is a horizontally continuous event. In the east and northeast, the reflector is marked by variable amplitude, moderately continuous reflector. Figure (8) shows the TWT structure contour map of the top of the Harash Member. The map also shows and confirms that Harash level has the same structural configuration as the underlying Arish on the upthrown block and the underlying pre-upper Cretaceous surface on the downthrown block. The event on this map shows a gradual dip of the horizon towards the north and northeast. As in the Arish map, close contours, that indicate a steep dipping horizon, are located at the southwest. Major faults of NW-SE trend, which are downthrown north and northeast, have been defined on the top of the Harash Member. There are some smaller faults, of approximately N-S trend, also defined at this level. The faults are mainly concentrated in the southwest area, which is interpreted as developing on the Nafoora Fault zone between the horst and the graben.

4. CONCLUSION:

The seismic data showed good definition of the Paleocen development and was useful in the geological understanding of this part of the section. 3D seismic survey, representing inline and cross-lines, are fully interpreted in this study. A thick section of the Paleocene rocks were deposited over all the areas of Bu-Fas High and El-Khatt Graben. Paleocene section in the southeastern Sirt Basin completely consists of carbonate rocks. The sedimentary patterns of the sequence, appear to be the result of a complex interplay of regional tectonism associated with eustatic sea level changes resulting in local regressive and transgressive sequences. The Paleocene sequence time-structure contour maps (Arish and Harash members) shows some irregularity in the contour patterns but a general dip towards the northeast has been observed. Large number of faults have been observed on the top of both members, where most of them are extensional normal with NW-SE trend, and downthrown toward the northeast. The dip of the faults commonly ranges from 80° to 70°, with a maximum displacement of about 30 ms. The trend of these faults appears to be compatible with the regional geological setting of the area. However, an accurate mapping of the fault blocks in this study, may help for placement of a proposed exploration wells in the area.

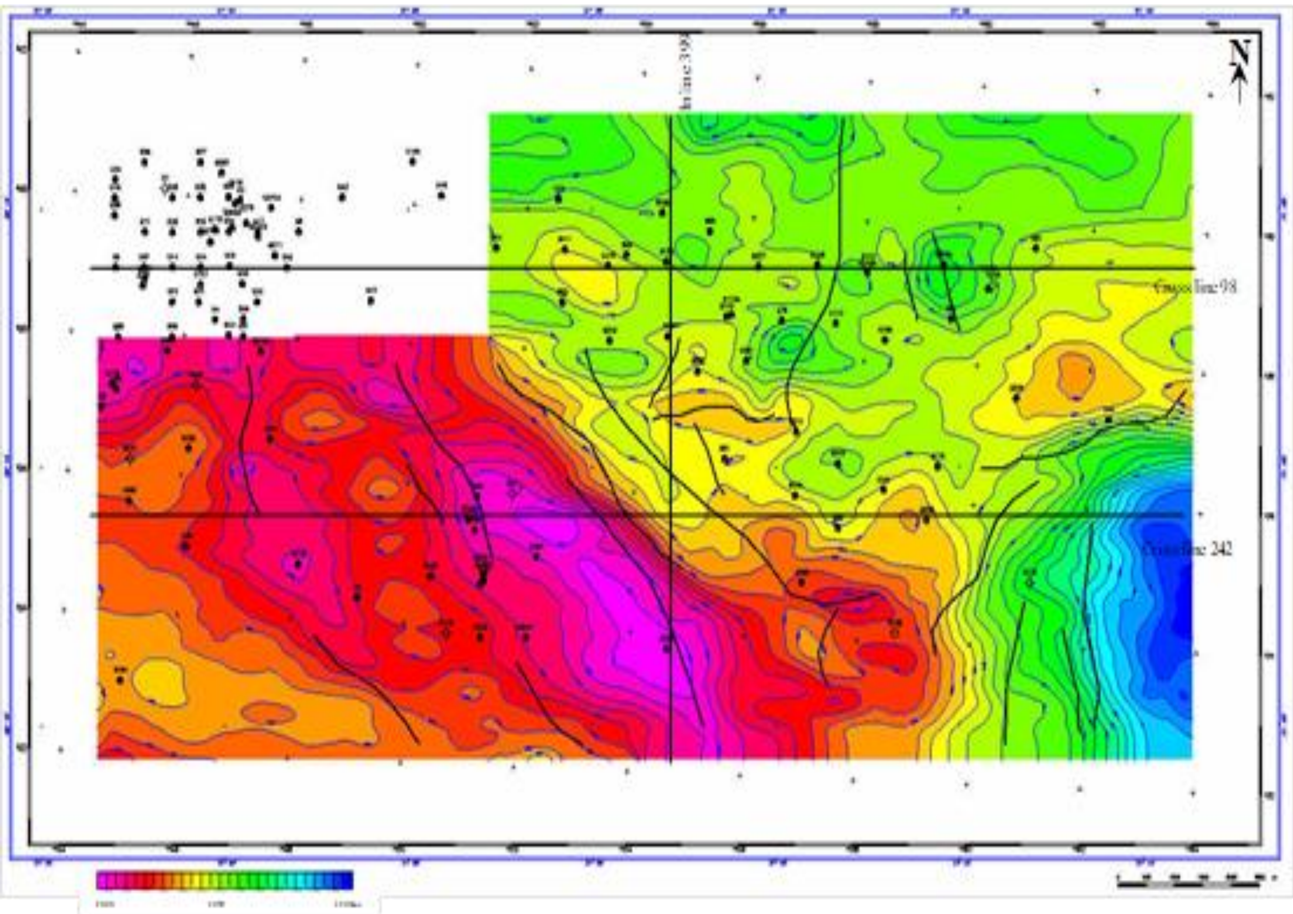

Figure 8. TWT structure contour map shows the top of Harash Members in the study area.

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