Egyptian Geophysical Society
EGS Journal, Vol. 14, No. 1, 71-78 (2016)

DELINEATION OF THE SUBSURFACESTRUCTURES OF THE CRETACEOUS FORMATIONS, USING THE SEISMIC DATA IN KOMOMBO BASINAL AREA, UPPER EGYPT, EGYPT

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تحديد التراكيب السطحية لتكاوين الكريتاسى باستخدام البيانات

السيزمية لحوض كوم امبو، صعيد مصر

الخلاصة: تقع منطقة كوم امبو فى جنوب الصحراء الغربية لمصر بين خطى عرض ٢٠` ٢٤° و ٢٥° شمالاً وخطى طول ٣٠` ٣٢° ونهر النيل شرقاً. تم تحليل وتفسير معطيات المسح الزلزالى الذى تم إجراؤه على منطقة الدراسة. كما تم تحديد ورسم الإطار التركيبى التحتسطحى العام للمنطقة وتحديد النطاقات الواعدة المناسبة للتجمعات البترولية. تم عمل مجموعة من الخرائط الزلزالية على منطقة الدراسة ممثلة بثمانية خرائط عمق والتى تم تفسيرها من حيث التراكيب الموجودة. وأخيراً تم تحديد أفضل أماكن لحفر الآبار فى الأماكن الواعدة.

ABSTRACT: *The Komombo concession is located in the western part of the Nile River, Upper Egypt, Egypt. The geophysical data used for the present study include 34 seismic reflection lines and borehole data. The well data include vertical seismic profiles and composite logs. The objective of this study is to do seismic interpretation of the given 2D seismic sections for identifying the structural traps (faults) and obtaining a better understanding of the regional subsurface geology, tectonic history of the studied area and a knowledge about the possibility of presence of hydrocarbons in this area.The depth structure contour maps constructed for most tops that based on the 2D seismic data showed two main extensional fault sets, a dominant northwest-southeast set parallel to the main bounding fault system and a subsidiary set trending east west. A third set (northeast-southwest) is present but not dominant.The proposed leads, based on the executed 2D seismic interpretation, represent promising areas for drilling exploratory wells in these new recommended leads.Deterministic estimates of the potential volumes for the leads have been carried out reflecting low case based on the difference in reservoir properties. Drilling more wells in these parts could add more hydrocarbon reserves in Komombo basinal area.*

INTRODUCTION

1. Location:

The studied area of Komombo basin lies in the southern Western Desert of Egypt, and restricted betweenlatitudes 24°20` N and 25° 00` N, and longitudes 32° 30` E and the Nile River E.

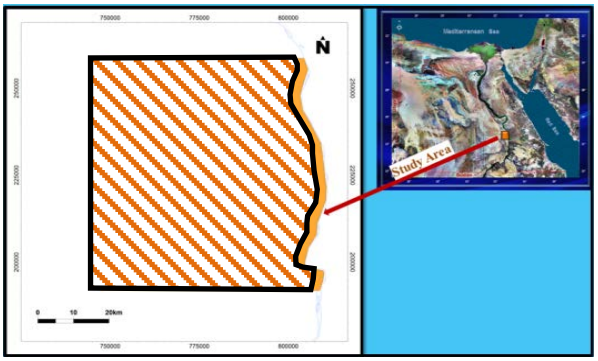

Figure 1: Location map of Komombo basinal area, Upper Egypt, Egypt.

GEOLOGIC SETTING

1. Stratigraphy:

The Western Desert as a huge platform with mean elevation of 500 a.s.l. consists of thick-layered sedimentary rocks, largely non-affected by tectonic disturbances (Said, 1962). Sandstones with a slight northward regional slope and dip marks up the largest part of the exposed and subsurface strata. Carbonate strata are confined to the resistant limestone cap of the Egyptian plateau.Sediments in Upper Egypt's basin are present in distinct depositionaldepressions separated by low uplifts or platform areas. Basins formed in the Jurassic - Lower Cretaceous sequences as non-marine rifts (Fathy et al., 2010).

There are two sequences, separated by an angular unconformity, can bedistinguished; a basal Early Cretaceous or Late Jurassic sequence lying on the metamorphic basement and an Early to Late Cretaceous sequence above. The basal sequence consists of non-marine clastics deposited in a restricted environment and include KomomboFormation, whichconsists of shale with sandstone and siltstone streaks. It is subdivided into Komombo A, Komombo Band Komombo C Members.Komombo A Member and Komombo C Member are reservoirs in the Komombo basinal area,whileKomombo B Member is the main source rock in the Komombo basinal area (Repsol 1998). However the overlying sequence consists of a basal non-marine section, grading upward into coastal marine deposits and include the Six Hills and Abu Ballas Formations.The basal unit of Six Hills Formation is made up of up to 600 to 700 m thick fluvial sandstone, paleosol, andtoward the top, grades to minor nearshore marine sandstone. It is called basal Clastics

(Klitzsch 1978) or better Six Hills Formation (Bartheland Boettcher 1978). These clastic sediments were deposited, while the area was subsiding and before the Aptian transgression advanced from the north. SixHills Formation is subdivided into A, B, C, D, E and F Mmembers. Six Hills D, Six Hills E and Six Hills FMembers are reservoirs in the Komombo basinal area.

It is generally assigned to Late Jurassic-Early Cretaceous age (Klitzsch and Lejal- Nicol, 1984). In the subsurface, based upon pollen investigations, Helal (1965) and Soliman

(1977) referred the lower part of the Six Hills Formation to Late Jurassic. Soliman (1977) also identified theLate Jurassic foraminifera in some Kharga wells. Schrank (1987) described the pollen of Middle to Late Jurassic from a horizon of about 300 m below the well defined overlying Aptian shales in Ammonite well-1. Bisewski (1982) noted the presence of marine influence at a horizon of 60 m below the top of the Six Hills Formation, to the south of Abu Tartur. This may be considered a prelude to the Aptian transgression, that overlained by a fluviatile series.

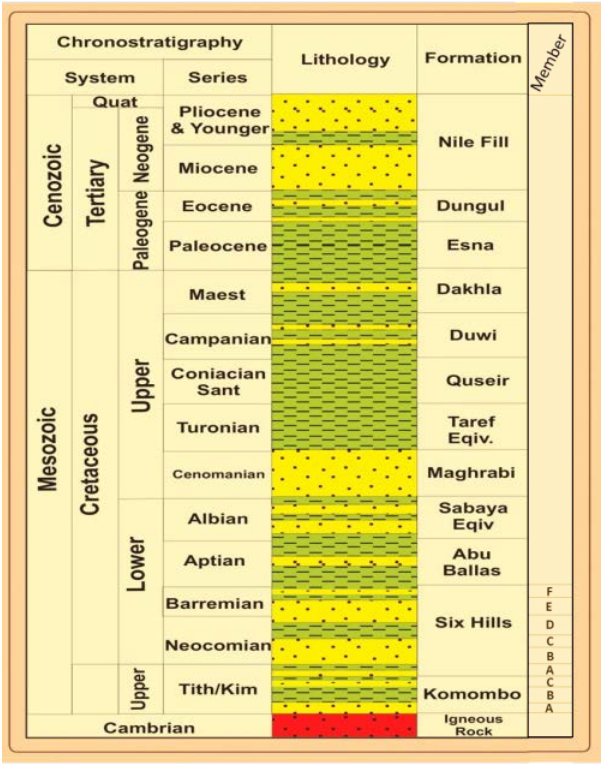

Figure 2: General lithotratigraphic column at Komombo basinal area (Repsol, 1998).

The first transgression, which reached the area of Southwest Egypt during this new structural cycle, was the Aptian transgression.

It is represented by the second formation from the bottom, the Abu Ballas Formation (Klitzsch, 1978, Barthel and Boettcher, 1978, Boettcher, 1982). It consists of up to 60 m of shale, siltstone and sandstone of a very shallow marine transgression of probably very high salinity (Barthel& Boettcher, 1978, and Boettcher, 1982).

Koch, et al., (2012), referring to the work presented here, shows some preliminary results from an on-going U.S. – Egypt collaborative project, that deals with the assessment of natural resources in an area located west of the Nile Valley, near Aswan and Komombo in the Western Desert of Egypt.

2. Structural Setting:

Structurally, the occurred reservoirs are controlled by two main extensional fault sets, a dominant northwest-southeast set parallel to the main bounding fault system and a subsidiary set trending east-west. A third set (northeast-southwest) is present, but no dominant.

The Aswan area is affected by many faults dated to the Cretaceous, trending E-W, N-S, N-E and N-W. The majority of these faults are normal and dextral strike-slip faults, which displaced the Precambrian crystalline rocks, the Late Cretaceous Nubian Sandstone and shale, the Late Cretaceous shale of the Dakhla Formation, and the Paleocene limestone of the Kurkur, Garraand Dungul Formations (Issawi,1969, EGSMA, 1981).

The analysis of the gravity anomalies in the studied area involves the lineaments on the Bouguer anomaly map on the top of the basement complex (Fig. 3). This line of reasoning leads to the establishment that, the lineament must be a fault (Abdel Zaher et al., 2009).

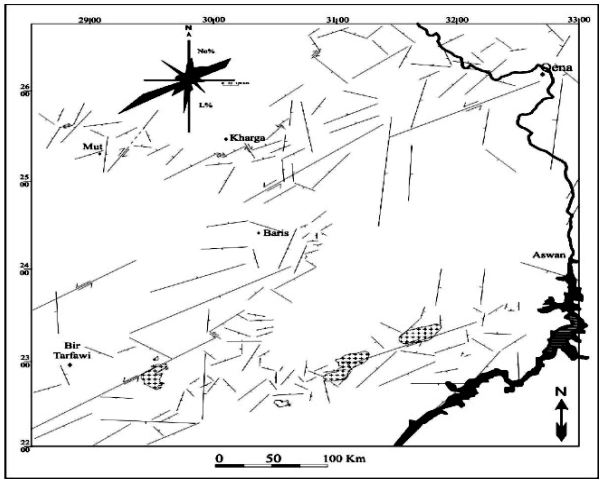

Figure 3. Structural lineaments on the Bouguer anomaly map and its rose diagram showing that the main trends are E-W, N-S, N55°E, N35°E and N55°W (Abdel Zaher et al., 2009).

SEISMIC DATA INTERPRETATION

1. Picked horizons:

The studied area shows an integration of the subsurface stratigraphic sections, that include the formations recognized for the southern Western Desert of Egypt. Some of these formation tops were picked, mapped and interpreted in this research work.

Seven horizon tops were picked in the studied area, including Komombo A, Komombo B, Komombo C, Six Hills D, Six Hills E and Six Hills F Members, and Abu Ballas Formation.

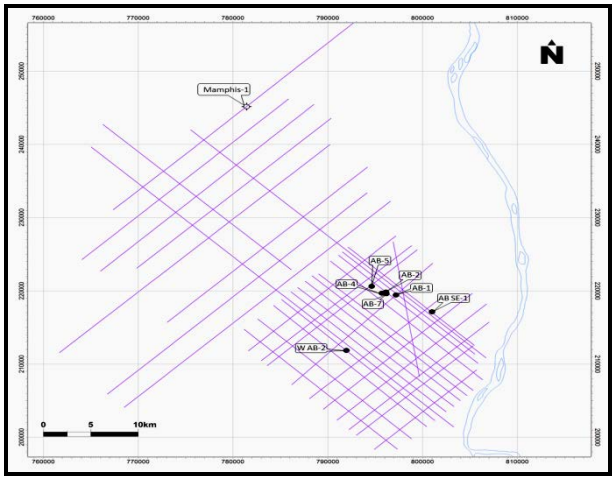

Figure 4: 2D Seismic survey of Komombo basin area, Upper Egypt, Egypt.

2. Depth structural contour maps:

2.1. Depth structural contour maps on the tops of Komombo formation:

The depth structural contour maps on the tops of Komombo A, B and C Members, based on the 2D seismic data (Fig. 5, 6 and 7), shows two main fault trends NW - SE and E - W to NE - SW, where the former trend is the dominant one.

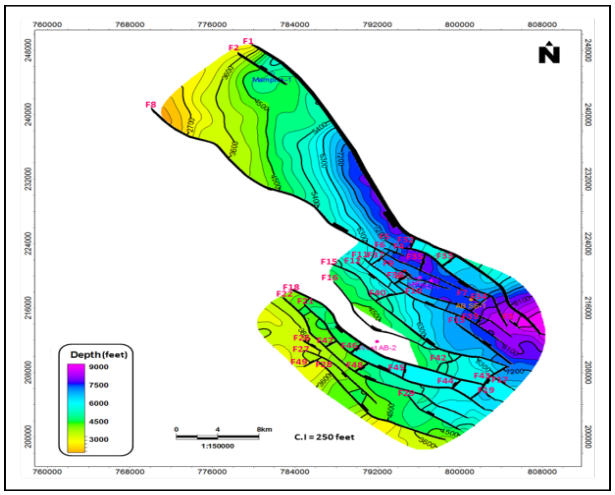

Figure 5: Depth structural contour map on the top of Komombo A member, based on the 2D seismic data of Komombo basinal area, Upper Egypt, Egypt.

The general configurations of Komombo Formation are alsostructurally controlled. The Komombo Formation is not found in the northwestern part,because it is pinching out in this direction, as indicated from Al Baraka wells. The interpreted depth values range from 9200, 8810 and 8307 ft, respectively, in their deepest locations to 2100, 2005 and 1790 ft, respectively, in their shallowest ones.

The location of the basin, during the deposition of this sequence, is main lied in the easternarea. The trend of Komombo Formation is mainly of NW–SE direction, that is and southeastern portions of the study the result of the Red Sea trend, whereasKomombo A and Komombo C Members representthe reservoir rocks in the studied area, While Komombo B Member represents the main source rock in the studied area, as indicated from Al Baraka wells.

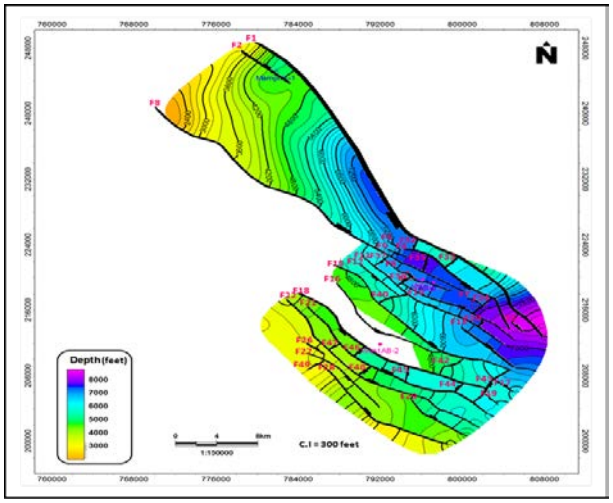

Figure 6: Depth structural contour map on the top of Komombo B member, based on the 2D seismic data of Komombo basinal area, Upper Egypt, Egypt.

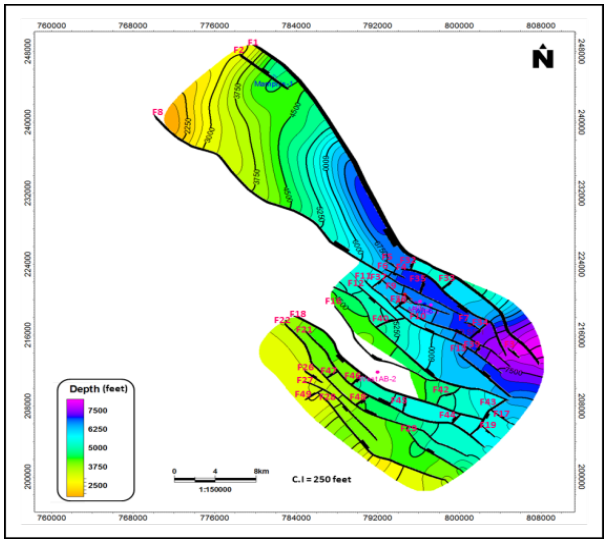

Figure 7: Depth structural contour map on the top of Komombo C member, based on the 2D seismic data of Komombo basinal area, Upper Egypt, Egypt.

2.2. Geo-seismic cross sections for 05-01-Cf 77-08 line:

The seismic and geo-seismic cross sections of 05-01-Cf 77-08 line (Figs. 8 and 9) show the structures of the studied area, which are represented by normal faults.The KomomboFormation is pinched out towards the northeastern direction, and eight seismic horizons (Basement complex, KomomboMember, Komombo B Member, Komombo C Member, Six Hills D Member, Six Hills E Member, Six Hills F Member and Abu BallasFormation).

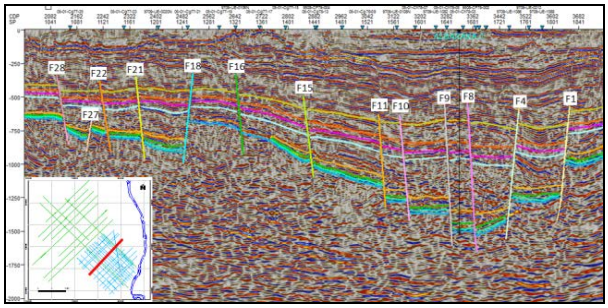

Figure 8: Seismic cross section for 05-01-Cf 77-08 Line of Komombo basinal area, Upper Egypt, Egypt.

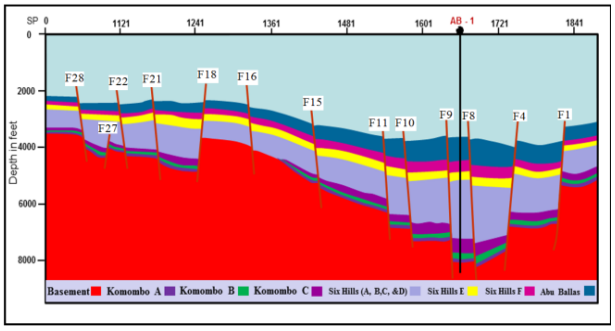

Figure 9: Geo-seismic cross section for 05-01-Cf 77-08 line, based on the 2D seismic data of Komombo basinal area, Upper Egypt, Egypt.

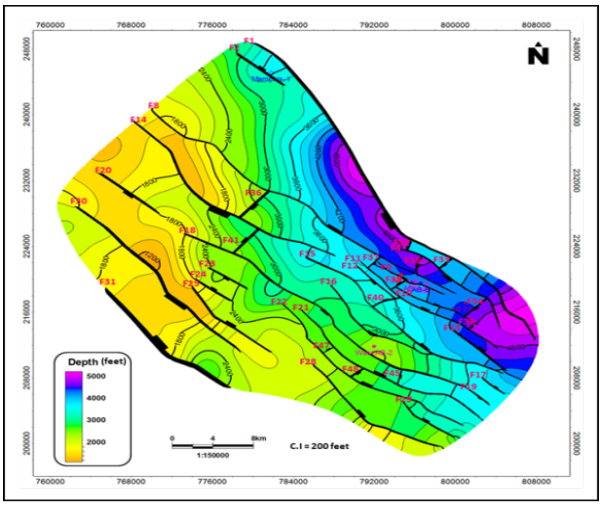

Figure 10: Depth structural contour map on the top of six hills D member, based on the 2D seismic data of Komombo basinal area, Upper Egypt, Egypt.

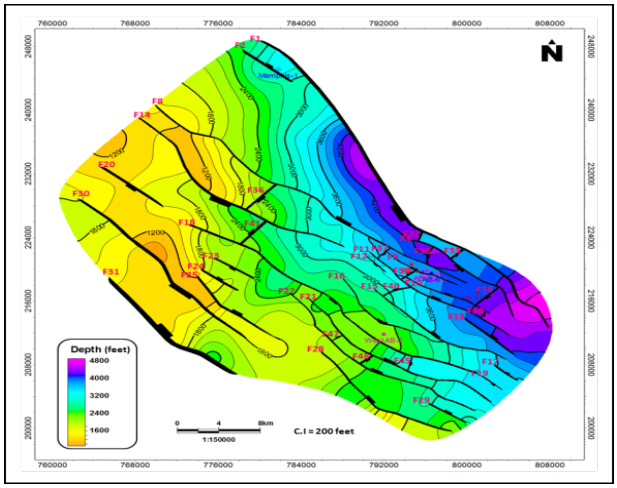

Figure 11:Depth structural contour map on the top of six hills e member, based on the 2D seismic data of Komombo basinal area, Upper Egypt, Egypt.

2.3. Depth structural contour maps on the tops of six hills formation:

The depth structural contour maps on the tops of six hills D, E and F members, based on the 2D seismic data in the studied area (Figs. 10, 11 and 12), shows also two main fault trends NW-SE and E-W to NE-SW, where the NW-SE trend is the dominant one.

The general configurations of the six hills D, E and F members are, thus, structurally controlled with the interpreted depth values that ranged from 5242, 4925 and 4610 ft in their deepest locations, to 1116, 905 and 687 ft in their shallowest locations. These faults the represent the initiation of interpreted seismic structures in the studied area.

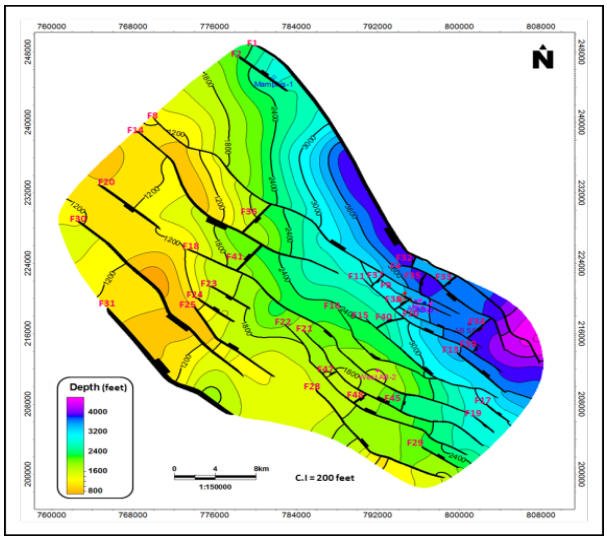

Figure 12: Depth structural contour map on the top of six hills f member, based on the 2D seismic data of Komombo basinal area, Upper Egypt, Egypt.

The location of the basin, during the deposition of this sequence is mainly lied in the eastern and southeastern portions of the studied area. The trend of six hills D, E and F members are mainly of NW-SE

direction, that is the result of the Red Sea trend, whereas the six hills D, E and F members represent the reservoir rocks in the studied area, as indicated from Al Baraka wells.

2.4. Geo-seismic cross sections for 9508-CG76 -005 line:

The seismic and geo-seismic cross sections of 9508-CG76-005 line (Figs. 13 and 14) show the structures of the studied area, which are represented by normal faults, and eight seismic horizons (Basement complex, Komombo A member, Komombo B member, Komombo C member, six hills D member, six hills E member, six hills F member and Abu Ballas Formation) areresulted.

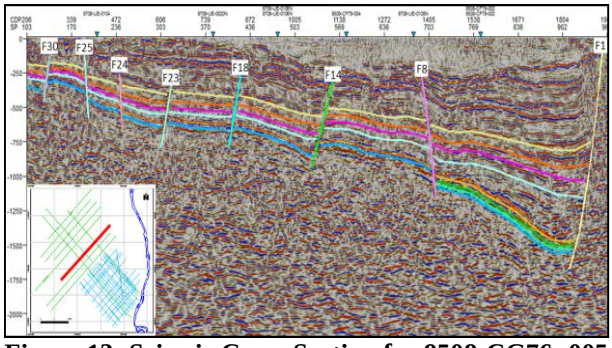

Figure 13: Seismic Cross Section for 9508-CG76 -005 Line of Komombo basinal area, Upper Egypt, Egypt.

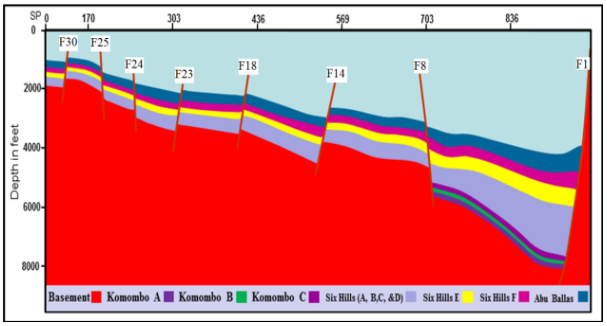

Figure 14: Geo-Seismic Cross Section for 9508-CG76-005 Line, Based on the 2D Seismic Data of Komombo basinal Area, Upper Egypt, Egypt.

2.5 Depth structural contour map on the top of Abu Ballas Formation:

The depth structural contour map on the top of Abu BallasFormation, based on the 2D seismic data in the studied area (Fig. 15), shows also two main fault trends NW - SE and E - W to NE - SW, where the NW - SE trend is the dominant one.

The general configuration of the Abu BallasFormation is, thus, structurally controlled, with the interpreted depth values, that range from 3810ft in its deepest location to 460 ft in its shallowest location. These faults represent the initiation of the interpreted seismic structures in the studied area.

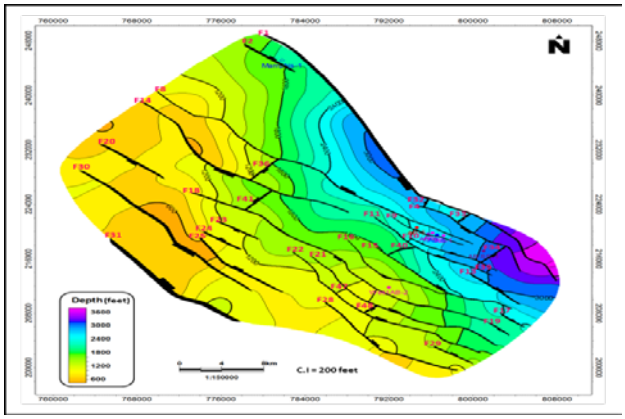

Figure 15: Depth structural contour map on the top of Abu Ballas formation based on the 2D seismic data of Komombo basinal area, Upper Egypt, Egypt.

The location of basin, during the deposition of this sequence, is mainly lied in the eastern and southeastern portions of the studied area. The trend of Abu Ballas is mainly of NW-SE direction that is the result of the Red Sea trend whereas Abu Ballas formation represents the reservoir rock in the studied area, as indicated from Al Baraka wells.

2. 6. Geo-seismic cross sections for 05-01-Cg77-19:

The seismic and geo-seismic cross sections of 9508-Cg77-19 line (Figs. 16 and 17) show the structures of the studied area, which are represented by normal faults, and eight seismic horizons are produced (Basement complex, Komombo A, Komombo B, Komombo C, six hills D, six hills E and six hills F members, and Abu Ballas formation).

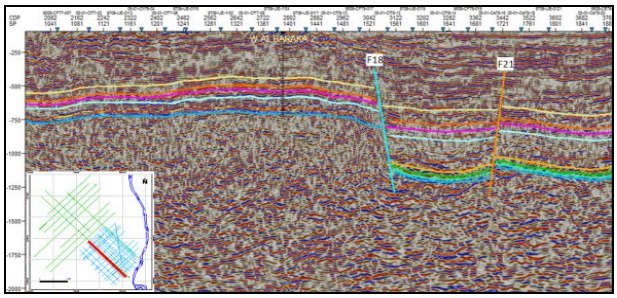

Figure 16: Seismic Cross Section for 05-01-Cg77-19 Line of Komombo basinal Area, Upper Egypt, Egypt.

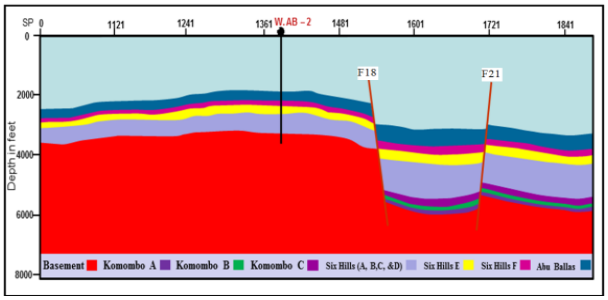

Figure 17: Geo-Seismic Cross Section for 05-01-Cg77-19 Line, Based on 2D Seismic Data of Komombo Basin Area, Upper Egypt, Egypt.

TREND ANALYSIS OF THESEISMIC DATA

The results of trend analysis of the seismic data are plotted as a rose diagram (Tables 1 and 2) (Figs. 18 and 19) The major trends counted in number percent (N %) are: NW-SE, E-W, NNW-SSE and NE-SW in decreasing order. Meanwhile, the major trends measured in length percent (L %) are NW-SE and NE - SW in decreasing order.

Table 1: Trend analysis of basement.

Basement				
Trend	**N**	**L (km)**	**N %**	**L %**
N- S	1	.8	1.04	.37
NNE - SSW	3	1.8	3.13	.83
NE - SW	10	10.6	10.24	4.88
ENE - WSW	5	2.6	5.21	1.2
E - W	13	26.6	13.54	12.25
WNW - ESE	9	22.4	9.38	10.31
NW - SE	44	131	45.83	60.31
NNW - SSE	11	21.4	11.46	9.85
Total	96	217.2	100.00	100.00

Table 2: Trend analysis of Abu Ballas.

Abu Ballas Formation				
Trend	**N**	**L (km)**	**N %**	**L %**
N-S	0	0	0	0
NNE-SSW	0	0	0	0
NE-SW	5	4.5	9.26	3.82
ENE-WSW	2	1.5	3.7	1.28
E-W	0	0	0	0
WNW-ESE	8	22	14.82	18.64
NW-SE	34	77.5	62.96	65.67
NNW-SSE	5	12.5	9.26	10.59
Total	54	118	100	100

N = Fault Number, L = Fault Length

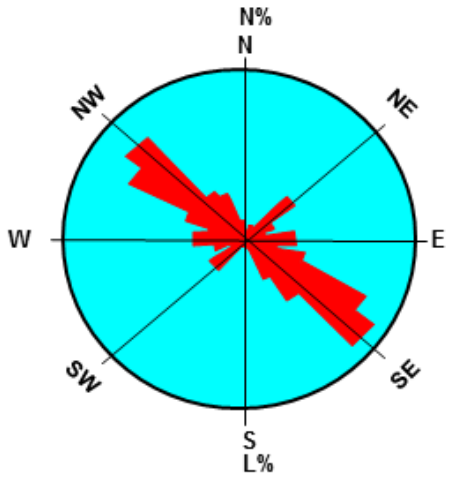

Figure 18: Rose Diagram, Based on the 2D Seismic Data, Showing the Dominant Trends in the Basement complex

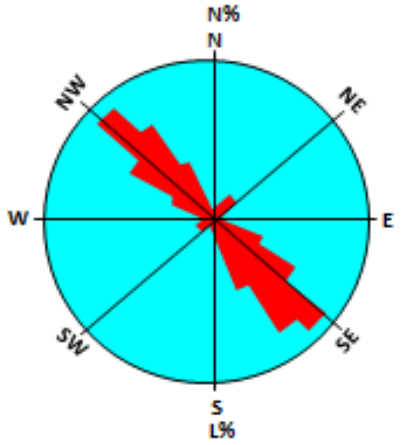

Figure 19: Rose Diagram, Based on the 2D Seismic Data Showing the Dominant Trends in the Abu Ballas Formation

LEADS AND PROSPECTS

A detailed depth map of Komombo basinal Area (Fig. 20) shows multiple separate structural culminations. The maximum structural closure of the culminations is at the central part of the studied area and on the downthrown side of the major NE- SW trending fault. In the studied area, "Lead A", "Lead B", and "Lead C" are shown as structures formed by three faults and are located at the central part of the studied area, "Lead E" is located at the southeastern part of the studied area. It is also dependant on the three aforementioned faults. "Lead G" is located at the southwestern part of the studied area. It is dependant on the four faults. "Lead H" is located at the northern part of the studied area.

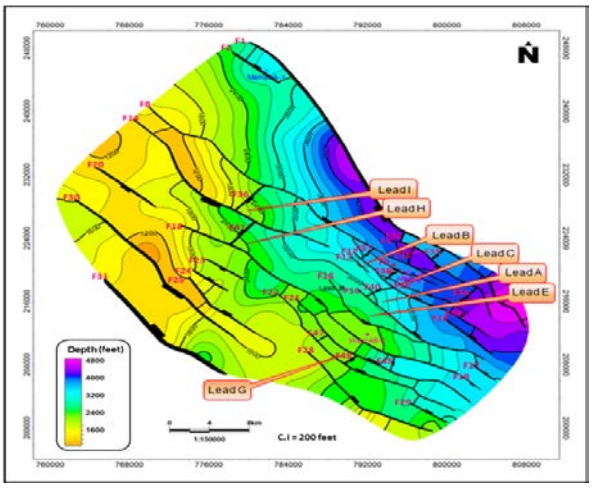

Figure 20: Depth Structural Contour Map on the Top of Six Hills E Member, Based on the 2D Seismic Data of Komombo basinal Area Showing the Detected Leads.

It is dependant on the three faults. "Lead I" is located at the northern part of the studied area. It is also dependant on the three faults. Thus, the seven leads "A", "B" , "C" , "E" , "G" , "H" and "I are fault-dependant

closures in the depth structural map. If these seven leads could be promoted to prospects, they will represent potential reserve additions in the studied area.

VI.ESTIMATION FOR THE PROSPECTIVE RESOURCES OF KOMOMBO BASINAL AREA

The Six Hills E Member is the main objective, if present with good reservoir properties. The lead parts have been assigned help to constrain the potential resource estimates.

Deterministic estimates of the potential unrisked volumes for the 7 leads have been carried out and estimated low case, based on the difference in reservoir properties, but did not reflect uncertainty in the prospect area. Uncertainty ranges assumed for properties (low) from the petrophysical analysis of Al Baraka -4 well were: net-pay (24.5 ft), porosity (14.5 %) and water saturation (47 %). The constant Bo of 1.019 was assumed.

We estimate the success case of recoverable volumes for all the leads as 67 MMbbls oil- in-place in the Six Hills E Member.

Table 3: The volumetric estimations of oil in place using the parameters ofAl Baraka field for the Six Hills ‘‘E’’ reservoir isas follow:

Element	Minimum
Area (acres)	4687
Net pay (ft)	24.5
PHI	14.5
So.	53
Bo	1.019
OOIP (MMSTB)	67
Risked OOIP (MMSTB)	12

SUMMARY AND CONCLUSION

Seismic interpretation is a process of transforming the physical responses displayed by the seismic lines into geologic information of interest, such as the structures. Seven horizons were picked in the studied area; these are: Komombo A, Komombo B, Komombo C, Six Hills D, Six Hills E, Six Hills F Members, and AbuBallas Formation. The structure contour maps constructed, based on the 2D seismic data show two main fault trends: NW-SE and E-W to NE-SW. The NW-SE trend is the dominant one. The depths of Komombo A, Komombo B, Komombo C, Six Hills D, Six Hills E and Six Hills F Members, and Abu Ballas Formation range from9170 ft to 2130 ft, from 8810 ft to 2005 ft, from 8307 ft to 1790 ft, from 5242 ft to 1116 ft, from 4925 ft to 905 ft, from 4610 ft to 687 ft and from 3810 ft to 460 ft, respectively.The detailed depth map of Komombo basinal area shows multiple separate structural culminations. The maximum structural closure of the culminations is located at the central part of the studied area and on the downthrown side of the major NE- SW trending fault**.** Thus, the seven leads "A", "B" , "C" , "E" , "G" , "H" and "I are fault-dependant closures in the depth structural map**.** Deterministic estimates of the potential unrisked volumes for the 7 leads have been carried out and estimated low case, based on the difference in reservoir properties. We estimate the success case of recoverable volumes for all the leads as 67 MMbbls oil- in-place in the Six Hills E reservoir.

ACKNOWLEDGEMENT

The authors would like to express their gratitude thanks to the lab members of the Geology Department, Faculty of Science, Al Azhar University, for their support during the progress of this study. I wish to thank the Ganoub El Wadi Petroleum Holding Company for providing the basic exploration data and encouraging him to proceed with the study.

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