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SEISMO- PETROPHYSICAL STUDY ON KAREEM FORMATION, BELAYIM LAND FIELD, WESTERN SINAI, EGYPT

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الخلاصة: تتناول هذه الدراسه التفسير السيزمى الانعكاسى و بيانات تسجيلات الآبار الرقمية المتاحة باستخدام برنامج الكمبيوتر (البتروفيزيقية التفاعلية) و قد تم تفسير البيانات السيزمية باستخدام برنامج سايزورك (هاليبرتون) و قد خلص الى قسمين لبيانات تسجيلات الآبار، بيانات رقميه جيده الآبار، مثل المقاومة الكهربية (العميقة و الضحلة) و المسامية (الصوتية و الكثافة و النيوترون) وأشعه جاما والسجلات المركبة وتم تقييم بيانات تسع آبار متفرقة هى (112-50, 112-54, 113-14, 113-24, 113-32-tri, 113-60, 113-69, 113-A-12 & 113-A-32ST-)، وتمت معالجة بيانات سجلات الابارالمقابل' لتقييم الخصائص البتروفيزيائية المختلفة وكذللك الحساب من خلال برنامج الكمبيوتر المتاح. تتنوع الخصائص البتروفيزيائيه المحسوبة من عملية تحليل سجلات الآبار بشكل عام رأسيا وأفقيا .

يمكن دراسة التباين الجانبي للخواص البتروفيزيائية في المنطقة الخاضعة للدراسة من خلال عدد من خرائط التدرج (خرائط إيزو بارامترية) والتي تتضمن محتوى الصخر الطفلى (Vsh٪) والسمك الفعال (Heff٪) والمسامية الفعالة (Øeff٪) وتشبع الهيدروكربونات (Shr٪) ولاستكمال رؤية الإمكانات الهيدروكربونية في المنطقة المدروسة، تم تنفيذ التوزيع الرأسي للخصائص البتروفيزيائية من خلال رسومات وعلاقات محسوبة للمحتوى الليثواوجى، و التشبع السائلى في شكل سجلات البيانات البتروفيزيائية (PDL). يمكن اعتبار هذه الرسومات و العلاقات بمثابة تمثيل رأسي مهم للخصائص البتروفيزيائية لأنها تستخدم لتقييم أكثر دقة في المقارنة بين الآبار المختلفة.

ABSTRACT: *Belayim Land oil field is considered as one of the largest oil fields in the Suez rift. This field is located at the central part of the Gulf of Suez, along the western coast of Sinai Peninsula. It lies to the east of Belayim Marine oil field.*
The present study deals with an integrated seismic interpretation and well-log analysis using Interactive Petrophysics computer program for Kareem Formation. The interpretation of seismic data has been done using Seis Works software (Halliburton) and represented with three seismic sections. The available well – log digital data are resistivity (deep and shallow), porosity (sonic, density and neutron), gamma-ray and composite logs for nine scattered wells (112-50, 112-54, 113-14, 113-24, 113-32-tri, 113-69, 113-A-12 & 113-A-32ST) to evaluate the different petrophysical characteristics available computer software. The petrophysical characteristics deduced from the process of well-log analysis are generally varying vertically and laterally. The lateral variation of petrophysical characteristic in the area under investigation could be studied through a number of gradient maps (iso-parametric maps); that include, shale content (Vsh %), effective thickness (Heff m), effective porosity (Øeff %) and hydrocarbon saturation (Shr %) to complete the vision of hydrocarbon potentialities in the studied area. The vertical distribution of petrophysical characteristics have been performed through the litho-saturation computerized cross-plots in the form of petrophysical data logs (PDL). The litho-saturation cross-plots may be considered as an important vertical representation for petrophysical characteristics, because they are used for more accurate evaluation for each individual well and in the comparison among the different wells.
The petrophysical characteristics of the Kareem Formation reflect the ability of this rock unit to generate, store and produce hydrocarbons. The shale content varies from 6 to 75, effective porosity ranges from 2 to 17% and hydrocarbon saturation ranges from 0-80%, which reflect good reservoir characterization.
As a recommendation, more exploration activities are needed to be done along the Belayim Land Field especially across the western part of the area under investigation.

INTRODUCTION

Belayim Land oil field is considered as one of the largest oil fields in the Suez rift. The field was discovered at the beginning of 1954 and it was put on production in September 1955. Belayim Land oil field is located at the central part of the Gulf of Suez, along the western coast of Sinai Peninsula (Fig. 1).

Belayim Land is a multilayer field with several separated sandstone reservoirs interbedded with shales and anhydrite intercalations. They range from Early to Late Miocene age and represented by (Zeit Fm, South Gharib Fm, Hammam Faraun Mbr, Feiran Mbr, Sidri Mbr, Kareem Fm, and Rudeis Fm.

STRATIGRAPHY

The stratigraphic section of Belayim Land oil field is shown in Fig. (2), (Abd El-Naby et al., 2009). It is also the normal section of the central part of the Gulf of Suez stratigraphic succession.

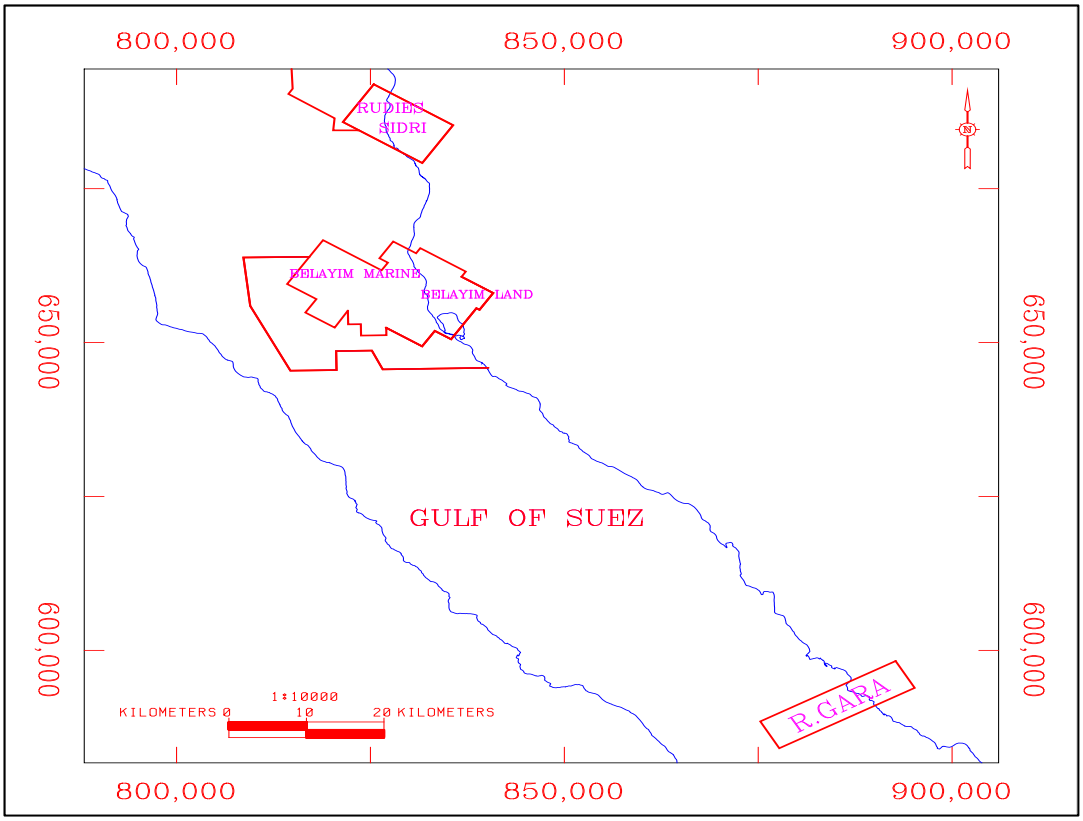

Fig. (1): Location Map of Belayim Land Field.

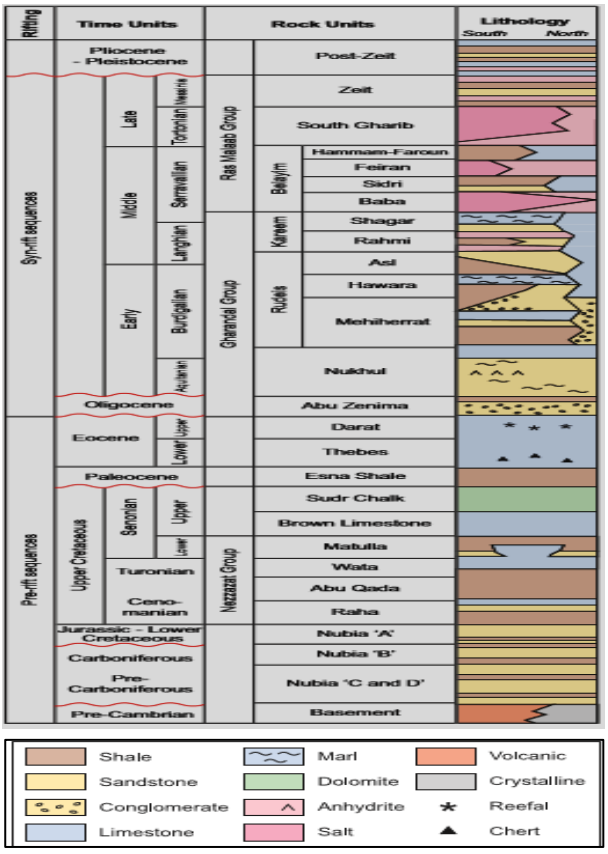

Fig. (2): Stratigraphic column of the Gulf of Suez (modified after Schlumberger, 1995; Abd El-Naby et al., 2009).

STRUCTURAL SETTING

Belayim Land oil field is located at the central dip province of the Suez rift, where the dip direction is northeast and the fault blocks are bounded by normal faults, with down throw toward the southwestern direction (Robson, 1971; Moustafa, 1976; Garfunkel and Bartov, 1977, Colletta et al., 1988, Patton et al., 1994; Bosworth, and McCaly, 2001, and Moustafa, 2004).

This structure is bounded to the west by a northwest clysmic fault trend (Awni et al., 1990). The Belayim Land field consists of a north -south trening anticline of 10 Km. long and 4 Km wide. This anticline is cut by two main faulting systems. One system (parallel to the gulf coast) representing a normal step faulting connected with the Suez Graben. The second one is represented by a series of trans current faults, which tend to subdivide the structure into different blocks.

The Belayim Land oil field occupies a northwest-southeast elongated rift block; it is bounded to the southwest by a major clysmic fault called the Belayim Land main bounding fault. It is bounded to the north by a north-northeast oriented transfer fault, with a down throw toward the northwestern direction and to the south by another transfer fault oriented NW-SE with down throw to the southwest direction, which is proved from seismic interpretation on time volume of belayim Land field, then converted to depth contour map (Fig. 3).

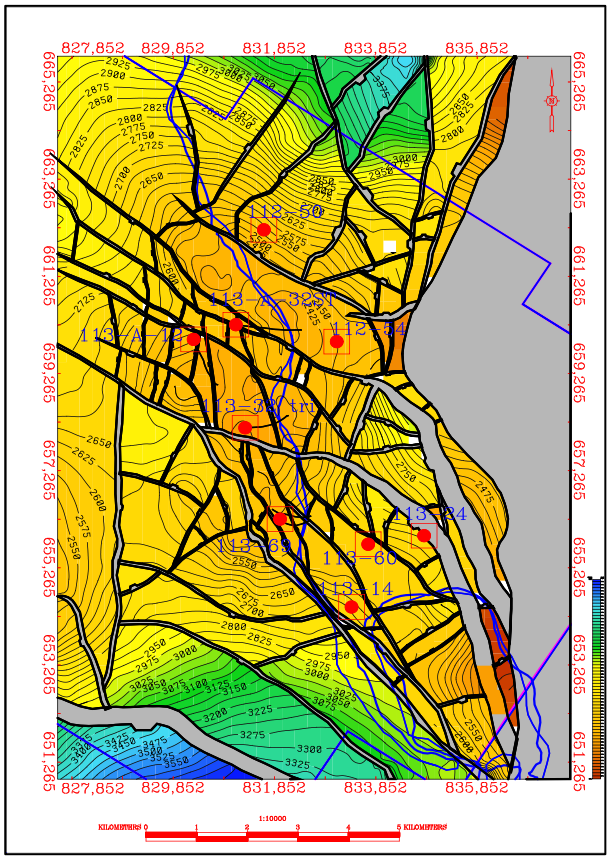

Fig. (3): Structure Contour Map on top Kareem Formation and structure affected the area. (C.I. = 25 m)

3D Seismic interpretation

Seismic data were integrated with well data, VSP data, and check shot data, to show the general structure of Belayim land field. Interpretation was also guided by some nearby surface geological models derived from surface geologic mapping in the Gulf of Suez by previous workers (eg. Moustafa 1976, Moustafa 2004). The interpretation of seismic data done by using SeisWorks software (Halliburton). The selected three seismic lines were selected on the basis of their quality, show in (Fig. 4-6).

- **The first seismic line**

(NW-SE) seismic section is located in the south-central part of the field (Fig. 4). This section shows sub-horst which formed by step fault next to the main field-bounding fault by another sub- graben This section passes through one key well with 113-69 at the central part of sub- horst.

- **The second seismic line**

(SW-NE) seismic section is located in the center most part of the field (Fig. 5).This section shows the main horst of the field which became wider. This section passes through some key wells beginning with 113-32 tri and 112-54 at the central part of the field.

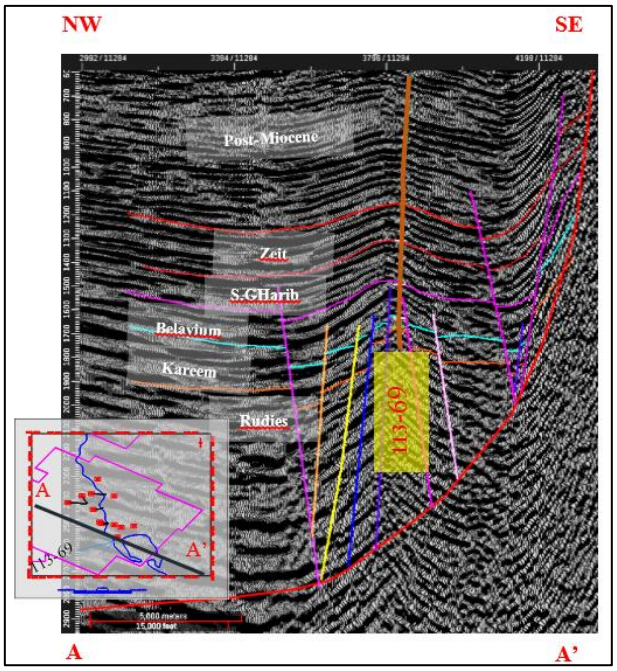

Fig. (4): (NW-SE) Cross-line Seismic section (11284) passing through south- central part of Belayim Land field.

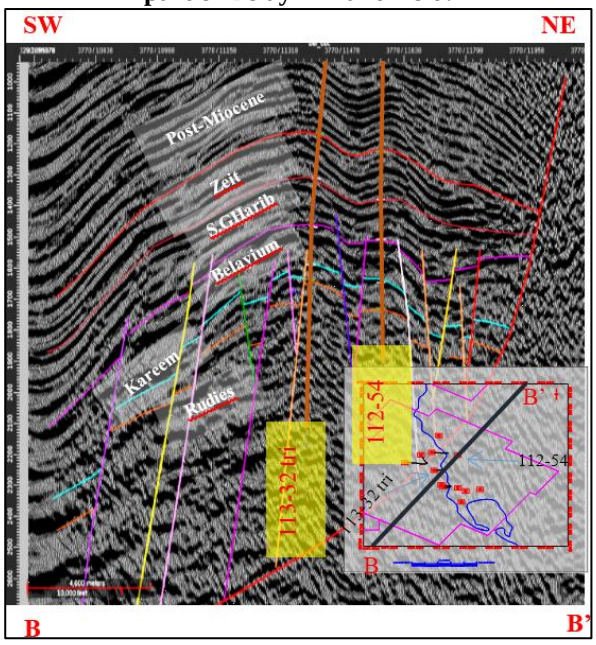

Fig. (5): (SW-NE) In-line Seismic section (3770) passing through the central part of Belayim Land field.

The third seismic line

(NW-SE) Seismic section no. 3 is located at the northern central part of the field (Fig. ٦). This section show a horst which was formed by step faults next to the main field-bounding fault by another sub-horst formed by synthetic fault and sub- grabens formed by anti-thetic faults. This section passes through 112-50 well which gives more control for the north high area of the field and its extension.

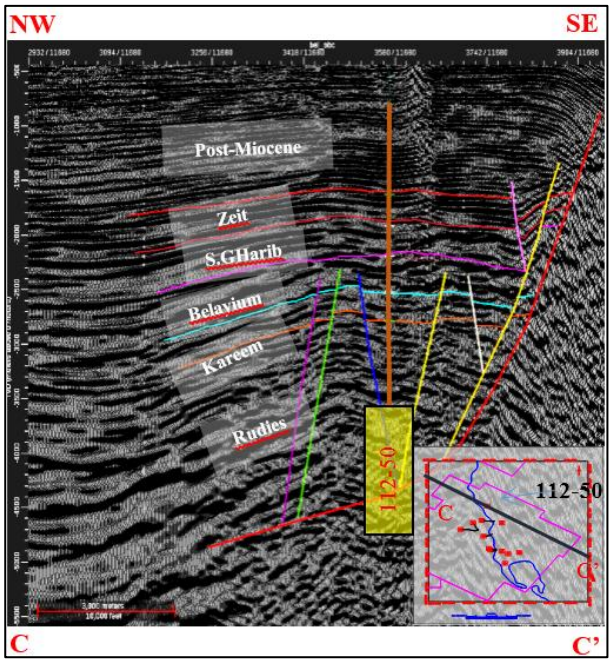

Fig. (6): (NW-SE) In-line Seismic section (3770) passing through north central part of Belayim Land field.

Well-Log Analysis

Well log analysis represents the most important stage in the evaluation of petrophysical characteristics. In this investigation; one process was applied to evaluate the petrophysical characteristics of Kareem Formation. This process depends on the application of computer softwares (computer processed interpretation), where the Techlog is used to evaluate the petrophysical characteristics of the studied formations in the form of litho-saturation plots. Petrophysical characteristics deduced from the process of well-log analysis are generally varied vertically and laterally.

Lateral Variations of Petrophysical Characteristics

Lateral variation of petrophysical characteristics could be studied through a number of gradient maps (iso-parametric maps); that include, shale content (Vsh %), effective thickness (Heff m), effective porosity (Øeff %) and hydrocarbon saturation (Shr %), shown in Fig (6-9), to complete the vision of hydrocarbon potentialities in the studied area. The final output in Table (1) includes the petrophysical parameters deduced from the computer program (CPI) for all hydrocarbon reservoirs.

Table (1): Summary of the Petrophysical parameters for Kareem formation.

Formation name	Well names	Heff (m)	Vsh (%)	Øeff (%)	Sw (%)	Shr (%)
Kareem fm.	113-A-12	49.5	22	15	20	80
	112-54	73	75	2	100	0
	113-24	48	26	16	45	55
	113-69	36	6	15	21	79
	113-A-32 ST	2	18	17	34	66

The petrophysical characteristics of Kareem Formation show that, the shale content increases relatively toward the north eastern part of the area under investigation and the maximum recorded value of shale content of 75% at 112-54 well, which is decreasing gradually toward the south, and shield out, where the minimum value of shale content is 6% at 113-69 well. The effective porosity increases toward the north western part of the studied area around 113-A-32 ST and 113-A-12 wells, and toward the south western part of the studied area, around 113-69 and 113-24 wells. It has the maximum value of 17% in 113-A-32 ST well and decrease toward the north eastern part of the studied area around 112-54 well, with value of 2%, where the change is porosity is irregular where effected structurally by normal faults with dip direction to the north west and south western direction, show in (Fig.3), so it give indication for down-dip blocks with high porosity than the eastern part. The effective thickness ranges from 2% to 73% and generally increases toward the north eastern part of the studied area. Where the maximum value at 112-54 well, which is 73% and decrease toward the north western part of the studied area around 113-A-32 ST well, with value of 2%, where the change is effective net pay thickness is irregular where effected structurally by normal faults, which 112-54 well with high effective thickness located within horst, and 113-A-32 ST located within graben, show in (Fig.3), finally all previous parameters reflect on hydrocarbon saturation increases toward the north western part of the studied area around 113-A-12, with maximum value of 80%, also toward west southern part of the studied area, around 113-69 wells, with value of 79%, and decrease toward the north eastern part of the studied area around 112-54 well, with value of 0%, where the change is hydrocarbon saturation is regular where effected stratigraphically by formation properties, where although 112-54 well with high position, but the shale volume is maximum value, and effective porosity is very small so, it will give indication for the less of hydrocarbon saturation, and 113-A-12 well with maximum value of 80%, is due to decreasing of shale volume and increasing of effective porosity.

Combined distribution maps of the Petrophysical parameters:

Figures (7-9) illustrate combined petrophysical characteristics within Kareem Formation.

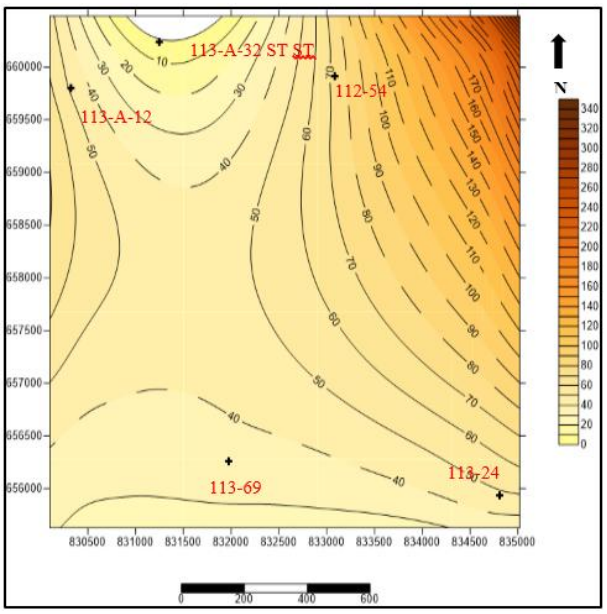

Fig. (7): Effective Thickness (m) map, (C.I. = 10 m), overlayed by structure map.

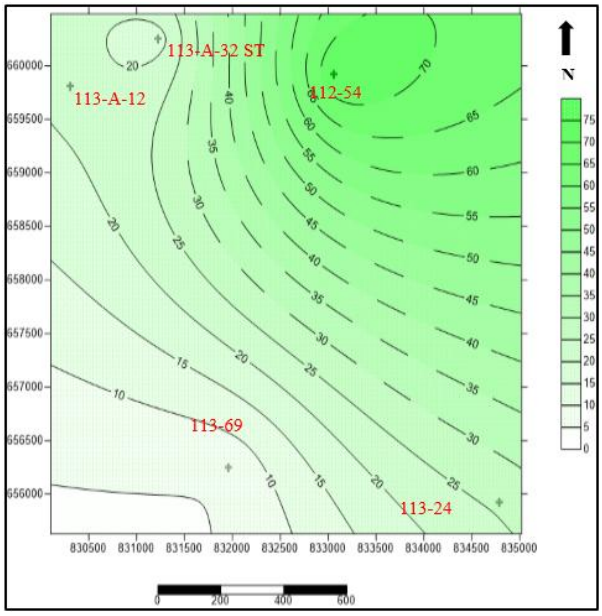

Fig. (9): Shale Content (%) map, (C.I. = 5 m).

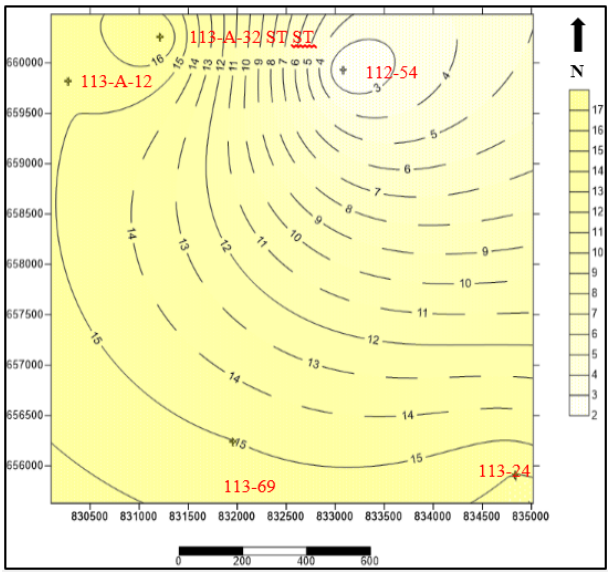

Fig. (8): Effective Porosity (%)) map, (C.I. = 1 m).

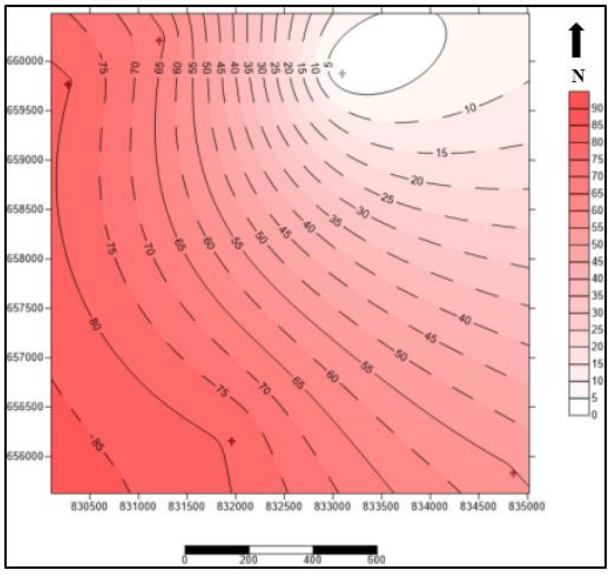

Fig.(10): Hydrocarbon Saturation (%) map, (C.I. = 5 m).

Vertical Variation of Petrohysical Characterization

The vertical distribution of hydrocarbon occurrences can be explained and presented through the construction of the litho-saturation cross-plots. The litho-saturation cross-plot is a representation, zone-wise, for the contents of fluids including water and hydrocarbon saturation, added to the rock types and contents.

Tables (2-4) (CPI) for two of the studied wells. Figures (11-13) represent petrophysical parameters obtained from Techlog software for these wells.

From the left to right the following tracks are found:

1- The first track is GR log for correlation.
2- The second track shows resistivity logs (shallow and deep curves).

3- The third track represent porosity Logs (NPHI and RHOB).
4- The fourth track: shows bulk volumes of water, movable hydrocarbons, oil and gas.
5- The fifth track: represent Matrix, silt and clay volumes.
6- The sixth track shows the effective porosity

Litho-Saturation Cross-Plot of 113-69 Well:

Table (2) represents the summary results of combined litho-saturation cross-plot of 113-69 well in (Fig. 11).

Table (2): Summary Results of the Combined Litho-Saturation Cross-Plot of 113-69 Well.

Vsh (%)	Øeff (%)	Sw (%)	Shr (%)	Heff (m)
6	15	21	79	36

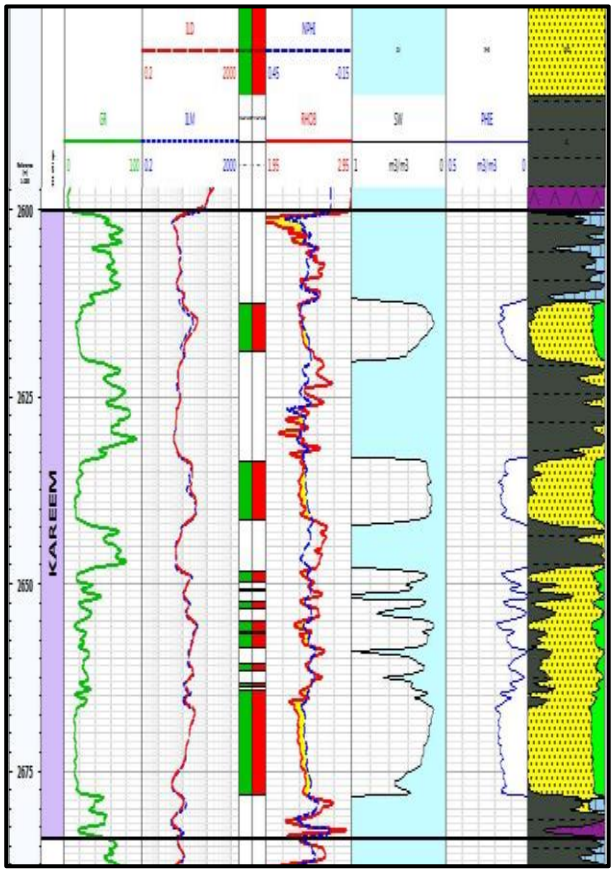

Fig. (11): Litho-Saturation Cross- Plot for Kareem Fm. in 113-69 Well.

Litho-Saturation Cross-Plot of 113-A-12 Well:

Table (3) represents the summary results of the combined litho-saturation cross-plot of 113-A-12 well in (Fig. 12).

Table (3): Summary Results of the Combined Litho-Saturation Cross-Plot of 113-A-12 Well.

Vsh (%)	Øeff (%)	Sw (%)	Shr (%)	Heff (m)
22	15	20	80	49.5

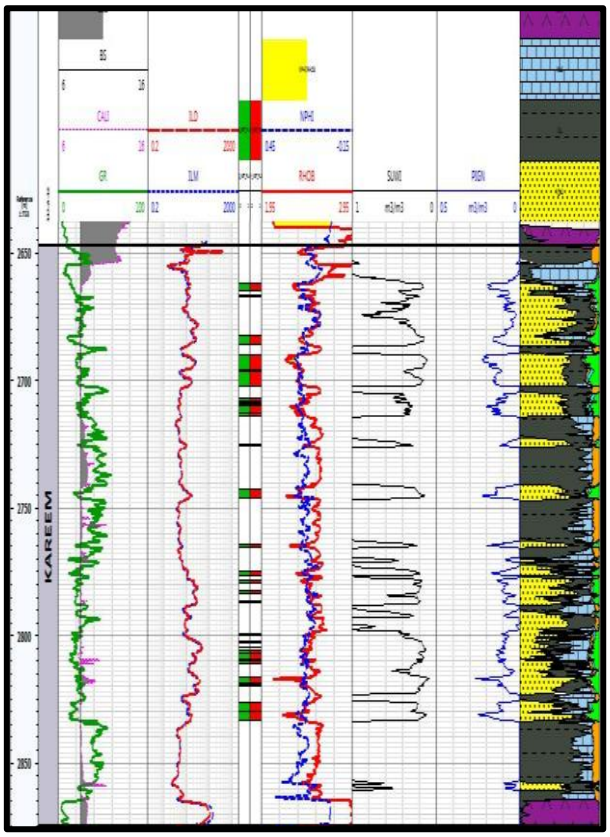

Fig. (12): Litho-Saturation Cross- Plot for Kareem Fm. in 113-A-12 Well.

Litho-Saturation Cross-Plot of 113-24 Well:

Table (4) represents the summary results of the combined litho-saturation cross-plot of 113-24 well in (Fig. 13).

Table (4): Summary Results of the Combined Litho-Saturation Cross-Plot of 113-24 Well.

Vsh (%)	Øeff (%)	Sw (%)	Shr (%)	Heff (m)
26	16	45	55	48

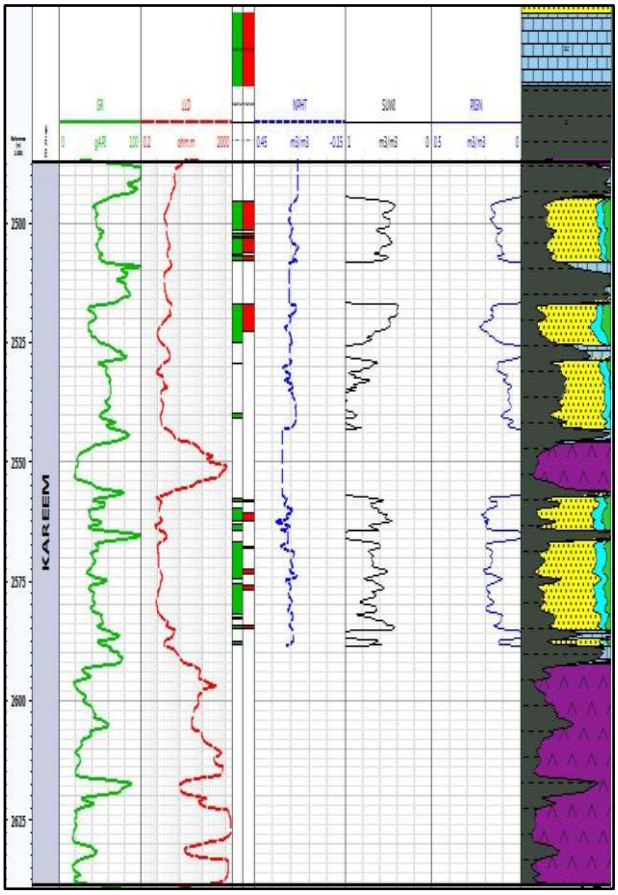

Fig. (13): Litho-Saturation Cross- Plot for Kareem Fm. In 113-24 Well.

SUMMARY AND CONCLUSIONS

Belayim Land is a large oil field, located in the central part of the Gulf of Suez, along the coast of the Sinai Peninsula, It also lies to east of Belayim marine oil field, also, Belayim Land oil field is located in the central dip province of the Suez rift, where the dip direction is northeast and the fault blocks are bounded by normal faults, with down throw toward the southwestern direction.

The field was discovered in 1954 and put on production in 1955. Belayim Land is a multi-layer field with several separated sandstone reservoirs interbedded with shales and anhydrite intercalations. The entrapment is formed by structural fault blocks.

From the Seismic point of view, the structure of Kareem Formation is represented by an asymmetrical monocline with a steep west-dipping flank and is dissected by some normal faults with down to the NE and SW throw. The throws of the normal faults range from 50 to 400 meters. Added, there are different normal faults dissect the top Kareem Formation. Each of these faults has several segments oriented NW and NNE linked together into a characteristic zigzag pattern.

The easternmost fault dips toward the NE direction (opposite to the other faults), forming a horst block in this part of the field.

The evaporitic sequence of the South Gharib – Zeit formations (Middle Miocene), provided the necessary and most efficient seals

Oil charge in Kareem Formation comes from six intervals, which are considered as source rock characteristics. These intervals consist of fine clastics and carbonates and are present in Carboniferous formations (Nubia B), in the Upper Cretaceous carbonates (Brown Limestone of the Sudr Formation), in the Paleocene-Eocene deposits (Esna Shale) and in the Lower and Middle Miocene fine clastics (Kareem, Rudeis and Belayim shales).

The petrophysical characteristics of Kareem Formation show that, the shale content ranges from 6 to 75% and increases toward 12-54 well, at the north eastern part of the area under investigation. The effective porosity of this formation ranges from 2 and 17% and increases in two accumulations, the smallest porosity is found around 113-69 and 113-24 wells at the south of the area under consideration and the largest one is around 113-A-12 and 113-A-32 ST wells, toward the south of the area under consideration. The hydrocarbon saturation has the maximum value of 80%in 113-A-12 and the minimum value of 0% is recorded in 112-54 well at the north eastern which is

From the previously mentioned deductions, the petrophysical characteristics of the Kareem Formation reflect the ability of its reservoirs to store and produce hydrocarbon.

As a recommendation, more exploration activities are needed to be done in the western part of kareem formation.

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