# Hydrocarbon Generating Basins and Migration Pathways in the Gulf of Suez, Egypt

Naglaa S. Mohamed[1], Ahmed N. Shahin[1], Ahmed M. ElKammar[2]

[1]Natural Resources Dept, Institute of African Research and Studies, Cairo University
[2]Geology Department, Faculty of Science, Cairo University
**Corresponding Author:** NaglaaSaleh 74@gmail.com

**Abstract:** The study aims to investigate the influence of rifting on the processes of organic matter maturation, hydrocarbon generation, expulsion, and migration, as well as the influence of rifting on the preservation of accumulated hydrocarbons in the Gulf of Suez. The study identified the presence of sixteen generating and expelling troughs based on the results of thermal burial histories: Darag, Nebwi, Lagia, October, Fieran, Amer, Belayim, July, Ramadan, Morgan, West Zeit, East Zeit, Ashrafi, Ghara, Gemsa, and Sharm troughs. These names were given after geographic areas or known oil fields in the proximity to the respective trough or in its vicinity. All the source formations in the sixteen troughs reached top oil window and expelled their hydrocarbons at 10 million years before present (mybp) and continued till present. Such timing post-dates the Early Miocene Mid Clysmic or Mid Rudeis "disturbing" event and the Late Miocene Messinian "quiet" event, which suggest high Migration and accumulation efficiencies for hydrocarbons generated in these troughs. The Darag, Amer, Belayim, Ghara, and Sharm troughs are considered the highest in preservation as migration started the latest among other troughs (4.8 and 2.5 mybp relative to 10 to 6 mmybp for the July, Ramadan, Morgan, West Zeit, East Zeit, Ashrafi, and Gemsa troughs). The suggested prospective areas for future exploration should be located updip and in the hydrocarbon migration pathway.
[Naglaa S. Mohamed, Ahmed N. Shahin, Ahmed M. ElKammar. **Hydrocarbon Generating Basins and Migration Pathways in the Gulf of Suez, Egypt.** *Life Sci J* 2013;10(5s):229-235] (ISSN:1097-8135). http://www.lifesciencesite.com. 41

***Keywords***: Petroleum Potential, Thermal Burial History, Great African Rift, Gulf of Suez.

## Introduction

The GOS (Figure 1) is an intercontinental rift (elongated graben) separating the Sinai Peninsula from the northern Eastern Desert. It extends for about 325 km in a north– northeast direction from Hurghada in the south to Suez City in the north. The graben is about 300 km long, and 30 to 50 km wide. It has excellent hydrocarbon potential, with the prospective sedimentary basin area measuring approximately 19,000 km$^2$, and it is considered as the most prolific oil province rift basin in Africa and the Middle East. This basin contains more than 80 oil fields, with reserves ranging from 1350 bbl to less than 1 million bbl; in reservoirs of Precambrian to Quaternary age (Schlumberger, 1984).

The time of petroleum expulsion and migration relative to the time of the main trap forming tectonic events is important, as the latter have a direct impact on petroleum accumulation and thus its preservation in the trap. The adopted method, by most workers, for predicting the level of maturation reached by the source beds, as well as the time and depth of hydrocarbon generation, expulsion and migration in a given basin is the burial geothermal geohistory modeling (Waples, 1985a&b; 1992; and El Shahat *et al*., 2009, Mohamed *et al*., 2005, Elleboudy *et al*., 2011). A geothermal gradient map for the Gulf of Suez is presented in Figure 2 using the corrected bottom hole temperature (BHT) according to Horner plot method (Fertle and Wichmann, 1977), and the present day surface temperature of twenty one drilled wells scattered along the Gulf of Suez.

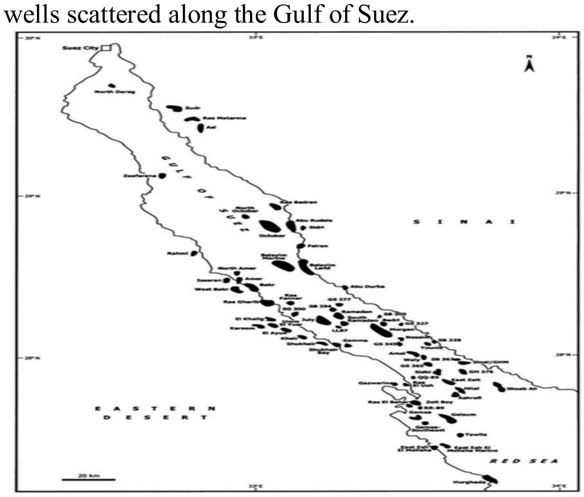



Figure 1: Location map of the major oil fields in the GOS, modified after Alsharhan, 2003

Maturation and hydrocarbon generation, migration, and entrapment are affected and controlled by the events immediately preceding the stage of peak-generation of hydrocarbons and their expulsion as Late Jurassic, Late Cretaceous and Oligocene unconformities that most effective and most disturbing tectonic event in the Gulf of Suez region (Beleity, 1982). It controlled the migration paths and the accumulation of oil expelled prior to this event. The last major tectonic event in the Gulf of Suez is the Late Miocene (Messinian) emergence, although of large magnitude (Said, 1981).

Shahin *et al*. (2002) concluded that Mheiherrat, Thebes, Esna, Lower Sudr, Matulla- Wata, Abu Qada-Raha formations and Nubia "B" lithostratigraphic units were characterized as sources of hydrocarbons in the Central GOS. They expected that the estimated remaining reserves in the Central GOS are 1.5 Billion Oil Equivalent Barrels (BOEB). Sharaf (2002) concluded that the Miocene oil in the Central GOS was sourced from carbonate-rich rock, deposited in reducing environment at normal salinities with minor contribution from clay-rich source rocks and terrestrial organic source. Alsharhan (2003) stated that major pre-rift and syn-rift source rocks have potential to yield oil and/or gas and are mature enough in the deep kitchens to generate hydrocarbons. Geochemical parameters, sterane distribution, and biomarker correlations are consistent with oils generated from marine source rocks. Oils in the GOS were sourced from potential source rock intervals in the pre-rift succession that are typically oil prone (type I), and in places oil and gas prone (type II), or composites of more than one type (multiple types I, II, or III for oil prone, oil and gas prone, or gas prone, respectively). Younes and Philp (2005) mentioned that the biomarker properties from Gas Chromatography-Mass Spectrometry (GC-MS) of the oil seepages in Gebel El Zeit area suggested marine siliciclastic syn-rift Lower Rudeis shale rocks rich in Tertiary angiosperm land plants. They also added that the oil expulsion and migration began during Middle Miocene and still continuing at present in Gebel El Zeit area. El Nady (2006) showed that the Middle and Upper Miocene source rocks in the Gulf of Suez are immature, originated mainly from mixed organic sources, have poor to fair potential to producing oil, and did not reach to the early stage of hydrocarbon generation till present time. Lower Miocene source rocks are mature, derived from marine organic sources, have good potential to generate oil and gas, and entered the early stage of hydrocarbon generation and oil window till present time. El Leboudy, *et. al*., (2011) stated that the geochemical analyses in the southern Gulf of Suez suggest the existence of seven effective and potential source rocks. Among these, the Sudr-Duwi and Matulla-Wata formations are the most prolific effective source rocks for generating oil and minor gas. El Nady (2012) recognized that the El- Khaligue-4 well in the Central Gulf of Suez is considered as a favorable episode for the accumulation of organic matter petroleum generation owing:

(1) Good source rocks,
(2) High thermal maturity level and
(3) Deposited with predominance of marine origin. El Nady *et al*. (2013) was concluded that Kareem and Rudeis formations have poor to good generating potential to generate both oil and gas at optimum maturity, while Matulla Formation has a very good and Nubia Formation has a poor generating potential to generate both oil and gas at optimum maturity

## 2.Materials and Methods:

### 2. 1.Measuring parameters:

The thermal burial history models were constructed through investigation of drilled potential source rocks, by several maturity parameters such as :

1- *Analytical measurements ;*

*Vitrinite reflectance* (Ro %) and *Thermal alteration index* (TAI):

These are used in calibrating and matching the geothermal history of the undrilled deep basinal sections. Accordingly, the maturity level reached by the deeply buried source rocks and the magnitude of tectonic and erosional events can be predicted.

2- *Calculation of the geothermal gradient in a given sedimentary sequence* :

It is one of the important parameters required to construct thermal burial history models (Wescott and Hood, 1994).

A geothermal gradient map for the Gulf of Suez is presented in Figure 2 using the corrected bottom hole temperature (BHT) according to Horner plot method (Fertle and Wichmann, 1977), and the present day surface temperature of twenty one drilled wells scattered along the Gulf of Suez. The geothermal gradient (GG) was calculated using the following equation:

GG = (BHT –Surface temperature) * 100 / Depth in feet at the measured BHT.

The geothermal gradient is expressed in degrees Fahrenheit ($^{o}$F) per 100 ft

## 3.Results and Discussions

### *3.1.Belayim Formation*

According to the thermal burial history models the measured vitrinite for Belayim Fm in the wells GS 173-3, show marginal maturity (0.69 %), but it is immature in the wells GS 9-1, Geisum W-34. and basinal point-22 (Figure 3). Belayim Fm reached the early stage of generation, where the base maturity is (0.62, 0.75, and 0.68). This suggests that the Belayim Fm is not mature enough to reach the phase of peak generation and expulsion in the drilled wells within the Gulf of Suez except at certain parts in the Southern Gulf.

### *3.2.Kareem/Rudeis Formations*

The subsidence and maturity profile, and measured maturity show that Kareem Rudeis formations are immature in the burial histories of some wells (Figure 3). While reached the oil window in other wells. Kareem-Rudeis formations indicate immature to marginally mature in NGOS, and CGOS, and mature (within the oil window) and reached the gas window in the SGOS.

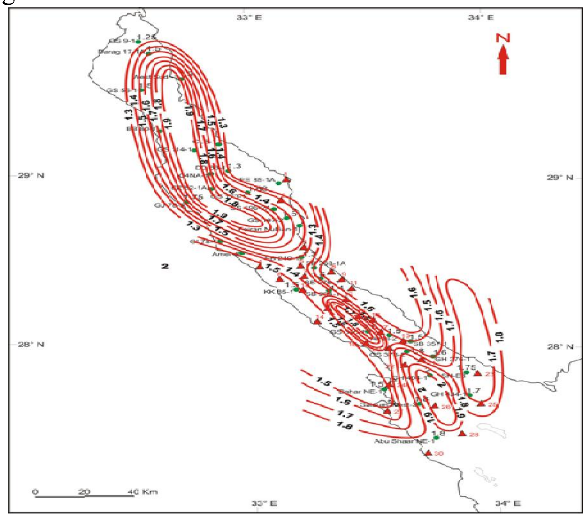


Figure 2: Geothermal gradient map, Gulf of Suez. Contour interval = 0.1 °F/100 ft.

### 3.3.Thebes Formation

According to their geological geochemical burial history models, Thebes Fm is mature and reached peak generation (Figure 3). The Thebes Fm is marginally mature in the NGOS and northern part of the CGOS, where the maturity increased southward to reach gas window in the SGOS.

### 3.4.Esna Formation

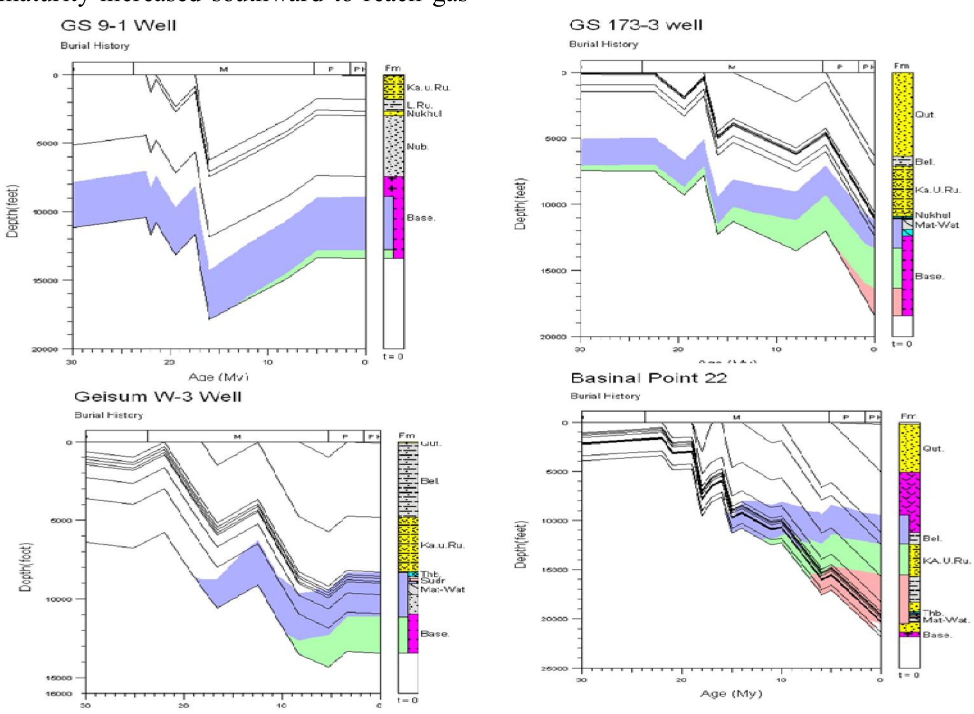
The thermal burial history models and maturity profiles of the wells (Figure 3) illustrate that the Esna Fm reached the early stage of generation. The Esna Fm reached the peak generation at about 0.2 mybp. Esna Fm not represented in NGOS and is marginally mature in the CGOS and reached the oil window and in some places the gas window in the South Gulf (Figure 3).

### 3.5.Sudr Formation

Subsidence profiles of the Sudr Fm show that it has reached peak generation in some wells (Figure 3). Sudr Fm is immature in the NGOS and is marginally mature within the stage of early generation in the northern part of the CGOS and maturity increases southward to reach the oil window in most of the SGOS and in few places to gas window.

### 3.6.Matulla and Wata Formations

These formations reached the early stage of generation and reached peak generation, expulsion and onset migration (Figures 3). Matulla and Wata formations show maturity in the early stage of generation in the NGOS and increase southward to reach oil window in the northern part of the CGOS and reached gas window in the Southern part of the CGOS and also in the SGOS.




O = Oligocene, M= Miocene, P= Pliocene, Pl = Pleistocene

Figure 3: Thermal burial history of the sedimentary sections of the wells GS 9-1, GS173-3, Geisum W-3, and basinal point 22, Gulf of Suez, Egypt.

### *3.7.Abu Qada Raha Formations*

According to burial history models these formations reached early generation and reached oil window (Figure 3) the maturity increases towards the center of the Gulf where the maturity ranges from marginally mature to mature in the oil window in the NGOS and northern part of the CGOS and to the gas window in the southern part of the CGOS and northern part of the SGOS, where these formations are missing in the southern part of the SGOS due to Erosion or non deposition.

### *3.8.Nubia B Member of the Nubia Formation*

Nubia Fm reached the peak generation as indicated by burial history models (Figure 3). The maturity generally increased towards the center of the Gulf where it ranges from marginally mature to mature in oil window in NGOS and northern part of CGOS, while maturity increased southward to reach gas window stage.

### 3.9.Mature troughs in the Gulf of Suez

Based on the results of thermal burial histories of twenty one wells and twenty nine basinal points which are pseudo sections constructed based on available magnetic depth to basement the resulted basinal areas are Darag, Nebwi, Lagia, October, Fieran, Amer, Belayim, July, Ramadan, Morgan, West Zeit, East Zeit, Ashrafi, Ghara, Gemsa, and Sharm troughs (elongated basins). In order to outline these generating troughs in order to represent the areal extent which is hydrocarbon expelling, the depth of peak generation and expulsion as predicted by the models was overlain onto a structure contour map of top of a source bed (Patton *et al*., 1994).

From the iso-reflectance maturity maps of all the source beds in the GOS (Figures 4 and 5), which represents the mature generating troughs for the Eocene and older rocks we can conclude that some basins may not be shown on some iso-reflectance maps due to either missing data or the subject formation is younger than the reference depth structure map.

***Belayim trough:***

Thebes, Esna, Sudr, Matulla and Wata, Abu Qada and Raha, and Nubia formations reached the oil window at about 2.5 to 0.3 mybp in the trough

***July trough:***

The source rock formations (Thebes, Sudr, Matulla and Wata, Abu Qada and Raha, and Nubia) started to generate hydrocarbons at 6 mmybp and continued uptil 1.1 such late timing of maturation of the source rocks implies high degree of preservation for hydrocarbons expelled in this trough.

***Ramadan trough:***

The source rock formations (Kareem and Rudeis, Thebes, Esna, Sudr, Matulla and Wata, Abu Qada and Raha, and Nubia) started to generate hydrocarbons at 8.2 mmybp and continued uptil 6.2. There are some source rock entered the gas window in this trough at about 3.7 to 0.32 mybp.

***Morgan trough:***

The source rock formations (Kareem and Rudeis, Thebes, Esna, Sudr, Matulla and Wata, Abu Qada and Raha, and Nubia) started to generate hydrocarbons at 8.7 mybp and continued until 0.1.

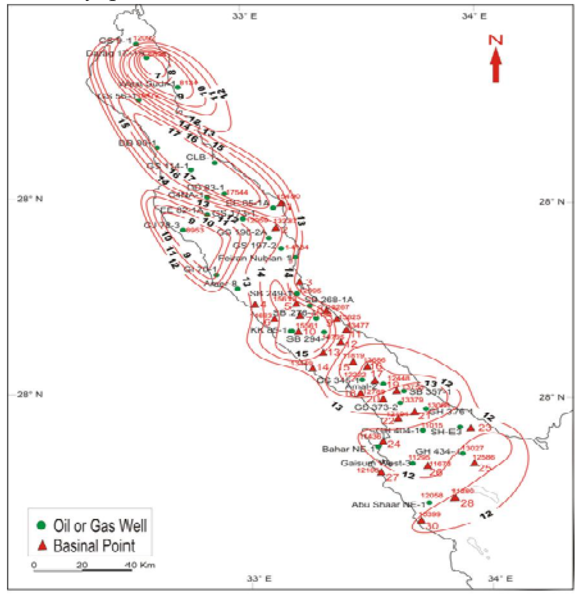



**Figure 4: Depth to peak generation and expulsion (Top Oil Window) map**

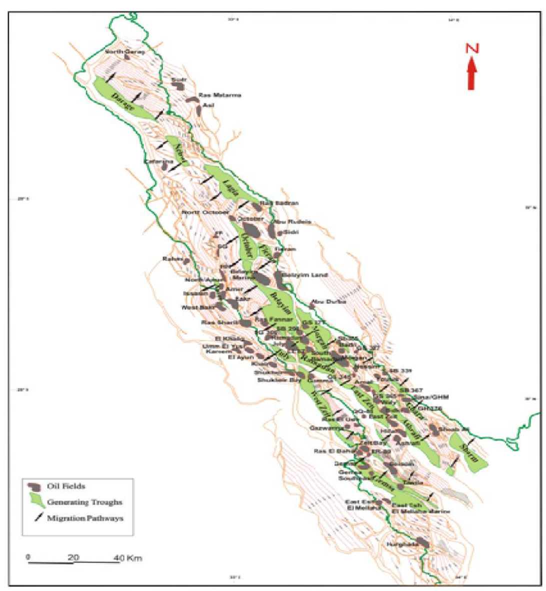



**Figure 5: Top Eocene depth structure contour map showing the outlines of generating troughs and the suggested migration pathways of hydrocarbons.**

.

In this trough there are some source rock entered the gas window at about 3 to 0.1 mybp.

***West Zeit trough*:**

The source rock formations (Kareem and Rudeis, Thebes, Esna, Sudr, Matulla and Wata, Abu Qada and Raha, and Nubia) started to generate hydrocarbons at about 7.4 to 2.2 mmybp.

***East Zeit trough:***

This is the first and may be the only instance that Belayim Fm reached the oil window in this trough together with other source rock formations (Kareem and Rudeis, Thebes, Esna, Sudr, Matulla and Wata, Abu Qada and Raha, and Nubia) where all the source rocks started to generate hydrocarbons at about 9.4 to 0.07 mybp. From Kareem and Rudeis to Nubia source rocks entered the gas window at about 6.44 to 3.36 mybp.

***Ashrafi trough:***

All the source rock formations (Kareem and Rudeis, Thebes, Esna, Sudr, Matulla and Wata, Abu Qada and Raha, and Nubia) started to generate hydrocarbons at about 6.9 to 1.3 mmybp. From Kareem and Rudeis to Nubia source rocks entered the gas window at time ranging from 3.5 to 1.5 mybp.

***Gemsa trough*:**

The source rock formations (Kareem and Rudeis, Thebes, Esna, Sudr, Matulla and Wata, Abu Qada and Raha, and Nubia) started to generate hydrocarbons since time ranging from 10 to 5.7 mmybp. The source rock formations entered the gas window at about 7 to o.9 mybp.

### 3.10.Mapping Time of Peak Generation

The time of peak generation and expulsion derived from the thermal subsidence models was mapped for each source formation in the recognized troughs. These maps suggest preservation time limits for the generated and expelled hydrocarbons and, consequently help in suggesting trends of promising plays and leads in areas which subsequently help in locating potential prospects. Therefore, the sequential order of petroleum expulsion and trap formation is of prime importance to explorationists. Help in predicting timing of expulsion and migration in relation to the known geologic events in the Gulf. Preservation of hydrocarbons expelled would be questionable if the trap formation post-dated the time of petroleum migration, i.e. if migration of oil precedes the trap forming tectonic event.

The late maturation, expulsion, and short distance migration would allow for excellent preservation of the hydrocarbons expelled and accumulated in all troughs. All the source formations in the troughs reached top oil window and expelled their hydrocarbons since 10 mmybp and continued to 0.1 mmybp, such timing post-dates the Early Miocene Mid-Clysmic or Mid-Rudeis disturbing event (16.6 mmybp) and pre-dates the Late Miocene Messinian quite event (5.3) only in the Southern Gulf, which suggest high migration and accumulation efficiency for hydrocarbons generated in these troughs. As stated above, the later the maturation and migration the higher the preservation. Therefore, from the preservation point of view, the Nebwi, Lagia, October, Fieran, and Belayim troughs are considered the highest in preservation as migration started the latest among all troughs (from 4.8 to 2.5 mmybp relative to 10 to 6 mmybp for the other troughs).

### 3.11.Mature Areal Extent

The base Belayim Fm maturity map shows that this formation is immature in Darag, Nebwi, Lagia, October, Fieran, Amer, and northern part of Belayim trough and marginally mature in southern part of Belayim, July, Ramadan, Morgan, West Zeit, Ghara, and Sharm troughs. But this formation is mature within the oil window in East Zeit, Ashrafi, and Gemsa troughs.

The base Kareem and Rudeis formations are immature in Darag, and marginally mature in Nebwi, Lagia, October, Fieran, Amer, July, Ramadan, northern West Zeit, southern Ashrafi, Ghara, and northern Gemsa troughs. And these formations fall within the oil window in Morgan, southern West Zeit, northern Ashrafi, southern Gemsa, and Sharm troughs.

The base Thebes Fm is immature in October, Fieran, and Amer troughs, and marginally mature in Darag, Nebwi, Lagia, July, and Ghara. Thebes Fm is immature in north to mature within oil window to south of Belayim trough, it is marginally mature to mature within oil window in Ramadan, Ashrafi, Gems, and Sharm troughs, Thebes Fm is mature within oilwindow in Morgan, West Zeit, northern East Zeit, while it entered the gas window in southern East Zeit trough. Esna Fm not represented in Northern Gulf so it didn't appear in both Darag, and Nebwi troughs, may be due to non deposition or erosion, it is immature in Lagia, Fieran, and Amer troughs, and marginally mature in October, northern Belayim, July, northern Ramadan, and Ghara troughs, Esna Fm is mature within the oil window to gas window in Morgan, West Zeit, East Zeit, Ashrafi, Gemsa, and Sharm.

The base Sudr Fm maturity map (Figure 6) shows that it is immature in Darag, Fieran, and Amer troughs and marginally mature in Nebwi, Lagia, and October, Sudr Fm is marginally mature to mature within oil window in Belayim, July, and Ghara troughs, and reached to gas window in Ramadan, Morgan, West Zeit, East Zeit, Ashrafi, and Sharm.

Matulla and Wata formations are marginally mature in Darag, Nebwi, Lagia, October, Fieran, and Amer, it is marginally mature to mature within oil window in Belayim, Ashrafi, ghara, and Sharm, Matulla and Wata formations reached oil window in

July trough, but reached gas window in Ramadan, Morgan, West Zeit, East Zeit, and Gemsa troughs.

Abu Qada and Raha formations are marginally mature in Darag, Nebwi, Amer, and Ghara, marginally mature to mature within oil window in Lagia, October, Fieran, Belayim, july, and West Zeit troughs. Abu Qada and Raha formations are mature to gas window in Ramadan, Morgan, East Zeit, and northern Ashrafi. These formations are missing in southern Ashrafi, Gemsa, and Sharm, as they generally not found in SGOS may be due to non deposition or erosion.

Nubia B member is marginally mature in Darag, Nebwi, Amer, and Ghara troughs, it is mature fall in oil window in Lagia, October, Fieran, July, West Zeit, Ashrafi, and Sharm troughs, Nubia B mrmber fall within the gas window in Belayim, Ramadan, Morgan, East Zeit, and Gemsa troughs.

**Migration Pathways and Oil Fields Charge**

The petroleum migration map (Figure 5) was constructed to illustrate the proposed updip migration paths of hydrocarbons where oil migrates updip towards the least pressure guided by the driving force of buoyancy.

North Darag, Sudr, and Ras Matarma, oil and gas fields are located updip and charged with hydrocarbons from the Darag trough. Asl Field reservoirs may have received their oil from the Nebei trough. The Lagia trough may be considered the main contributor to Ras Badran Field and also to North October and October fields. Fieran trough charged Belayim Marine Field, Belayim trough can be considered the feeder for a large number of oil fields such North Amer, Amer, Bakr, West Bakr, Ras Gharib, Abu Durba, BS 305, Badri, and GS 327. Morgan Field reservoirs may have received their oil from Morgan trough, July Field from July trough, Ramadan, South Ramadan, and SB 294 may be charged with hydrocarbons from Ramadan trough, Amal, Waly, Sidki, GS 345, and East Zeit oil and gas fields are located updip and charged with hydrocarbons from the East Zeit trough. Shoab Ali Field reservoirs may have received their oil from the Ashrafi trough. The Ashrafi trough may be considered the main contributor for GH-376 Field. Other small but mature basins in the southern part of the Gulf of Suez, are the potential charging areas for the Hilal and Ashrafi fields. West Zeit trough charged for Gazwarina, Ras El Ush, and QQ 89 fields. Gemsa trough is the contributor for the fields Gemsa, Geisum, Gemsa southeast, and Tawila.

The suggested prospective areas for future exploration should be located updip and in the hydrocarbon migration pathway. Examples are locations to the south from Asl Field, south Zaafarana Field, and north Ras el Ush Field.

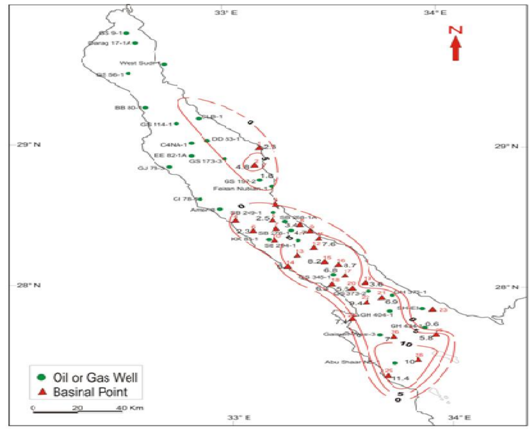



**Figure 6: Time of hydrocarbon peak generation, expulsion, and migration of the Nubia Fm Gulf of Suez. Contour interval = 5 mmybp**

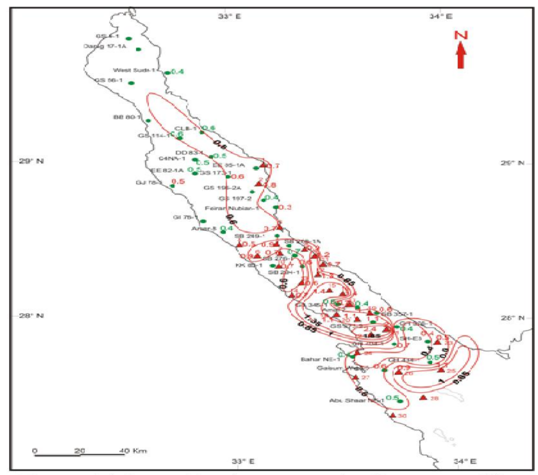



**Figure 7: Isoreflectance maturity map of the Sudr Formation Gulf of Suez. Contour interval = 0.2 & 0.25 %Ro eq.**

**Conclusions**

The study identified the presence of sixteen generating and expelling troughs, all the source formations in the sixteen troughs reached top oil window and expelled their hydrocarbons at 10 million years before present (mybp) and continued till present. Such timing post-dates the Early Miocene Mid Clysmic or Mid Rudeis "disturbing" event and the Late Miocene Messinian "quite" event, which suggest high Migration and accumulation efficiencies for hydrocarbons generated in these troughs. The Darag, Amer, Belayim, Ghara, and Sharm troughs are considered the highest in preservation as migration started the latest among other troughs. The suggested prospective areas for future exploration should be located updip and in the hydrocarbon migration pathway. Examples are locations to the south from Asl Field, south Zaafarana Field, and north Ras el Ush Field.

**4.References**


1-Alsharhan, A.S., 2003, Petroleum geology and potential hydrocarbon plays in the Gulf of Suez rift basin, Egypt, AAPG Bulletin, V. 87, pp. 143-180.

2-Beleity, A.M., 1982, The composite standard and definition of paleoevents in the Gulf of Suez: EGPC 6 th E & P Conference, Cairo, 23 p.

3-El Leboudy, M. M., et. al., 2011: Hydrocarbon Potential and Undiscovered Reserves in the Southern Gulf of Suez, Egypt: 10th Offshore Mediterranean Conference and Exhibition "OMC", Ravenna, Italy, 14 pp.

4-El Nady, M. M. 2006. The hydrocarbon potential of Miocene source rocks for oil generation in the South Gulf of Suez, Egypt. *J. Pet. Sci. Tech*. (24):309–361.

5-El Nady. M. M., 2012. The Advantage of Rock-Eval pyrolysis, LG and GC/MS in characterizing organic matter: Case study of El-Khaligue-4 well, central Gulf of Suez, Egypt. J. Energy Sources, (34): 1448 – 1458

6-El Nady M. M. Mohamed N. S. and Shahin A. N. 2013. Source-Rock Potential of Miocene-Paleozeoic Sediments in GH-376 Oilfield, South Gulf of Suez, Egypt. Accepted in J. Energy Sources

7-El-Shahat, W., Villinski J. C., El-Bakry, G., 2009, Hydrocarbon potentiality, burial history and thermal evolution for some source rocks in October oil field, northern Gulf of Suez, Egypt Journal of Petroleum Science and Engineering 68 (2009) 245–267.

8-Fertle, H.W., and Wichman, 1977, How to determine static bottom hole temperature from well log data. World Oil, V. 184, p. 105-106.

9-Mohamed, N.S., Shahin, A.N., El Kammar M.A., Sharaky, A.M., 2005, Influence of the African Rifting System on the Petroleum Potential in East Zeit Area, Egypt. M.sc. Thesis, Cairo University, Egypt, 219 pp.

10-Patton, J.L., Moustafa, A.R., Nelson, R.A. and Abdine, S.A., 1994, Tectonic evolution and structural setting of the Suez rift, in. London, S.M., (ed.), Interior rift basins, AAPG Memoir 59, pp. 9-55.

11-Said, R., 1981, The geological evolution of the River Nile: Springer Verlag, New York, 151 p.

12-Schlumberger, 1984, Well evaluation conference, Geology of Egypt, 64p.

13-Shahin, A.N., Sharaf, L.M., and El Leboudy, M.M., 2002, Distribution of effective hydrocarbon source beds in time and space and preservation time limits of petroleum in relation to the tectonic events in the Central part of Gulf of Suez: Middle Earth Research Center Ain Shams University, Earth Science Series, V. 14, pp. 26-48.

14-Sharaf, L.M., 2002, Study of Miocene oils in the Central Gulf of Suez and their genetic relationship with their equivalent from the Northern Gulf of Suez based on biomarker distribution: Middle Earth Research Center, Ain Shams University, Earth Science Service, 16, pp. 25-41.

15-Waples, D.W., 1985, Geochemistry in petroleum exploration, International Human Resources and Development Corporation, Boston, 232 p.

16-Waples, D.W., Kamata, H., and Suizu, M., 1992a, The art o maturity modeling part 1: Finding a satisfactory geologic model. AAPG Bulletin, V. 76, pp. 47-66.

17-Waples, D.W., Suizu, M., and Kamata, H., 1992b, The art of maturity modeling part 2: Alternative models and sensitivity analysis, AAPG Bulletin, V. 76, pp. 31-46.

18-Wescott, W.A., and Hood, W.C., 1994, Hydrocarbon generation and migration routes in the East Taxas Basin. AAPG Bulletin, V. 78, pp. 287-307.

19-Younes, M. A., and Philp, R. P., 2005, Organic geochemical characteristics of source rock dependent biological markers and carbon isotope distribution from crude oils in the Southern Gulf of Suez province, Egypt, Second International Petroleum Conference and Exhibition, Cairo, 2005 (abstract).


2/28/2013