Egyptian Geophysical Society
EGS Journal, Vol. 16, No. 1, 65-70 (2018)

FORMATION EVALUATION FOR SOME OIL PRODUCING WELLS IN GEBEL EL-ZEIT AREA, GULF OF SUEZ, EGYPT

M.M. SHAWN[1]; A.S. ABU EL-ATA[2], E.H. SHENDI[3] and I.Z. EL-SHAMY[4]

(1) Head of Exploratory Search, Petrozeit Oil Company, Maadi, Egypt.
(2) Faculty of Science, Ain Shams University, Cairo, Egypt.
(3) Faculty of Science, Suez Qanal University, Ismailia, Egypt. 01150285418
(4) Faculty of Science, Helwan University, Cairo, Egypt.

التقييم التكويني لبعض الآبار المنتجة للبترول بمنطقة جبل الزيت، خليج السويس، مصر

الخلاصة: يمكن للأساليب الجيولوجية السطحية أن تساعد في تحديد التراكيب تحت السطحية التي قد تحتوي على موائع، ولكنها غير قادرة على التنبؤ ما إذا كانت هذه التراكيب تحتوي على الهيدروكربونات أم لا. وبناء على ذلك، ليس هناك حل آخر سوى حفر بئر لتحديد حقيقة وجود الهيدروكربونات تحت السطح من عدمه. التقييم البتروفيزيائي للطبقات هو عملية استخدام قياسات البئر لتقييم خصائص التراكيب تحت السطحية والأهداف الرئيسية للتقييم هي: تحديد الخزانات، وتقدير حجم الهيدروكربونات في مكانها، وحساب الهيدروكربونات القابلة للاسترداد. ولا يوجد في منطقة جبل الزيت سوى حقل واحد لإنتاج النفط وهو حقل رأس العش. وأدى تفسير قياسات (TDT) لبعض آبار هذا الحقل إلى تقسيم طبقة الماطلة إلى نطاقات صخرية مختلفة داخل كل بئر، في حين أن تكوين المالحه لم يغطي بالكامل بواسطة هذه التسجيلات في بعض الآبار. تختلف نسبة التشبع المائي (S_W) داخل طبقة الماطلة، من ٣٠٪ إلى ٨٠٪. وقد لوحظت مناطق الغاز في بعض الآبار و قد تم فيها تحديد مستوى خط تماس الغاز و الزيت (GOC). قطاع المالحه يتكون من الرمال النظيفة مع وجود حجم قليل من الكاولينيت في معظم الآبار. سمك طبقة التارمات حوالي ± ٧٨ قدماً، فوق مستوى خط تماس الزيت و الماء (OWC)، داخل تكون المالحه. طبقة التارمات لها نفس العمق و تقريباً نفس السمك في جميع الآبار، و هي تفصل النفط أعلاها عن الماء أدناها.

ABSTRACT: *Surface geological methods can help to identify the interesting sub-surface structures which may contain fluids, but are unable to predict whether they contain hydrocarbons or not. Accordingly, there is no solution other than drilling a well to really determine the presence of hydrocarbons below the surface. Formation evaluation is a process in which borehole measurements are used to evaluate the characteristics of subsurface formations. The primary objectives of formation evaluation are: the identification of reservoirs, the estimation of hydrocarbons in place and the estimation of recoverable hydrocarbons. Gebel El Zeit area has only one oil producing field which is Ras El Ush (REU) Oil field. The TDT interpretation for different REU Field wells resulted in divided the Matulla Formation into different intervals within each well, while the Malha Formation did not be covered by the TDT log in some of these wells. The S_W varies, in the intervals of the Matulla Formation, from 30% to 80%. Gas zones were observed in some wells and the GOC were detected. The Malha Formation is a clean sand formation with little kaolinite volume in most wells. The thickness of the Tarmat section is about ±78 ft, above the OWC, within the Malha Formation. The Tarmat section has the same depth and almost has same thickness in all wells. It separates the oil, above, from the water, below.*

INTRODUCTION

Gebel El Zeit area is located in the south western offshore margin of the Gulf of Suez region, approximately 400 km to the south east from Cairo, and covers about 1400 km^2 in area (Fig. 1). Exposures on the Gebel El-Zeit western flank show regional southwest dip. As seen throughout the studied area, the main bounding clysmic faults are prevailing, the cross faults having trends east-west and northeast-southwest can be mapped and traced from outcrops. The types of fault regimes and the regional tectonic events that developed the Suez rift have also controlled the Miocene facies development in Gebel El-Zeit area. Pre-rift strata well developed in Gebel El-Zeit especially in the axial trough (East and West). The lower and middle Miocene clastic sections have been well established in the surface and subsurface of Gebel El-Zeit area.

The geologic, stratigraphic, structure and tectonic settings of the Gulf of Suez including the Gabel El-Zeit area have been studied by many authors, among them are Youssef (1957), Kostandi (1959), Said (1962, 1971 and 1990), Abdallah et al. (1963), Hassan (1967), Weissbrod (1969), Bosworth, (1985), Hermina et al. (1989), Evans and Moxon (1988).The only oil producing field in Gebel El-Zeit area is Ras El Ush (REU) Oil field. All wells in REU field were drilled directionally from land behind the coast line. In Ras el Ush field, the main producing pay zones are found in the Matulla and Malha formations. The objectives of the TDT interpretation of REU field wells were monitoring the gas cap intervals, determining the oil saturation and positioning of the oil-water contact and the gas-oil contact as well as determining the source of water production.

METHODOLOGY

The objective of the TDT Sigma runs was to determine the position of the oil-water contacts, the gas-oil/gas-water contacts and the reservoir oil saturation profile. Sigma is used to discriminate between hydrocarbons and saline water, since chlorine has a very large capture cross section compared to hydrocarbons and reservoir rocks. The greater the total salt counts (NaCl per 1000 ppm) in the formation waters, the better the TDT tool quantitatively describes the water saturation.

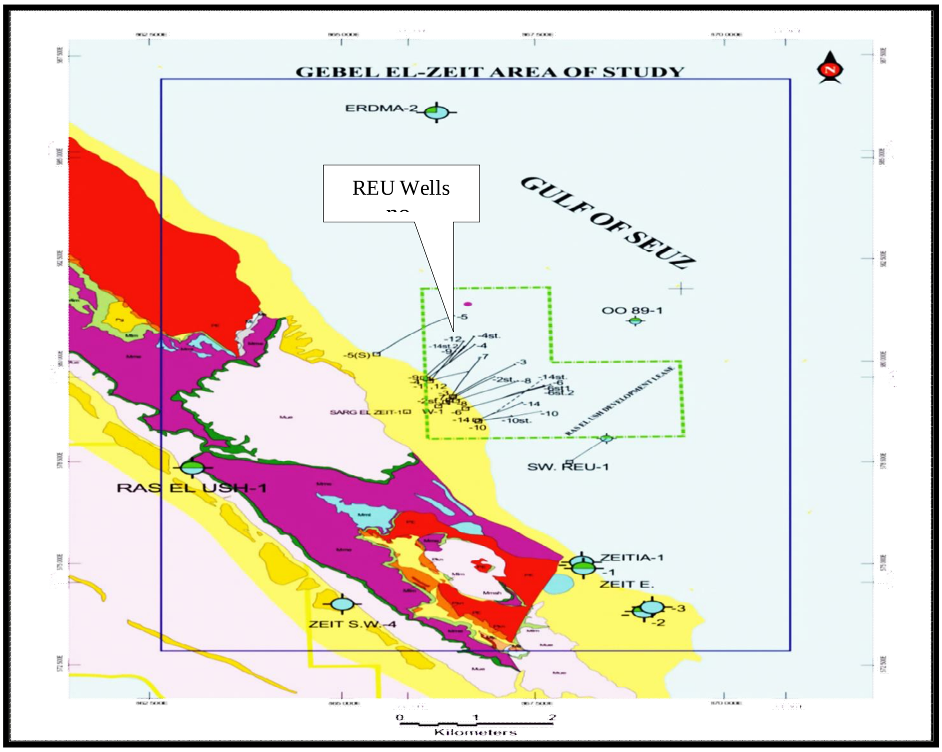

Fig. 1: Location Map of the Study Area.

In the analysis done for the REU wells, cased hole porosity from TDT (TPHI) and the far and near capture counts were used to evaluate the presence of gas. When the borehole gases musk the TPHI reading from the TDT, gas evaluation will be disabled and sigma will only be used to differentiate water from hydrocarbons. The total and the effective porosities along with the lithology volumes, the volume of shale and original open hole water saturation were used in the sigma calculation in order to enhance the match with the sigma responses. In the wells, which do not have open hole data, GR-TDT and TPHI-TDT were used to generate a basic formation evaluation. Sigma saturation result is highly influenced by lithology. In the interpretation done for REU wells, no caliper data are available from old runs so washed out intervals could not be highlighted. In presence of washout, sigma reads high values and the saturation computation will indicate more water. Absence of the photoelectric factor PEF in the open hole data of some wells in the study area (for example REU-3, REU-9, REU-8 & REU-7), would also affect the accuracy of lithology modeling.

The capture cross-section (SIGMA) curve from TDT Sigma mode can be used to determine quantitative water saturation at the time TDT is logged. Sigma is used to discriminate between hydrocarbons and saline water, since chlorine has a very large capture cross section compared to hydrocarbons and reservoir rocks. The effects of water salinity, porosity, and shale lines on the measured parameter sigma (the quantitative part of the water saturation solution) are similar to those on resistivity logs. A simple interpretation model presumes that formation sigma is equal to the sum of the constituent sigma values weighted by the fractional volume occupied. The capture cross-section (SIGMA) measurement can be expressed as follows:

$$\Sigma_{log} = \Sigma_{ma}\,(1-\Phi_e-V_{sh}) + V_{sh}\Sigma_{sh} + \Phi_e S_w \Sigma_{wa} + \Phi_e\,(1-S_w)\,\Sigma_{hyd}$$

Where:

- Σ_{ma}: matrix capture cross-section (here used as variable matrix composed of Quartz & Calcite).
- Σ_{sh}: clay capture cross-section.
- Σ_{wa}: water capture cross-section.
- Σ_{hyd}: hydrocarbon capture cross-section.
- Φ_e: is the effective porosity and S_W is the water saturation.

The sigma log value is then used to calculate moveable water saturation. Transformation of the functional volume model in the previous equation yields the classic solution for S_W:

$$S_W = \frac{(\Sigma_{log} - \Sigma_{ma}) - \Phi_e\,(\Sigma_{hyd} - \Sigma_{ma}) - V_{sh}\,(\Sigma_{sh} - \Sigma_{ma})}{\Phi_e\,(\Sigma_{wa} - \Sigma_{hyd})}$$

The following endpoint values were used:

Σ Illite: 41 cu	Σ Kaolinite: 21 cu
Σ Quartz: 4.7 cu	Σ Calcite: 7.4 cu
Σ Water: 81	Σ Oil: 19 cu
Σ Gas: 5 cu	

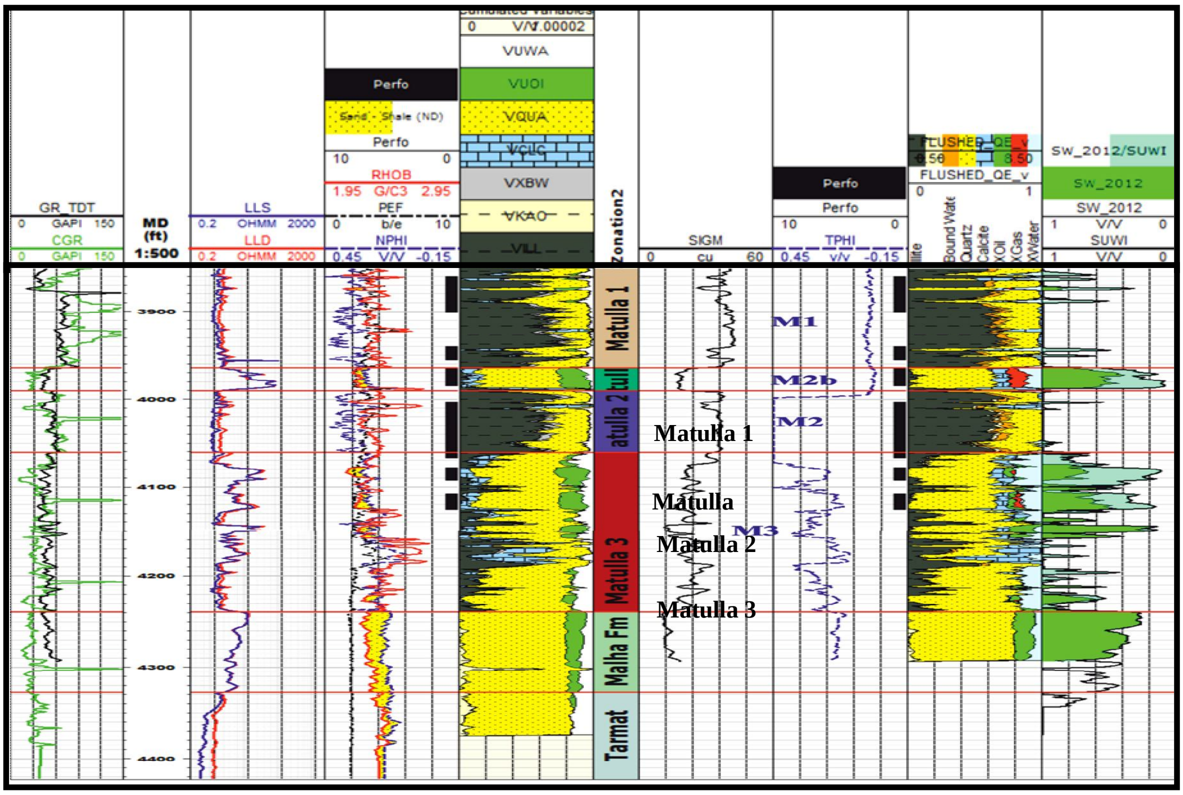

Fig. 2: TDT Sigma Saturation Analysis for REU-2/st well.

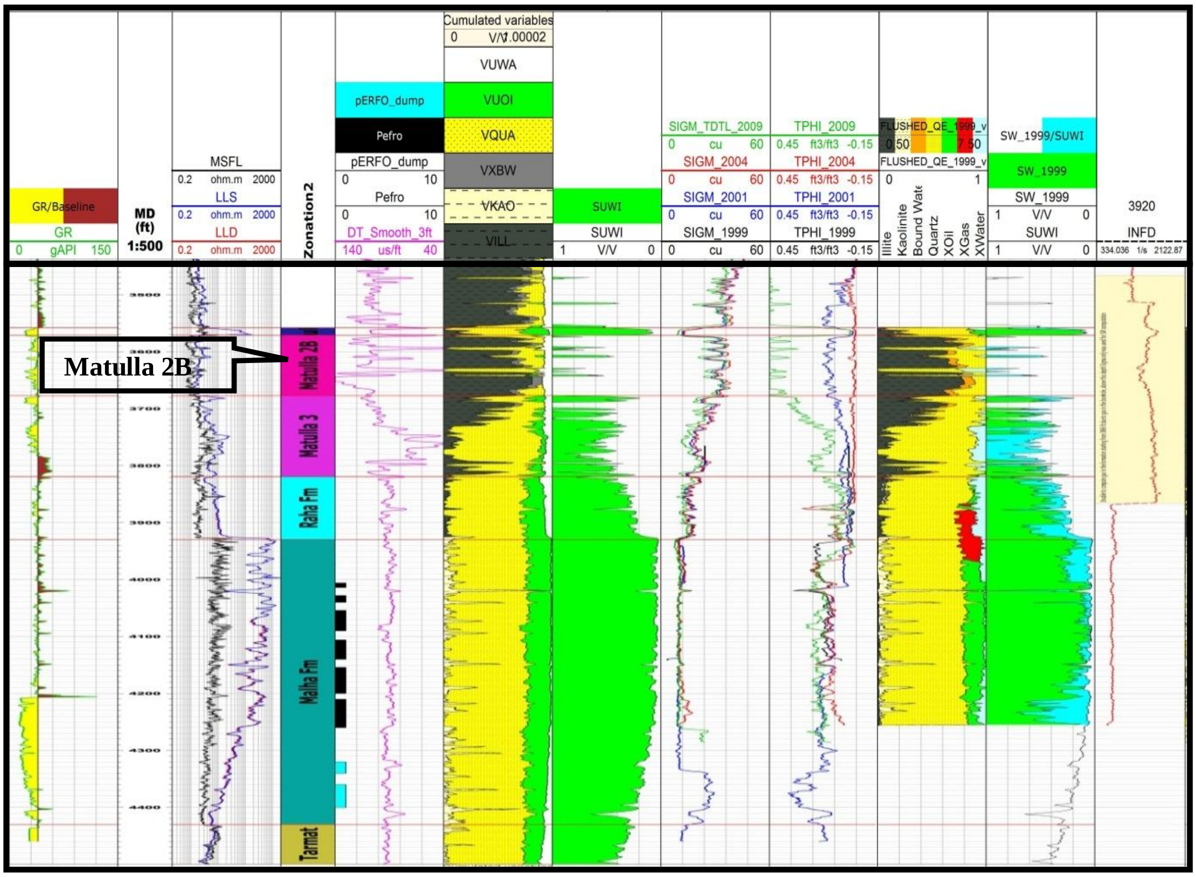

Fig. 3: TDT Sigma Saturation Analysis for REU-3 well

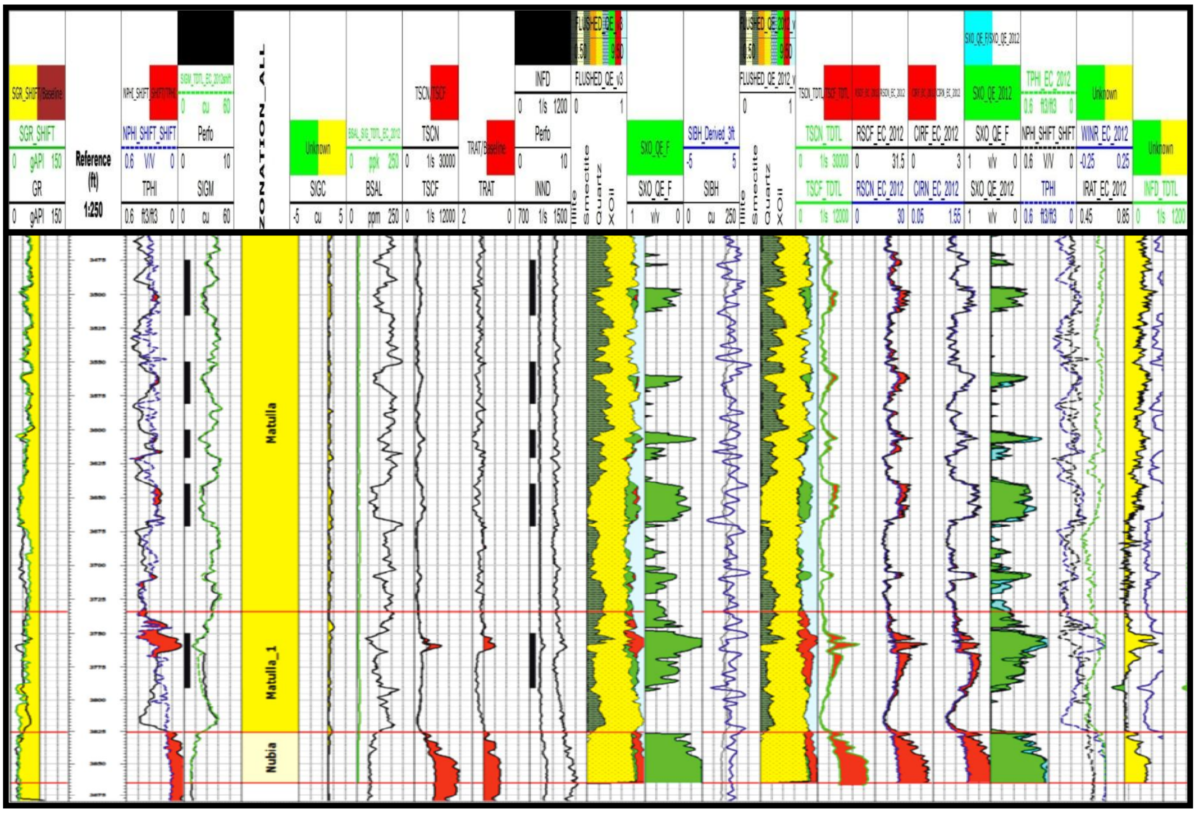

Fig. 4: TDT Sigma Saturation Analysis for REU-4/st3 well

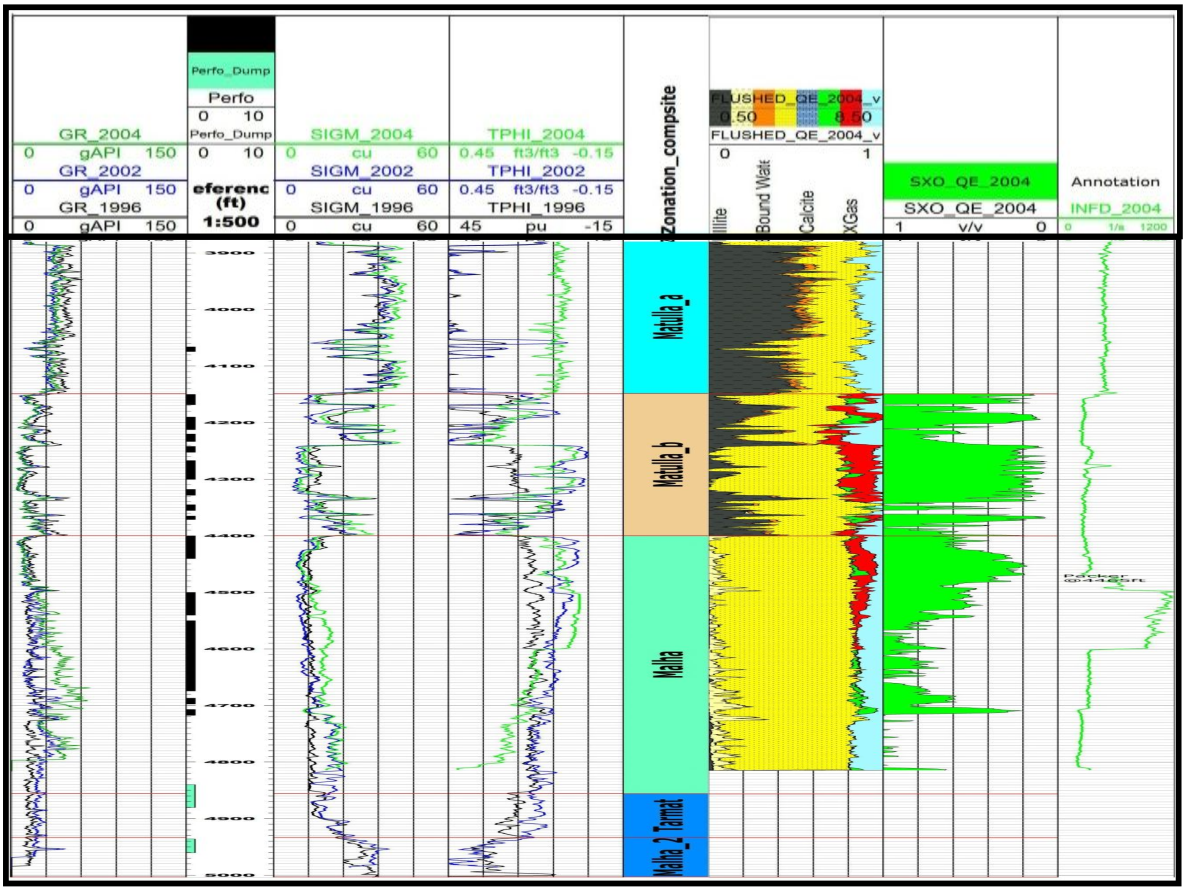

Fig. 5: Shows TDT Sigma Saturation Analysis for REU-6st

RESULTS AND DISCUSSION

a. TDT Sigma Analysis for REU-2/ST Well:

A single TDT run was recorded in 2002. Matulla Formation in this well can be divided into four intervals. The first interval is shale with minor sand streaks that shows S_W of around 80%. The sand interval 3963-3991 ft MD shows S_W of 50%. The TPHI against this interval indicates gas in the borehole and the sigma was used for gas saturation computation. The bottom sand interval topped with a shale interval acts as a barrier between the two sand bodies. The TPHI in front of the lower sand was used for gas computation, which indicates minor gas at the top of the interval and S_W is 65%. The TDT run did not cover the full interval of Malha Formation, only the top 50 ft. Either S_W changes are observed nor gas is present (Schlumberger, 2012) (fig.2).

b. TDT Sigma Analysis for REU-3 Well:

The latest TDT run was recorded in 2004. The gas volume computation was possible in all the runs except the 2004 run where the gas level in the borehole was deeper that the expected GOC in the formation. In the 2004 run, the gas computation was stopped at the depth of the gas in the borehole due to the gas presence in the borehole. Matulla Formation starts with a shale interval inter-bedded with some sand streaks. The first TDT run did not cover the full interval (Schlumberger, 2012) (fig.3).

c. TDT Sigma Analysis for REU-4/st3 Well:

Only one TDT run recorded in 2012 for REU-4/st3 well. A detailed correlation has been done between the REU-4 original hole and the side track. The GR and NPHI of the original hole were depth matched to the side track to be used as reference porosity for gas computation. The GR and NPHI were also used for basic formation evaluation to drive the shale volume and the effective porosity for sigma interpretation (fig. 4). The top section of the Matulla Formation from 3327-3492 ft MD is mainly shale with an average illite volume of 45%. Sigma results do not show potential hydrocarbon zones in this interval except for thin sand streaks. The water saturation over this sand streak is around 70%. The first zones of interest in the Matulla Formation are 3495-3513 ft & 3559-3569 ft MD. The water saturation S_W over these zones averages 50%. The sigma run over the interval 3601-3622 ft MD shows a minor increase in the S_W on the top 11 ft; however, the bottom 9 ft is almost completely watered out. The sigma result over the zone form 3638-3668 ft MD shows lower S_W than the previous zones (~ 40% S_W). The zone from 3705-3710 ft MD shows around 50% water saturation. The 10 ft above and below this zone is almost completely depleted. The TDT 2012 results over the bottom section of the Matulla Formation, from 3735 to 3788 ft MD, suggest that this zone is contributing gas. The GOC is observed at 3788ft MD. The S_W over this gas zone is around 30% and the inelastic and capture near and far counts separation is the highest at the top of the perforated zone at 3750-3760 ft MD indicating that this zone is contributing with the highest gas percentage. Facies of the Malha Formation is clean sand with less than 5% kaolinite volume. The sigma and TPHI results over Malha show that a gas cap is formed and flushed 95% of the previous oil, the new recorded TPHI_TDT overlays the TPHI recorded in 2012 confirmed the presence of the gas cap (Schlumberger, 2012).

d. TDT Sigma Analysis for REU-6/st Well:

REU-6/st well does not have open hole logs. The latest TDT run was recorded in 2004. The top section of the Matulla Formation from 3887-4148 ft MD (Matulla a) is mainly shale with an average illite volume of 70%. Sigma results do not show potential hydrocarbon zones in this interval.

The interval from4148-4400 ft MD (Matulla b) is divided into 4 sand bodies. The interval 4174-4240 ft MD shows the first gas cap formed and the observed GOC is at 4197 ft MD. The next interval 4239- 4342 ft MD shows homogenous gas from the top to the bottom of the interval, the most bottom interval shows small gas cap starting at 4363 ft MD. In 2004 TDT run, the Matulla section shows continuous gas in the formation from top to bottom with some residual oil patches. Malha Formation is a clean sand section with less than 15% kaolinite volume. The TDT run of 2004 confirmed the presence of gas with almost the same S_W at the top section of Malha, while it can be observed an increase in the water saturation below 4482 ft MD with some intervals kept at the original S_W. The Tarmat section from 4855-4933 ft MD does not show change in saturation as expected. But due to the dump flood process which takes place just above the Tarmat, the OWC reached 4715 ft MD. This water is coming from an aquifer below the Tarmat (Schlumberger, 2012) (Fig.5).

CONCLUSION

The only oil producing field in Gebel El-Zeit area is Ras El Ush (REU) Oil field. The main producing pay zones in that field are Matulla and Malha formations. The objective of the TDT Sigma runs was to determine the position of the oil-water contacts, the gas-oil/gas-water contacts and the reservoir oil saturation profile. The capture cross-section (SIGMA) curve from TDT Sigma mode is used to determine quantitative water saturation at the time TDT is logged. Sigma is used to discriminate between hydrocarbon and saline water. A single TDT run was recorded in REU-2st well. Matulla Formation in this well can be divided into four intervals. The upper sand interval shows S_W of 50% while the bottom one shows S_W of 65%. In the upper 50 ft of Malha Formation no S_W changes were observed nor gas presence. The REU-3 well TDT run was recorded in 2004. The gas volume computation was not possible in this run where the gas level in the borehole was deeper that the expected GOC in the formation. Matulla Formation starts with a shale interval inter-bedded with some sand streaks. Only one TDT run was recorded for REU-4ST3. The first zones of interest in the Matulla Formation are 3495-3513 ft & 3559-3569 ft MD. The S_W over these zones averages 50%. Also the zone from 3705-3710 ft MD show around 50% water saturation. The sigma and TPHI results over Malha Formation show that a gas cap is formed and flushed 95% of the previous oil. The latest TDT run were recorded for REU-6ST in 2004 in which the Matulla section shows continuous gas in the formation from top to bottom with some residual oil patches. The TDT run of 2004 confirmed the presence of gas with almost the same S_W at the top section of Malha Formation, while it can be observed an increase in the water saturation below 4482 ft MD with some intervals kept at the original S_W. The OWC reached 4715 ft MD. This water is coming from an aquifer below the Tarmat.

REFERENCES

Abdallah, A.M., Adindani, A. & Fahmy, N., 1963.- Stratigraphy of the Lower Mesozoic rocks, western side of the Gulf of Suez, Egypt *Paper- Geological Survey of Egypt, Mineral Resources Department, vol.27:* 1-23.

Bosworth, W., 1985. Geometry of propagating continental rifts. *Nature,* 316: 625-627.

Evans, A.L. & Moxon, I.W., 1988. Gebel Zeit chronostratigraphy: Neogene syn-rift sedimentation atop a long-lived paleohigh. *In: Proceedings of 8``' Exploration Conference, Cairo, November, 1986.* Vol. 1. Egyptian General Petroleum Corporation, Cairo: 251-265.

Hassan, A.A., 1967. A New Carboniferous occurrence in Abu Durba-Sinai, Egypt. *In: 6'h Arabian Petroleum Congress, Baghdad, II.* Bagdad University, Bagdad: 1-8.

Hermina, M., Klitzsch, E. & List, F.K., 1989. *Stratigraphic Lexicon and Explanatory notes to the Geological Map of Egypt, 1:500,000.* Conoco Inc., Cairo: 1-263.

Kostandi, A.B., 1959. Facies maps of the study of the Paleozoic and Mesozoic sedimentary basins of the Egyptian region. *In: UAR 1, Arabian Petroleum Congress Cairo, Congress 2.* Cairo University, Cairo: 54-62.

Said, R., 1962. *The Geology of Egypt.* Elsevier, Amsterdam: 1-377.

Said, R., 1971. - The Explanatory notes to accompany the Geological Map of Egypt. *Geological Survey of Egypt, Paper, 56:* 1-123.

Said, R., 1990. Chapter 24: Cenozoic. *In: R.* SAID (ed.), *The Geology of Egypt.* Balkema, Rotterdam: 451-486.

Schlumberger internal Ras El Ush TDT Interpretation Report, *September, 2012*.

Weissbrod, T., 1969. The Paleozoic of Israel and adjacent countries. Part 2: The Paleozoic outcrops in southwestern Sinai and their relation with those of southern Israel. *Israel Geological Survey, Bulletin,* 48: 1-32.

Youssef, M.I., 1957. Upper Cretaceous rocks in Kosseir area. *Bulletin of Institute Desert Egypte, vol.7:* 35-54.