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A PETROPHYSICAL STUDY ON THE LOWER BAHARIYA FORMATION IN BED-1 FIELD, WESTERN DESERT, EGYPT

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دراسة بتروفيزيائية على تكوين حرية السفلى فى حقل بدر الدين-١ بالصحراء الغربية، مصر

الخلاصة: من خلال هذا البحث تم عمل تقييم بتروفيزيائى شامل فى حقل BED-1 لدراسةَ تكوين بحرية السفلى فى ست آبار هى بدر الدين (١-٢، ١-٣، ١-٤، ١-٥، ١-٦ و ١-٨). ولقد وجد أن سمك الحجر الرملِى الصافى لتكوين بحرية السفلى يتراوح مِنْ ١٤ متراً إلى ٧٨ متراً بمحتوى طينى متوسط من ٥,٣ % إلى ١٦,٩ %. وجد أيضاً أن قيم المسامية وقيم إشباع الصخر بالماء والمشتقة من تسجيلات الآبار والتى تم حسابها لكل بئر إخترقت تكوين بحرية السفلى يمكن أن تلقى بعض الضوء على كمية الهيدروكربون الكامنة هذا الخزان.

ومن التحليل البتروفيزيائى: وجد تفاوت مسامية تكوين بحرية السفلى من ٨,٨ % إلى ١١,٢ %، بمتوسط ١٠,٥ %. هذه المسام مملوءة بأكثر من ٧٤ % من الهيدروكربون. وجد أيضاً أن النفاذية فى منطقة الدراسةَ تتراوح بين ٠,٠٧ مللى دارسى (نفاذية منخفضة) إلى ١٠٥٢ مللى دارسى (نفاذية عالية) بقيمة متوسطة ٥١٥ مللى دارسى وذلك كما استنتجت من تحليل العينات اللبية المقطعية لآبار الدراسة.

علاوة على ذلك، تشير قياسات ضغط التكوين المتكرر إلى وجود ميلين للسائل، إحداهما للنفط والآخر للماء بمستوى الماء الحر عند عمق ٣٦٠٩ متر.

لذا نوصى بتطوير النشاط الإستكشافى لتقييم تكوين بحرية السفلى فى منطقة الدراسة.

ABSTRACT: *A comprehensive petrophysical evaluation has been made in six wells in the BED-1 field which penetrated the Bahariya Formation, namely, BED 1-2, 1-3, 1-4, 1-5, 1-6 and 1-8.The study shows that the thickness of the net sand of the Lower Bahariya Formation ranges from 14 m to 78 m. The shale content is low (5.3 % to 16.9 %). The log-derived net/gross, porosity and water saturation calculated using all available raw logs. The petrophysical results can infer the hydrocarbon potentialities of this reservoir.*

From petrophysical analysis, it was found that, the porosity of the Lower Bahariya Formation varies from 8.8% to 11.2%, averaging 10.5%. The pores are filled with more than 74% of hydrocarbons. Also the permeability is between 0.07 to 1052 md, with an average value of 515 md as deduced from core analysis for the study wells.

Furthermore, RFT pressure measurements indicate the presence of the two fluid gradients, one for oil (0.3 psi/ft) and the other for water (0.5 psi/ft), with a free water level at 3609 mss.

Based on the study results it recommended that a development/exploration activity to be conducted to assess the Lower Bahariya Formation in the area of interest.

INTRODUCTION

The BED-1 field forms part of the Badr El Din concession in the Western Desert some 300 km west of Cairo. This field is located on the edge of the Qattara Depression (figure 1).

The target formation in this study is the Bahariya Formation. It extends in the subsurface over most of the Western Desert and rests conformably on the Kharita Member of the Burg el Arab Formation.

The lithologies, microfauna and flora associated with the Formation in the Western Desert indicate that the major part of the Formation was deposited on a wide, extensive shallow marine shelf.

The BED-1 structure is a NE dipping, elongated NW-SE trending fault block, approximately 10 km long and up to 2 km wide. These faults show a general dipping to the NE, NW and SE and bounded to the south by a WNW-ESE trending, SSW having normal fault (Abu El-Ata, 1988).

The Formation is characterised by fine to very fine grained-sandstone, with subordinate shale (Said, 1990).

The Bahariya Formation is essentially a sand/siltstone/shale sequence with very few limestone beds, with occasionally radioactive admixtures in the sands such as glauconite (Said, 1990).

Unlike the Kharita, the Bahariya Formation has got complicated nature and lithology expressed in:

a) Thin sand streaks that the conventional logging tool cannot discriminate.
b) High silt content of most of sand streaks.
c) Gradation in the sand size to silt within one and the same streak which makes it not possible to delineate the sand/silt boundary, especially with the high radioactivity of the sand (in the Kharita it is much simpler to define the boundary easily even from the GR log only).

The present petrophysical study has been carried out on the Lower Bahariya Formation using core and well log data from six wells in BED-1 Field, namely BED 1-2, 1-3, 1-4, 1-5, 1-6 and 1-8 (figure 2).

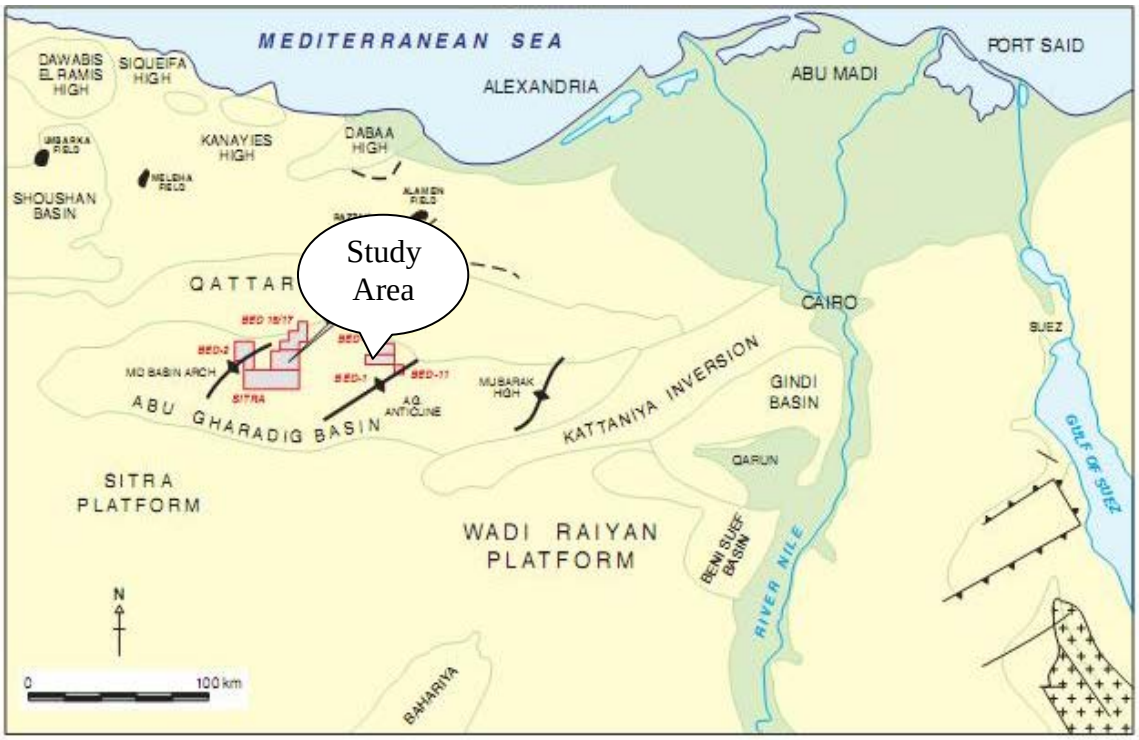

Figure (1): Location map of the studied area.

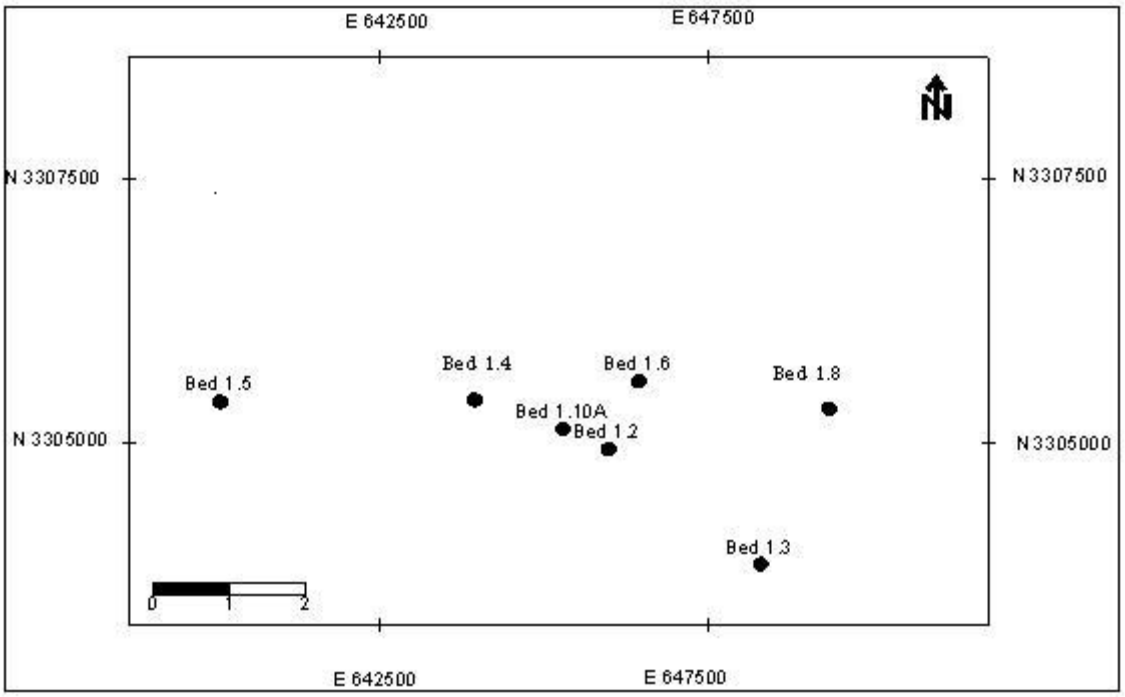

Figure (2): Location map of the studied wells.

METHODOLOGY

The petrophysical evaluation of the Lower Bahariya Formation was carried out using a software computer programme. This software was also used to build the database of core and log data.

Well evaluation was made. This involved the two wells (BED 1-1 and BED 1-6) in which cores were taken in the Bahariya Formation.

The full field evaluation was followed by computation of sums and averages for each reservoir layer.

Density, neutron, dual laterolog (DLL) and micro-spherical focused (MSFL) log data were borehole corrected. From DLL and MSFL data an invasion corrected deep resistivity was derived. Borehole size, mud resistivity data and bottom temperature were taken from the log headers. Also, corrections for invasion could not be made because of shallow resistivity data are not available.

PETROPHYSICAL ANALYSIS

The evaluation has been carried out through the following steps:

1. Net Sand Determination

In order to exclude the shale zones which are clearly non-reservoir, a cutoff based on 50% Vsh has been applied throughout, with Vsh derived from the GR using the following equation:

Vsh = (GR – base sand line)/(base shale line – base sand line) (Sclumberger essentials, 1982)

Beyond this no porosity or saturation cutoffs have been applied.

2. Porosity Derivation

In the Lower Bahariya sand /shale sequence porosity was determined using the density log as well as neutron and sonic logs. The density-derived porosities were calibrated to the core data.

A core-derived matrix density was used as 2.66 g/cc. The hydrocarbon corrected porosity was computed from the density based on the flushed zone oil saturations, which were established using the MSFL. In this calculation an oil density of 0.55 g/cc was used and mud filtrate density values corresponding to the mud filtrate resistivities values as reported in the log headers. The porosity was subsequently calibrated to the in-situ core porosity.

Summary of the porosity calculation parameters are:

matrix density = 2.66 g/cc

in-situ stress conditions = 5500 psi uniaxial

in-situ core porosity = Phi in-situ = 0.96*Phi atmospheric.

HC corrected porosity calibration factor = 0.974

The porosity calculation in the relatively highly water saturated zone could not be calibrated to in-situ core porosity, since all cores were taken in the oil zone. To compute porosity, the same matrix density of 2.66 g/cc was used as in the oil zone, For the fluid densities, mud filtrate densities were taken corresponding to the mud filtrate resrstivities/salinities as reported on the log headers.The average log porosity of the Bahariya is 14.5% with a standard deviation of 5.8% (figure 3).

The correlation between the porosity obtained from logs and routine core analyses versus depth for the Lower Bahariya Formation in the studied wells indicates that the relationship is proportional and the values revealed from the core samples are nearly equal to those obtained from log analyses, where the porosity values obtained from core analyses are nearly coincident with those obtained from log analyses (figure 4). This coincidence reflects that the core samples and log results are good representatives for the formation.

3. Saturation Determination

The water saturation in the virgin zone (Sw) and in the flushed zone (Sxo) were determined using Archie equation (Archie, 1972)

$Sw = ((\Phi^{-m} \times Rw)/Rt)^{1/n}$ (for virigin zone)

$Sxo = (Rmf)/Rxo)$ (for flushed zone)

where:

Rw: formation water resistivity, ohm.m

Rmf : mud filtrate resistivity (for flushed zone), ohm.m

Rt : true formation resistivity, ohm.m

Rxo: flushed zone resistivity

m : cementation exponent

n : saturation exponent

Φ : porosity, fraction or percentage

Porosity has been established as described in the previous section. The invasion corrected LLD was used as Rt. Rw, m and n values were taken as follows :

m = 1.96

n = 2.03

Rw = corresponding to 110 Kppm NaCl eq (0.024 ohmm) at formation temperature.

By correlating the hydrocarbon saturation values obtained from core analyses with those obtained from logs it was found that, they are in good coincidence with each other for the BED-1 Field (Figure 5).

The average water saturation in the Bahariya is 27.7% with standard deviation of 15.59% saturation units (figure 6).

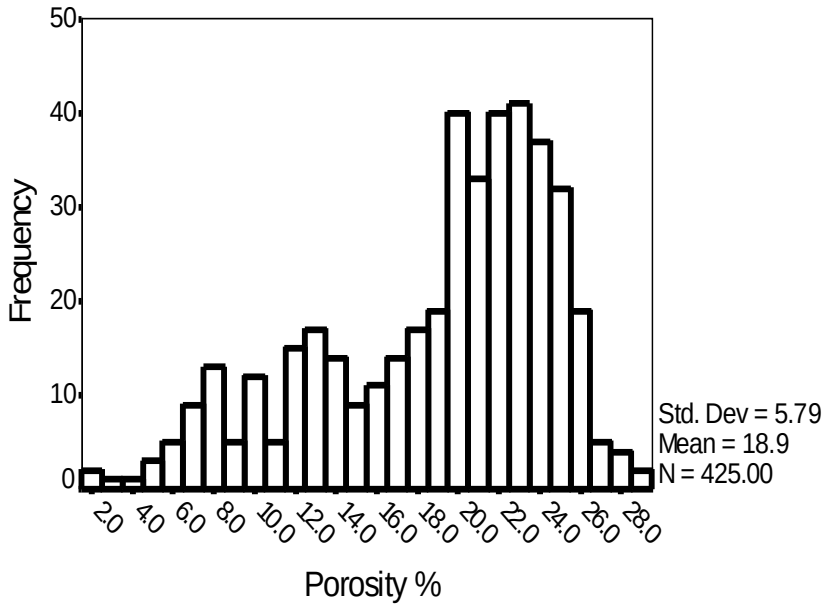

Figure (3): Porosity histogram of the Lower Bahariya Formation for BED 1-4 well.

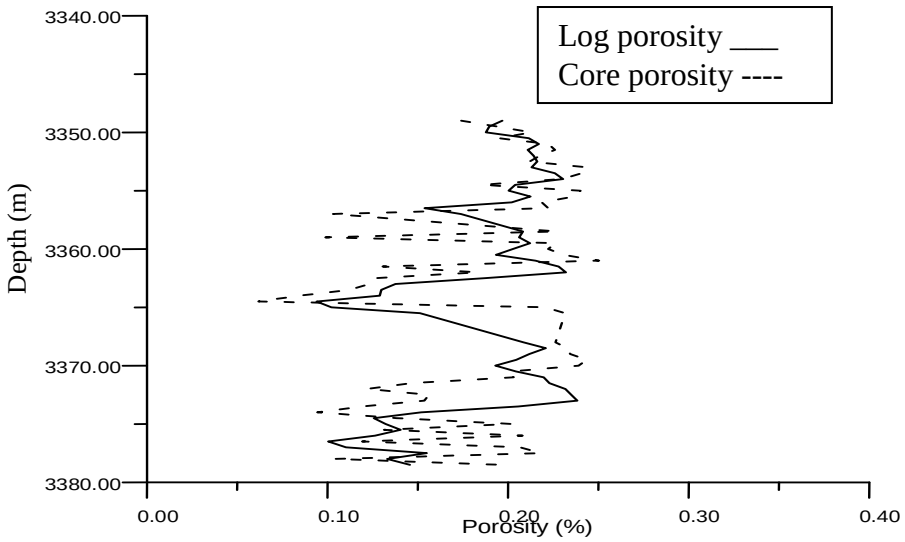

Figure (4): The relation between the porosity from log and core data versus depth of the Lower Bahariya Formation for BED 1-2 well.

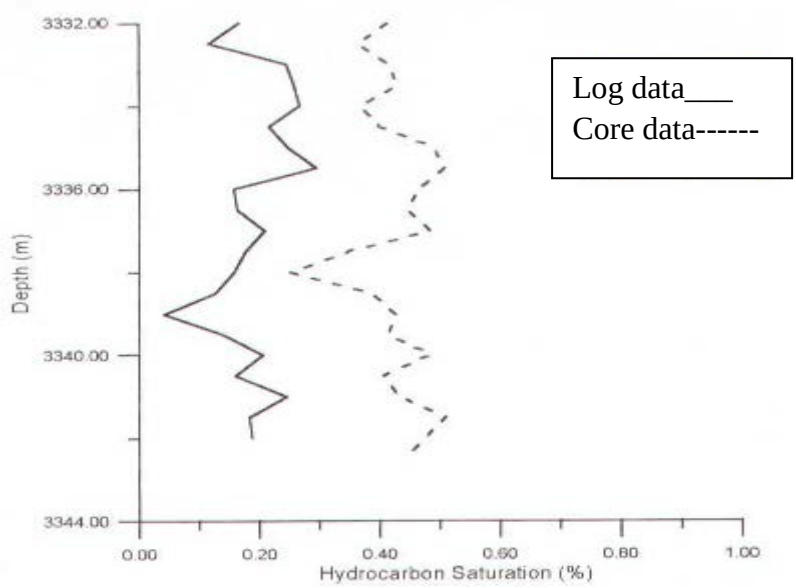

Figure. (5): The relation between hydrocarbon saturation from log and core analysis versus depth of the Lower Bahariya Formation, BED 1-5 well.

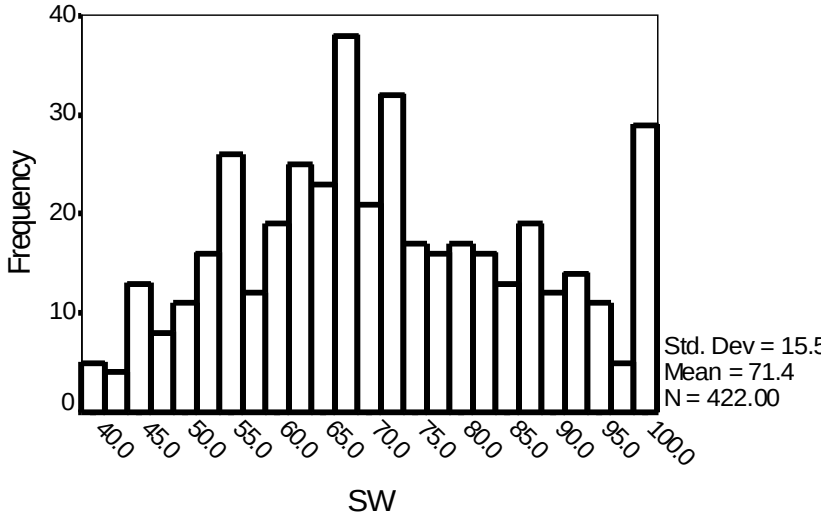

Figure (6): Saturation histogram for the Lower Bahariya Formation for BED 1-4 well.

4. Repeat Formation Tester

The Repeat Formation Tester (RFT) data is used for interpreting some reservoir characteristics (Hilchie, 1982), such as the nature of fluids for the Lower Bahariya Formation by using six wells in BED-1 Field in the Western Desert of Egypt.

The values of the Lower Bahariya Formations pressure measurements were plotted versus the depth to obtain the pressure gradients and to identify the nature and densities of the fluids (oil or water). Also, these measurements specified and located the depths of contacts by monitoring the abrupt changes in the pressure gradients. The pressure profiles of Bahariya Formation in BED 1-5 and 1-8 wells were constructed (figures 7 and 8). The free water level has been located at 3600, 3609 mss in BED 1-5 and BED 1-8 wells respectively. The difference in these values may referred to a presence of a fault system between the two wells.

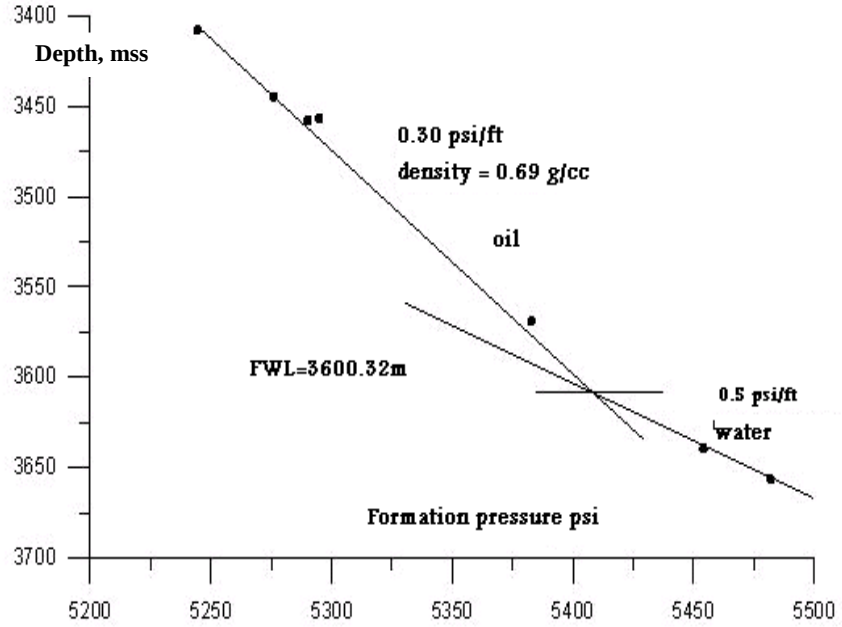

Figure (7): Formation Pressure analysis of the Lower Bahariya Formation in BED 1-5 well.

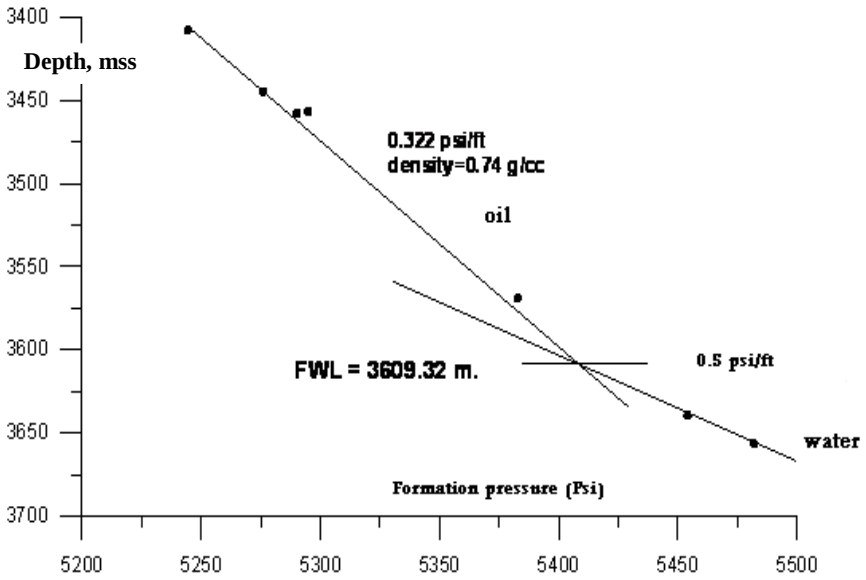

Figure (8): Formation Pressure analysis of the Lower Bahariya Formation in BED 1-8 well.

SUMMARY AND CONCLUSION

1- For the Lower Bahariya Formation at the BED-1 area, the net sand varies from 14 to 78m. The shale content (5-17%).

2- The sandstone porosity varies between 8.8 and 11.2%, and averages 10.5%, with standard deviation of 5.8%.

3- There is a strong positive correlation between the log-derived porosity and core analysis, which supports our log interpretation.

4- The hydrocarbon saturation values obtained from core analysis and log interpretation are mostly coincident with each other for the BED-1 Field.

5- The average water saturation in the Lower Bahariya is 27.7% with standard deviation of 15.59% saturation units.

6- From RFT data two fluid gradients have been established. The upper gradient (0.3-0.32 psi/ft) indicates oil with density of 0.69-0.74 gm/cc. The lower gradient (0.5 psi/ft) shows water with a density of 1.15 gm/cc.

7- The free water level is interpreted at depths 3600 mss in BED 1-5 well and 3609 mss in BED 1-8 well.

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