Formation Evaluation of the Ras Qattara Reservoir in "Shams" Field, North Western Desert, Egypt

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Abstract: The Late to Middle Jurassic Ras Qattara Formation acts as a hydrocarbon reservoir in the subsurface in the Western Desert, Egypt. The present work is devoted to study the subsurface setting and reservoir characteristics of the study area to evaluate the hydrocarbon potentiality of the Jurassic rocks in Shams field, The first objective of this paper is to do seismic interpretation of twenty 2D seismic sections and construct 3D structure model to delineate the geometry and the detailed structural features affecting Ras Qattara reservoirs in Shams field. The second objective is to evaluate the Ras Qattara reservoir through the analysis of lithofacies types and determination of the different reservoir parameters characterizing the pay zone. These were carried out by using the available well log data to spotlight the promising locations for further development and exploration.

Six wells (Shms-1x, Shms-2x, Shms-4, Shms-6, Shms-7 and Shms-8) were utilized for this study. The interpretation of seismic lines and 3D structure model revealed five faults forming Shams field horst block, the trend of these faults is northwest–southeast. These faults represent the structural control for the hydrocarbon accumulation in Shams field. Ras Qattara facies map shows that the characterized by sandy facies which reflect fluvio-deltaic condition during sedimentation of Ras Qattara member. The results of neutron- density cross plots revealed that, the lithology of Ras Qattara reservoirs are mainly sandstone with some calcareous cement. The petrophysical data were illustrated vertically via the Litho- Saturation cross-plots and laterally through the iso-parametric maps; these were aimed to clarify the lateral variation of petrophysical parameters, reservoir thickness and suitable place for drilling new productive wells. Petrophysical analysis of these wells showed that Shams field is characterized by good reservoir parameters.

Based on the obtained results, it can be stated that the Shams field may attain commercial hydrocarbon accumulation in Ras Qattara Formation, andthere is a good opportunity to drill more development and exploratory wells to enhance the productivity from Shams field.

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Keywords: formation evaluation, ras qattara reservoir, "shams" field, north western desert, egypt

1 Introduction:

The Western Desert of Egypt still has a significant hydrocarbon potential as recent oil and gas discoveries have suggested (Dolson et al. 2001). Perhaps 90 % of undiscovered oil reserves and 80% of undiscovered gas reserves in Egypt are located in the Western Desert (Zein El-Din et al. 2001). The Shams field that forms the scope of this study lies in the Shoushan Basin, north Western Desert, Egypt (Fig.1). Shams field has attracted the interest of numerous researchers, authors and oil companies. It represents an area of about 10 km2 bounded by latitudes 30° 47' 12"- 30° 52' 18"N and longitudes 26° 52' 30"- 26° 59' 48"E.

2 Geological Setting:

The Shoushan Basin, which is the largest of the coastal basins, is a half-graben system with a maximum thickness of 7.5 km of Jurassic, Cretaceous, and Palaeogene sediments **(ElShazly, 1977; Hantar, 1990)**.

The northern part of the Western Desert comprises a number of sedimentary basins that received a thick succession of Mesozoic sediments. The general stratigraphic section in the northern Western Desert ranges in age from Paleozoic to Cenozoic (Neogene) as summarized in (Fig. 2). The post- Paleozoic succession in this area comprises four sedimentary cycles of Lower to Upper Jurassic, Lower Cretaceous, Upper Cretaceous, and Eocene to Miocene **(Sultan and Halim,1988)**.

The late - Middle Jurassic Ras Qattara Formation is a massive sandstone overlying the Paleozoic, occasionally with thin silty intervals. It sometimes graded into marine deposits. Sonic logs generally show the abrupt change between the stable pattern of this sandstone and the pattern of Khatatba sandstone. The depositional environment of the Jurassic rocks was defined as fluviatile, (Khalda Petroleum Comp., 1987)., The Ras Qattara Formation appears to be filled on old Paleozoic relief. The sands considered as a good reservoir, but unfortinatly with no sealing rock.

The Middle Jurassic Khatatba Formation includes both sandy reservoir intervals and organic-rich shales with source rock potential. Potential seals include the massive carbonates of the Upper Jurassic Masajid Formation **(EGPC,1992).**

Abu Shady, (2003) evaluated the Khatatba sandstones through studying the sedimentary environments and petrophysical characteristics of the Khatatba Formation (Middle Jurassic) north part of Western Desert. Khatatba Formation consists of dark shale which contains TOC ranging between 3.60 and 4.20wt.%indicating an excellent source rock **(Peters and Cassa, 1994).**

The shales and limestones of some of the Jurassic units in the Shushan basin in the north Western Desert act as a source rock for oil generation in the central part of the basin **Al sharhan and Abd El-Gawad, (2008)**.

Shushan Basin witnessed Jurassic and Early Cretaceous extension followed by Late Cretaceous early Tertiary inversion **(El Awdan et al., 2002).**

The Safa is divided into Lower and Upper parts by the kabrit member, which characterized by the dominance of limestones.

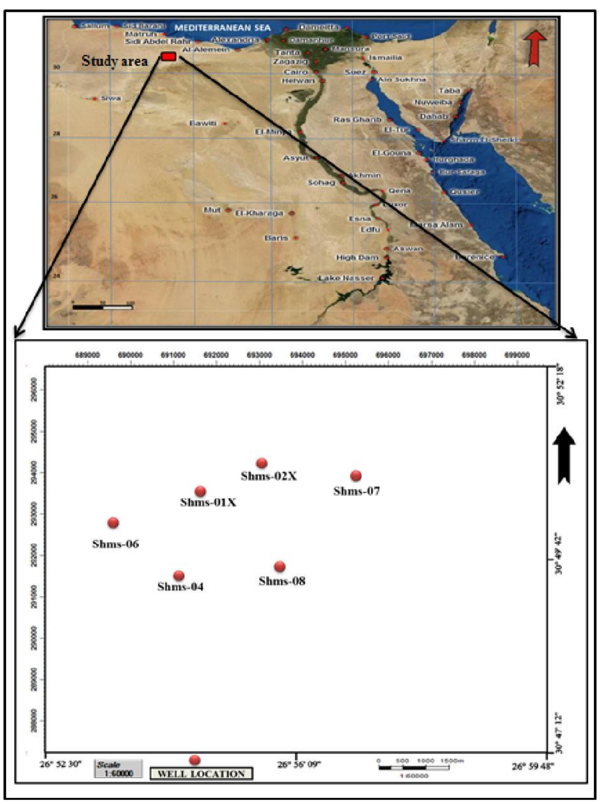

Fig.1): Location map of the study area showing the location of the drilled wells in Shams field, north Western Desert Egypt.

The Lower Safa member is composed of shale, siltstone, sandstone and Limestone streaks, it is underlies the Kabrit member. While The Upper Safa member overlies the Kabrit member.

The Upper Safa member is composed of siltstones, sandstone and shale with minor of limestone streaks.

3 Results and Discussions

1.1 Seismic Interpretation:

The interpretation of twenty seismic lines (Fig.3) covering the study area leads to identify themost important seismic reflectors throughout Ras Qattara Formation. Moreover, seismic interpretation revealed a set ofelevennormal faults namely F2, F3, F4, F5, F6, F7, F8, F9, F10, F11 and F12forming Shams field horst block (Fig.4).

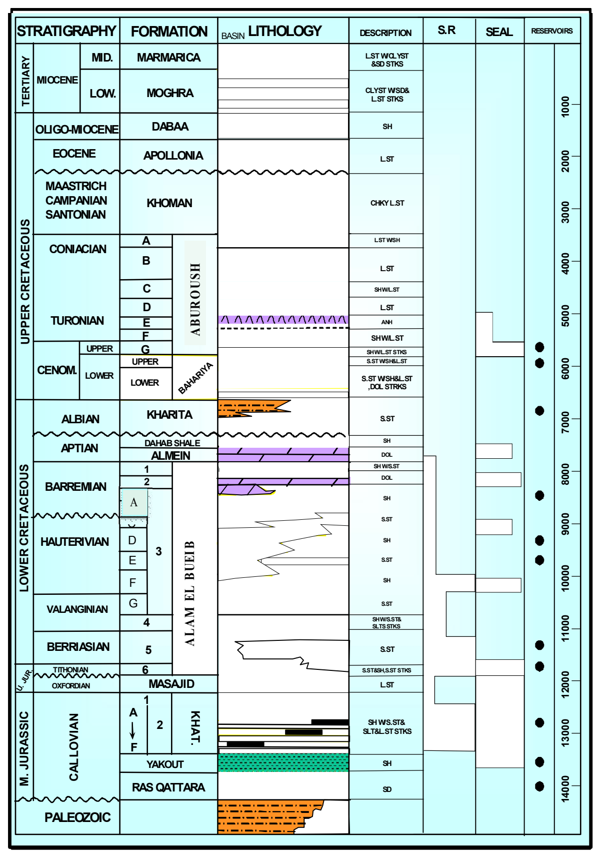

Fig.2): A Generalized stratigraphic column of the North Western Desert (Khalda, 2001).

1.1.1 Horizons Interpretation:

Figure 5 shows the interpreted seismic line (X line-1) this section shows one interpreted horizon; Ras Qattara crossed by four normal faults (F6, F7, F8 and F11). the first one is (F11) which has downthrown side towards the northwest direction, the second set is (F8) and has downthrown side towards the west direction, the third set is (F7) and has downthrown side towards the southwest direction, and the fourth set is (F6) and has downthrown side towards the southwest direction.

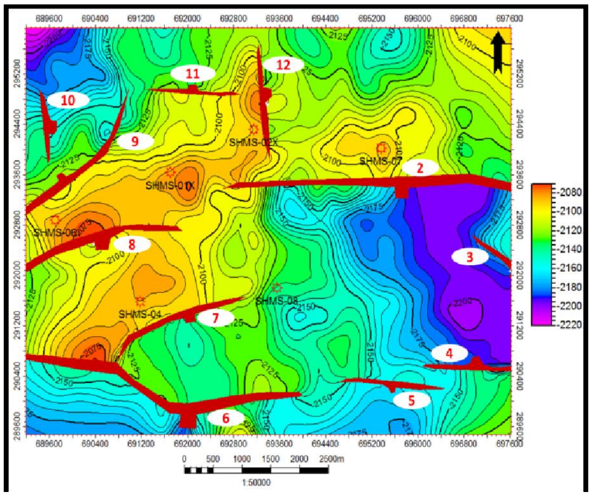

Fig.4): Faults affecting the area under investigation.

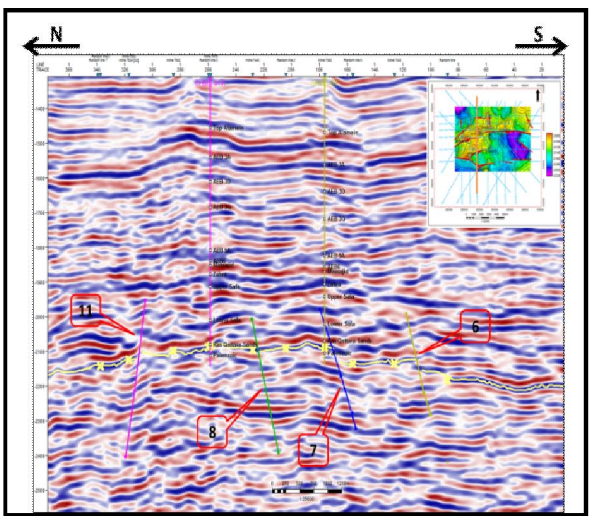

Fig.5): Seismic line (X-line) passing through well SHMS-1X and SHMS-4 well. Show Four normal faults are detected in this section (F11, F8, F7 and F6).

Figure 6 Shows the interpreted seismic line (Xline- 14755). This line trends north to the south direction and it is located in the east part of the area under investigation. This section shows three sets of normal faults, the first one is (F2) which has downthrown side towards the northeast direction, the second set is (F4) which has downthrown side towards the southeast direction, and the third set is (F5) which has downthrown side towards the southeast direction.

Figure 7 shows the interpreted seismic line (cross-line). This line trends northwest to the southeast direction and it is located in the west part of the studied area. This line passes through wells SHMS-6 and SHMS-4. This section shows four sets of normal faults, the first one is (F9) which has downthrown side towards the west direction, the second set is (F8), third set is (F7) and the fourth set is (F6) we mentioned before in the first section. These faults effect all horizons under investigation forming a horst structure.

From seismic sections interpretations, Shams field is represents a horst block bounded by eleven faults which took northwest –southeast oriented normal faults forming the main structural trap in this area under investigation.

1.1.2 Depth Structural Contour Maps:

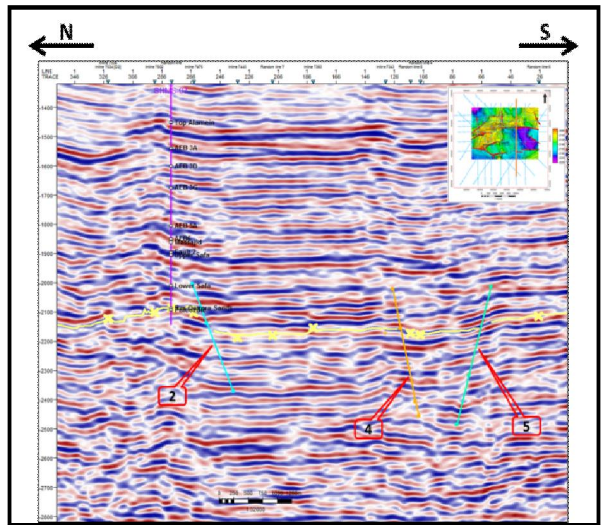

Fig.6): Seismic line (Xline- 14755) passing through well SHMS-7. Show Three normal faults are detected in this section (F2, F4 and F5).

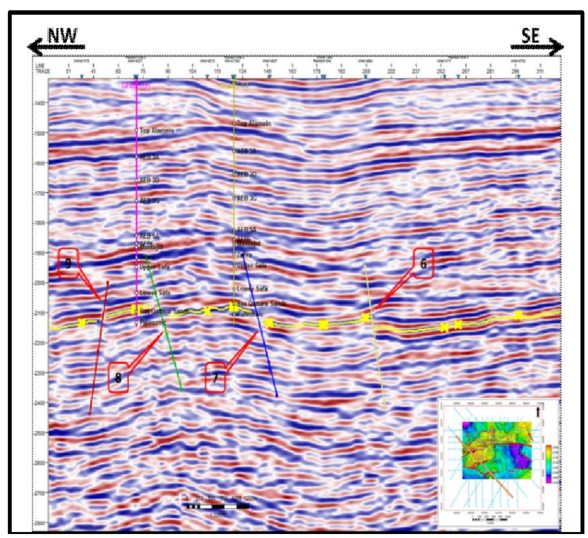

Fig.7) Seismic line (cross-line) passing through wells SHMS-6 and SHMS-4. Show Four normal faults are detected in this section (F9, F8, F7 and F6).

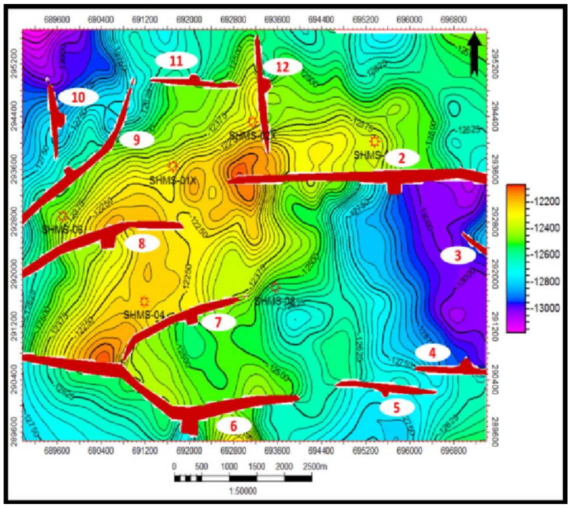

Fig. 8): Depth structure Contour map of the Ras Qattara horizon.

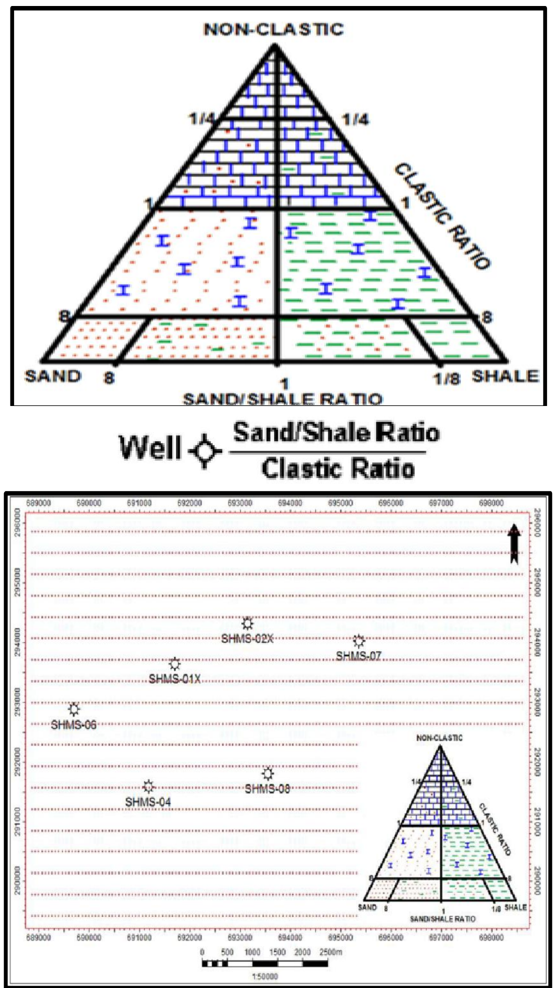

Fig. 11): Triangle facies map of Ras Qattara reservoir.

Figure 8 shows the depth structural contour map shows the structural elements in terms of depth rather than time. The depth value of Ras Qattara varies between -12195 and -12411 ft. (TVDSS) and achieve its maximum value toward the central part of the study area.

1.2 Lithofacies Maps:

The lithofacies maps reflect that the Ras Qattara formation is characterized by sandstone facies in all of the study wells. These facies reflect fluvio-deltaic sandstones environment fig. 11).

1.3 Reservoir petrophysics:

1.3.1 Neutron-Density cross-plot.

The Neutron-density cross-plots are commonly used to determine the lithology (using the neutron and density logs) and accurately evaluate the matrix porosity of carbonate rocks.

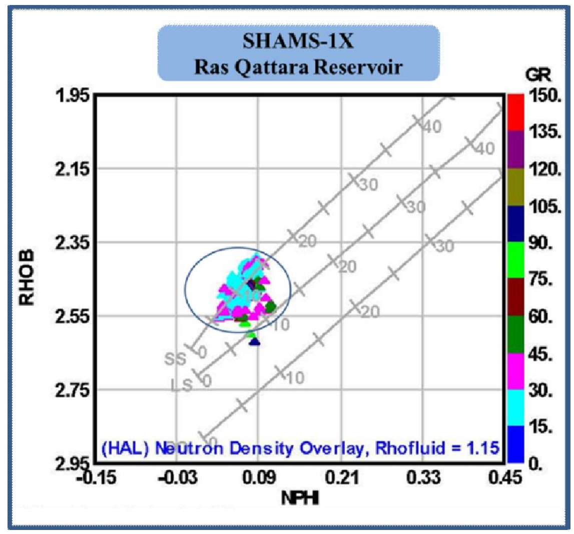

Fig.12) Density neutron crossplot of the Ras Qattara reservoir in SHMS-1X well.

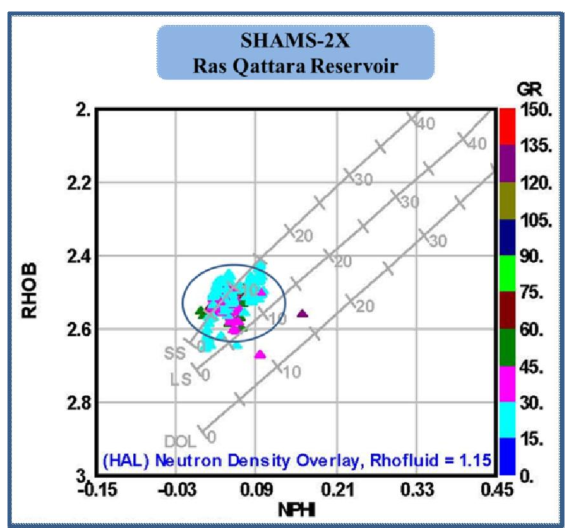

Fig. 13) Density neutron crossplot of the Ras Qattara reservoir in SHMS-2X well

Also, the effect of shale can be observed on the crossplot, where the shale effects tend to be in the southeast quadrant of the crossplot **(Pouponand Leveaux, 1971).**

Figure 12, 13, 14, 15, 16 and 17 Shows the neutron-density crossplot of the Ras Qattara reservoir, the major of plotted points are aligned on sandstone line, with porosity ranging from 5% to 20%. Some other points are scattered between limestone and sandstone lines. The points scattered in the direction of dolomite line are due to shale effect.

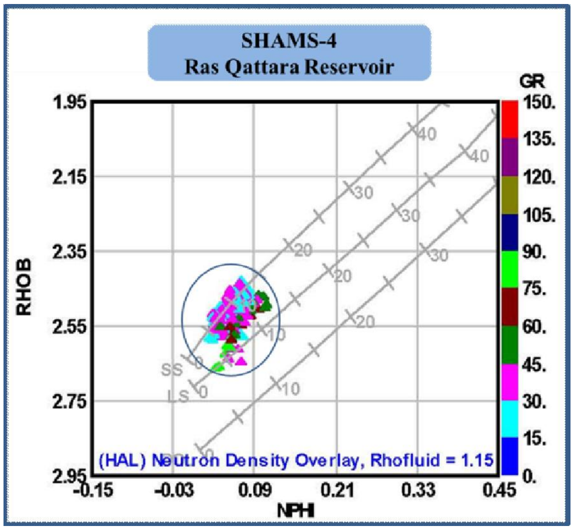

Fig. 14) Density neutron crossplot of the Ras Qattara reservoir in SHMS-4 well

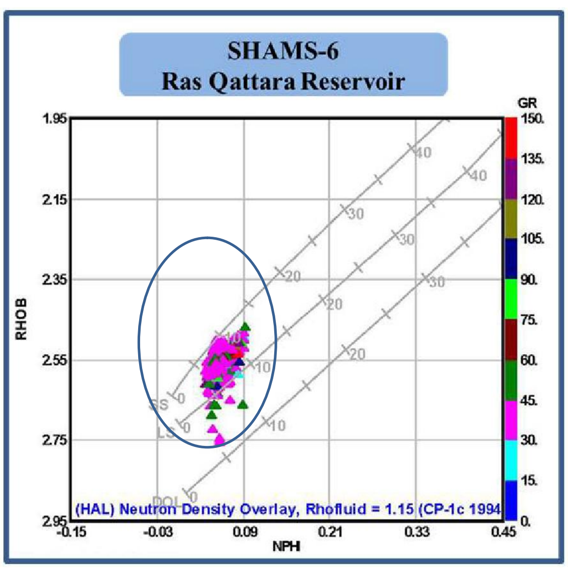

Fig. 15) Density neutron crossplot of the Ras Qattara reservoir in SHMS-6 well

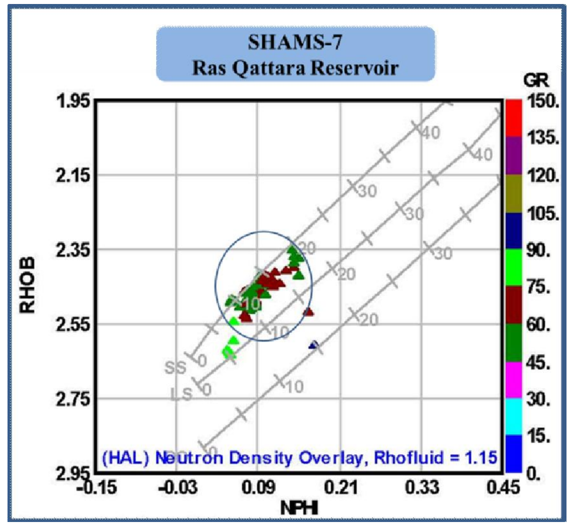

Fig. 16) Density neutron crossplot of the Ras Qattara reservoir in SHMS-7 well

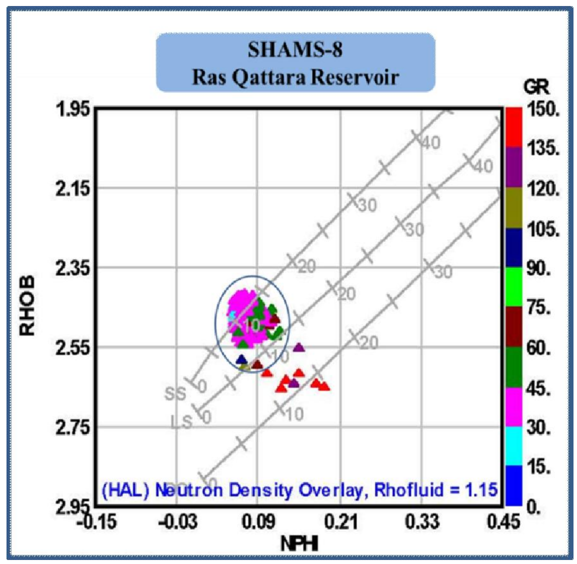

Fig. 17) Density neutron crossplot of the Ras Qattara reservoir in SHMS-8 well

1.3.2 Reservoir Pressure Measurement:

The repeat formation tester (RFT) is a device capable of providing an estimate of formation permeability through the interpretation of pretest pressure data record during drawdown and buildup **(Stewart and Wittmann, 1979).**

The pressure analysis of Ras Qattara reservoir was studied in the SHMS-1X well. The average pressure reading is 5757psi, and The RFT plot of SHMS-1X well (Fig. 18) illustrates gas gradient of 0.15 psi/ft. and water gradient 0.5 psi/ft. Also RFT data indicates a probable gas water contact at depth (13202' / -12422').

Figure (Fig. 19) shows the analysis of pressure data for Ras Qattara reservoir in SHMS-4 well. The average pressure reading is 5742psi, and the RFT plot illustrates gas gradient of 0.15 psi/ft. and water gradient 0.41 psi/ft. and the gas water contact at depth (13164’ / -12410’).

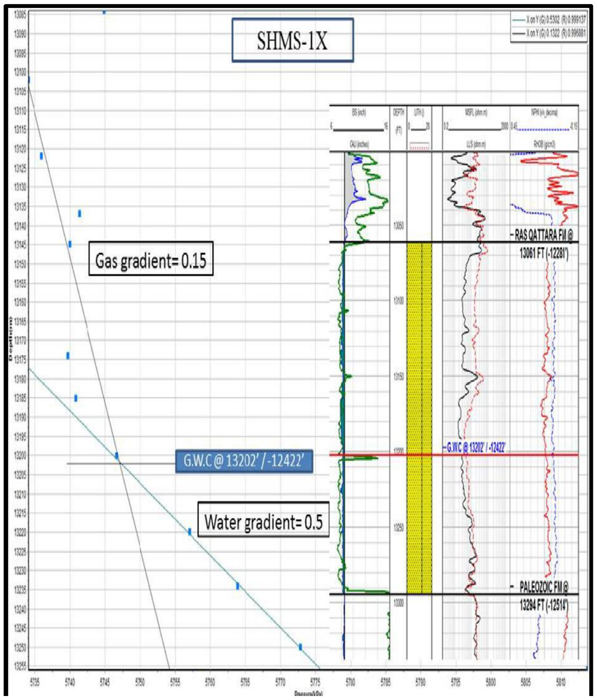

Fig. 18) Analysis of the Ras Qattara reservoir pressure data (RFT) in SHMS-1 well.

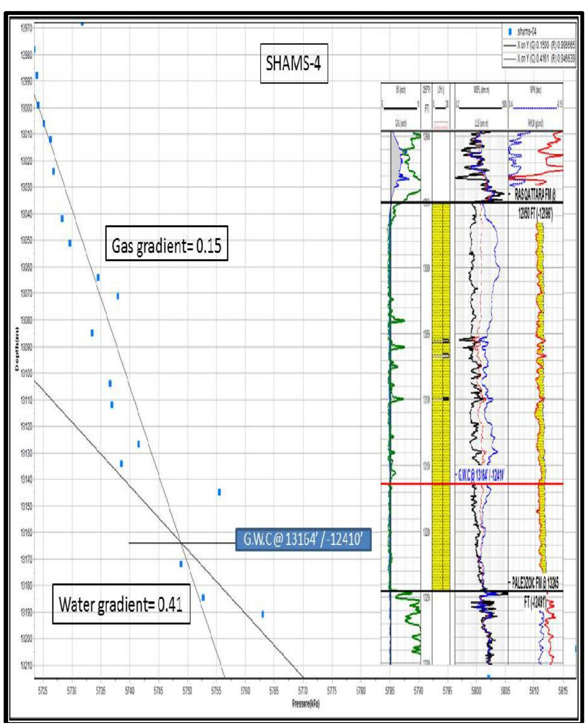

Fig. 19) Analysis of the Ras Qattara reservoir pressure data (RFT) in SHMS-4 well.

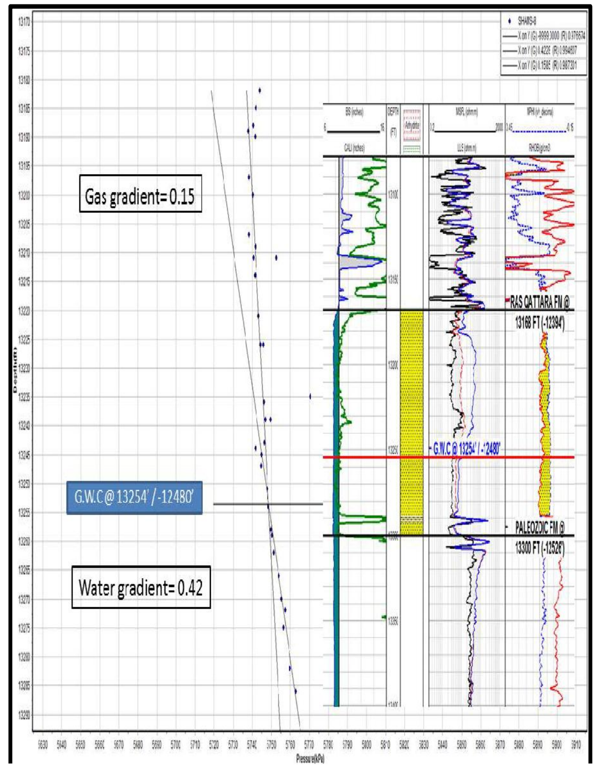

Fig. 20) Analysis of the Ras Qattara reservoir pressure data (RFT) in SHMS-8 well.

Figure 20 shows the analysis of pressure data for Ras Qattara reservoir in SHMS-8 well. The average pressure reading is 5750psi, and the RFT plot illustrates gas gradient of 0.15 psi/ft. and water gradient 0.42 psi/ft. and the gas water contact at depth (13254’ / -12480’).

1.3.3 Horizontal Variation of Petrophysical Characteristics:

A number of isoparametric maps, which are thenet pay, shale content, effective porosity, water saturation, and hydrocarbon saturation maps, represent the lateral variation of petrophysical characteristics.

1.3.3.1 Ras Qattara reservoir maps:

The effective porosity distribution map (Fig. 21), states that the effective porosity attains 5 %, at SHMS-6 and SHMS-7 wells, while it reaches 9.7 %, at SHMS-8 well. The Effective porosity values in Ras Qattara increase from central part of the study area to south direction, and decreases in the west and northeast directions.

The water saturation distribution map of the Ras Qattara reservoir in the study area (Fig. 22) reflects that the water saturation increases in the west and northeast directions, while it decreases in the north and south directions. The water saturation increases reaching maximum value, 78 %, at SHMS-6 well and decreases till reach minimum value, 25%, at SHMS-1X well.

The shale volume distribution map of the Ras Qattara reservoir (Fig. 23) shows that the shale volume content increases in the west and northeast directions and the highest value 8.4% at SHMS-6 well. while it decreases in the central part of the study area, north and south where it reaches the minimum value 3 % at SHMS-2X.

The net pay thickness distribution map of Ras Qattara reservoir (Fig. 24) shows that the net pay thickness attains its lowest values, 0 ft, at SHMS-6 and SHMS-7 wells. The net pay attains its highest value, 198 ft, at SHMS-4 well and increases from the southwest to the north directions.

The hydrocarbon saturation map of Ras Qattara reservoir (Fig. 25) shows that the hydrocarbon saturation increases from the south to the north directions. It decreases in the west and northeast and west directions of the study area. Hydrocarbon saturation attains maximum value, 75 %, at SHMS-1X well and the minimum value, 22 %, at SHMS-6 well.

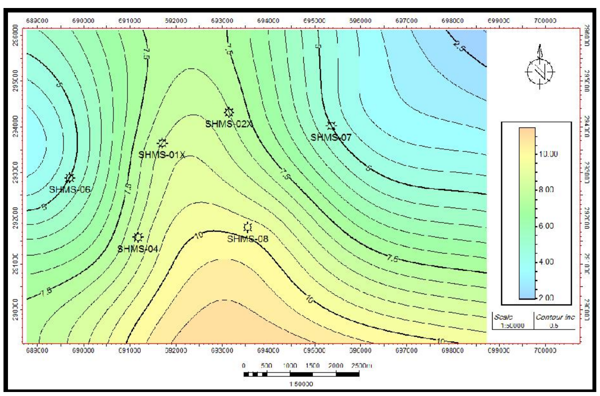

Fig. 21) Effective porosity map of the RAS QATTRAR reservoir

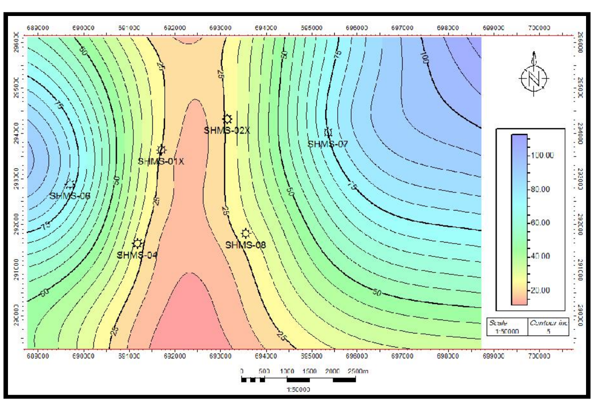

Fig. 22) Water saturation map of the RAS QATTRAR reservoir

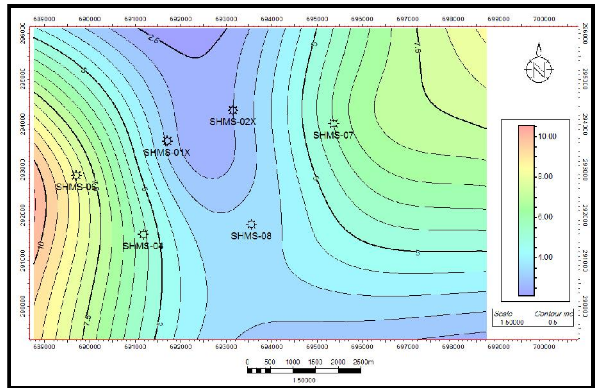

Fig. 23) Shale volume map of the RAS QATTARA reservoir

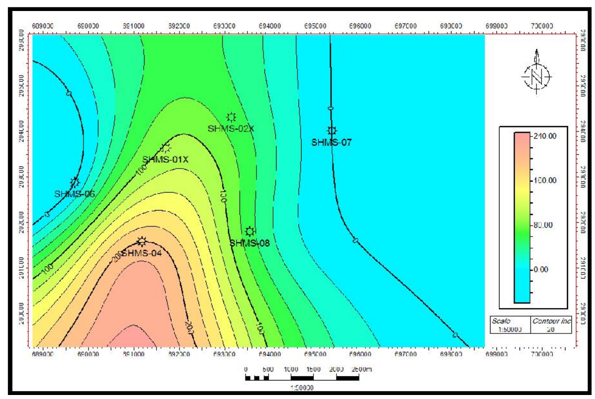

Fig. 24) Net pay map of the RAS QATTARA reservoir

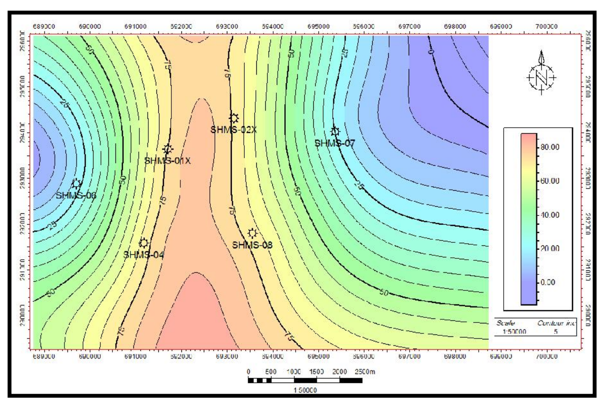

Fig. 25) Hydrocarbon saturation map of the RAS QATTARA reservoir

3. Conclusion

The Ras Qattara reservoirs is comprehensively described and analyzed in thisstudy area. The hydrocarbons are accumulated inthe trap has the form of three-way closurestructures or as a fault block structures. Some ofthe trapping structures could have possibly beencharged by hydrocarbons.

From the estimated petrophysical parameters together with seismic interpretation and subsurface geology of the studied area, it can be stated that the Ras Qattara Formations are rich with hydrocarbon potentiality and could be considered as promising reservoirs.

This was supported by the high structural position, good porosity, low shale content, low water saturation and a high percent of hydrocarbon saturation.

Accordingly, we have a good opportunity to drill more development and exploratory wells in the north and south parts to enhancement the productivity from the Shams filed.

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