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Formation Evaluation of the Jurassic Rocks in "Shams" Field, North Western Desert, Egypt.

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Abstract

The Middle Jurassic Khatatba 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 Upper and Lower Safa reservoirs in Shams field. The second objective is to evaluate the Safa 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. Upper and Lower Safa facies map shows that the Safa member is characterized by sandy shale facies which reflect fluviomarine condition during sedimentation of Safa member. The results of neutron- density cross plots revealed that, the lithology of Upper and Lower Safa 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 Safa member, and there is a good opportunity to drill more development and exploratory wells to enhance the productivity from Shams field.

Keywords: *Formation evaluation, seismic interpretation, well log analysis, facies map, shams field, 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' 45"- 30° 52' 35"N and longitudes 26° 25' 30"- 26° 33' 25"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 **(El Shazly, 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 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.

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.

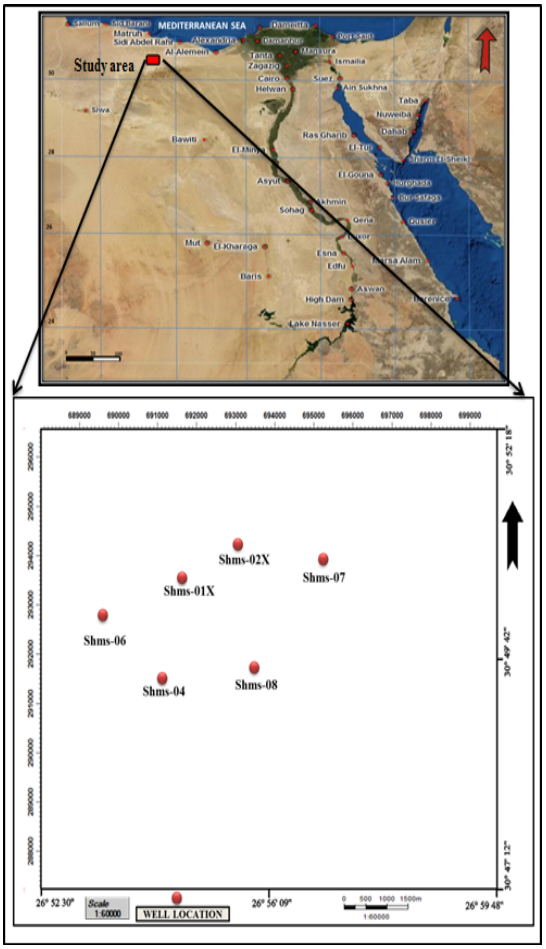


Fig.1): Location map of the study area showing the location of the drilled wells in Shams field, north Western Desert Egypt.

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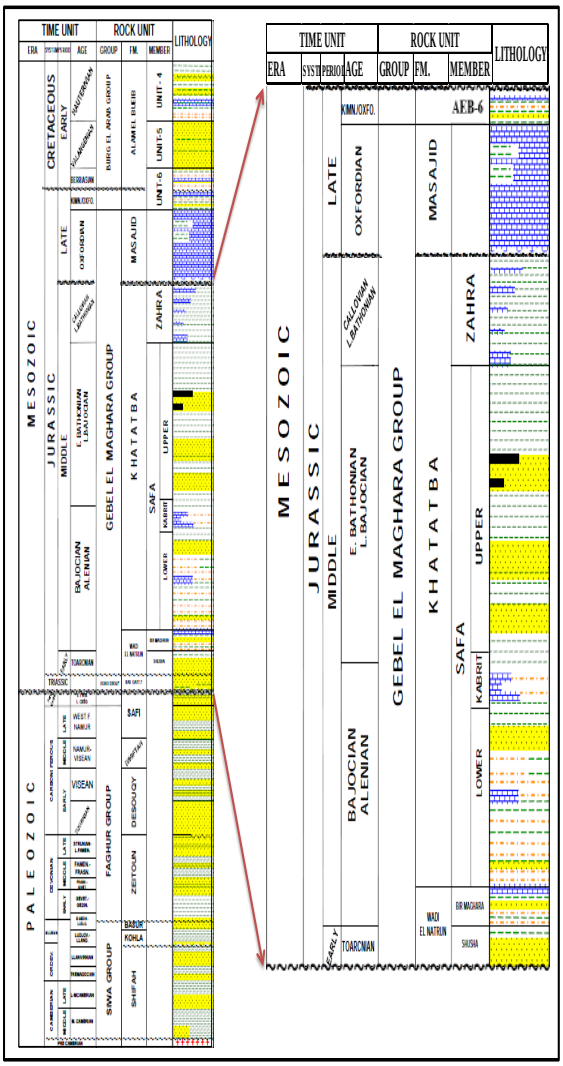


Fig.2): A Generalized stratigraphic column of the North Western Desert (Khalda, 2001).

3 Results And Discussions

1.1 Seismic Interpretation:

The interpretation of twenty seismic lines (Fig.3) covering the study area leads to identify the most important seismic reflectors throughout Upper and Lower Safa members. Moreover, seismic interpretation revealed a set of five normal faults namely F1,F2,F3,F4 and F5 forming Shams field horst block (Fig.4).

1.1.1 Horizons Interpretation:

Figure 5 shows the interpreted seismic line (Rline-1) this section shows four interpreted horizons; Masajid, Upper Safa, Kabrit and Lower Safa crossed by two normal faults (F1and F5). F1 has downthrown side towards the northeast direction, (F5) has downthrown side toward the southwest direction.

Figure 6 shows that the interpreted seismic line (Xline-14711) has two normal faults (F2 and F5). F2 has downthrown side towards the northeast direction.

Figure 7 shows the interpreted seismic line (Rline-3) this section shows two normal faults (F3 and F4). F3 has downthrown side towards the northeast direction, (F4) has downthrown side towards the southwest direction. These faults effect all horizons under investigation forming a horst structure.

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

3.2 Depth Structural Contour Maps:

Figure 8 shows that the structurally lowest part of Upper Safa member is represented in the northwestern corner, and the highest part is at the central and eastern parts of the area under investigation. Figure 9 shows the depth structural contour map on the top of Lower Safa member, the lowest part is in the western part and the highest part is in the central part at Shms-02X and Shms-07 wells.

1.1.2 Structural Modeling:

Building the reservoir structural model refers to the combined work of defining the structural horizons of the hydrocarbons accumulation and interpreting the fault pattern that affects the reservoir **(Cosentino, 2001).**

The 3D structure model of Upper and Lower Safa member shows that the Upper and Lower Safa have the same displacement, which means that the two Safa members were subjected to the same tectonic movement. Furthermore, the paleo-topography plays an important role in sediment thickness in our study area. The faults forming a horst block are an integral part in forming the trap for the hydrocarbon accumulations in Shams field (Fig.10).

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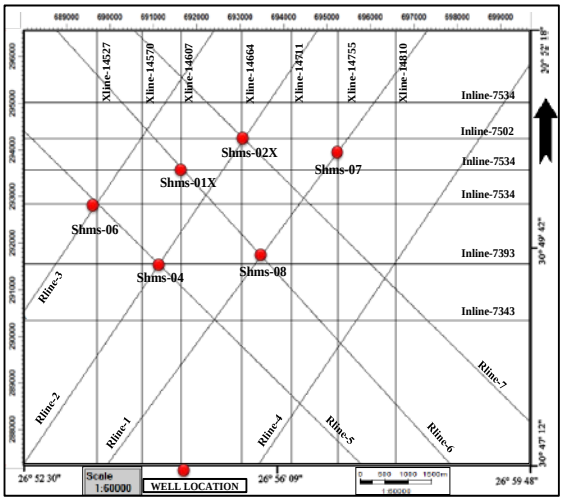


Fig.3): Base map of seismic lines and wells in the study area.

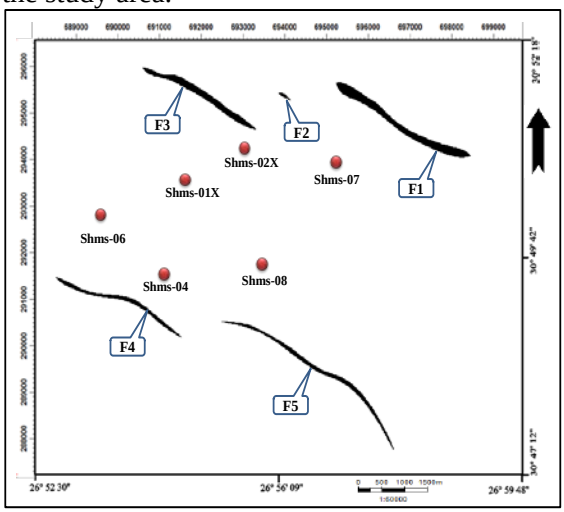


Fig.4): Faults affecting the area under investigation.

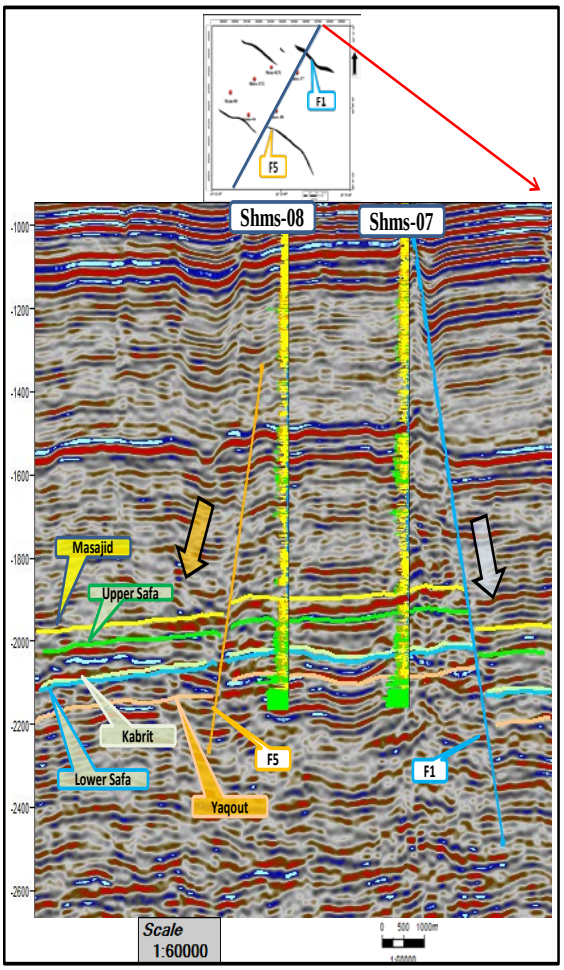


Fig.5): Seismic line (Rline-1) passing through Shms-07 and near Shms-08 wells. Two normal faults are detected (F1 and F5).

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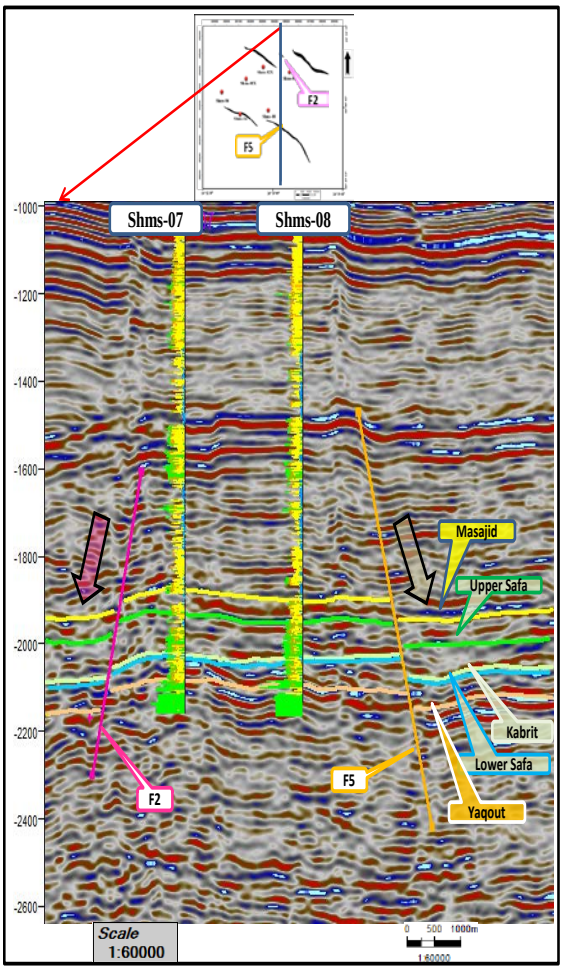


Fig.6): Seismic line (Xline-14711) passing near Shms-07 and Shms-08 wells. Two normal faults are detected (F2 and F5).

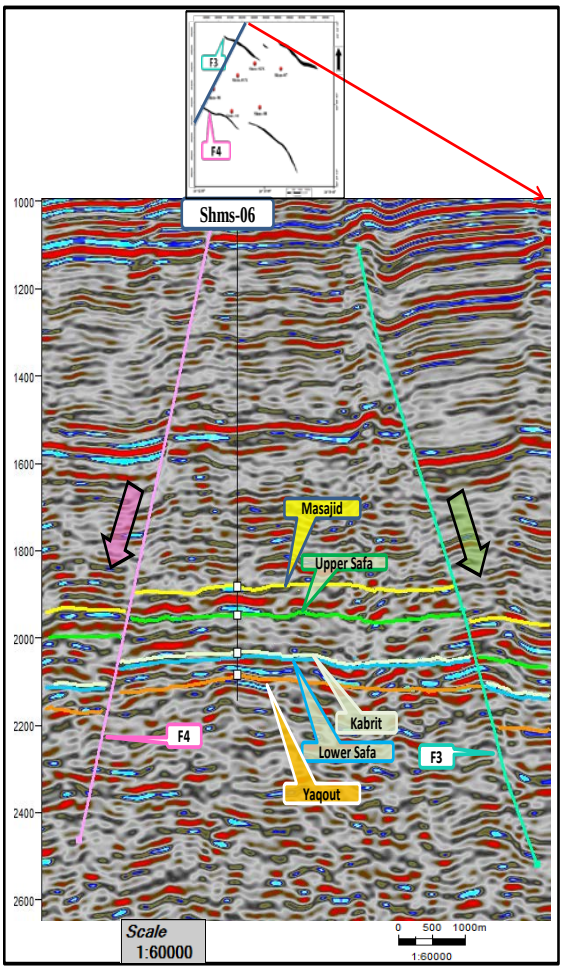


Fig.7): Seismic line (Rline-3) passing through Shms-06 well. Two normal faults are detected (F3 and F4).

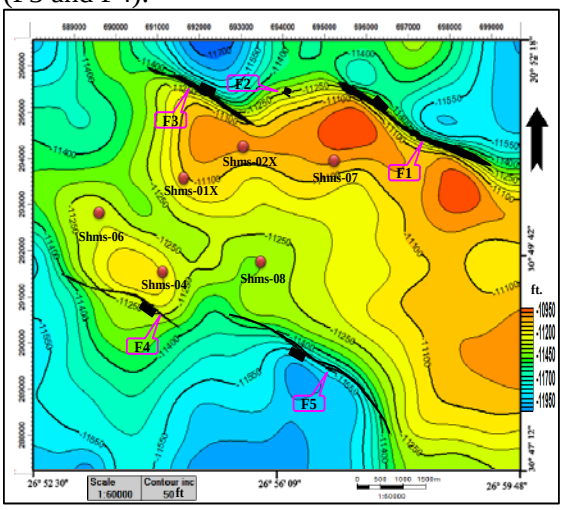


Fig.8): Depth structure contour map on top Upper Safa reservoir.

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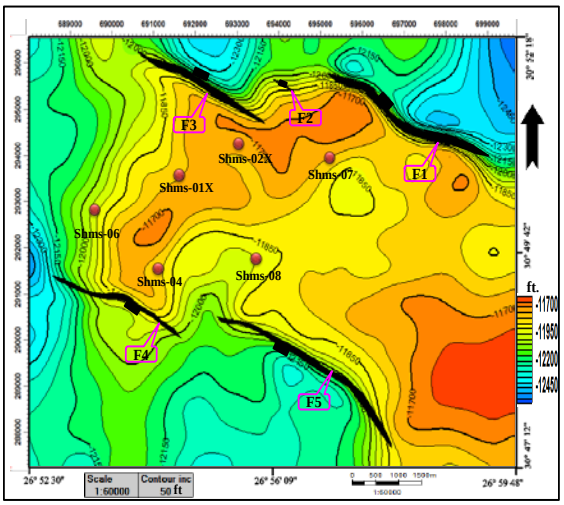


Fig.9): Depth structure contour map on top Lower Safa reservoir.

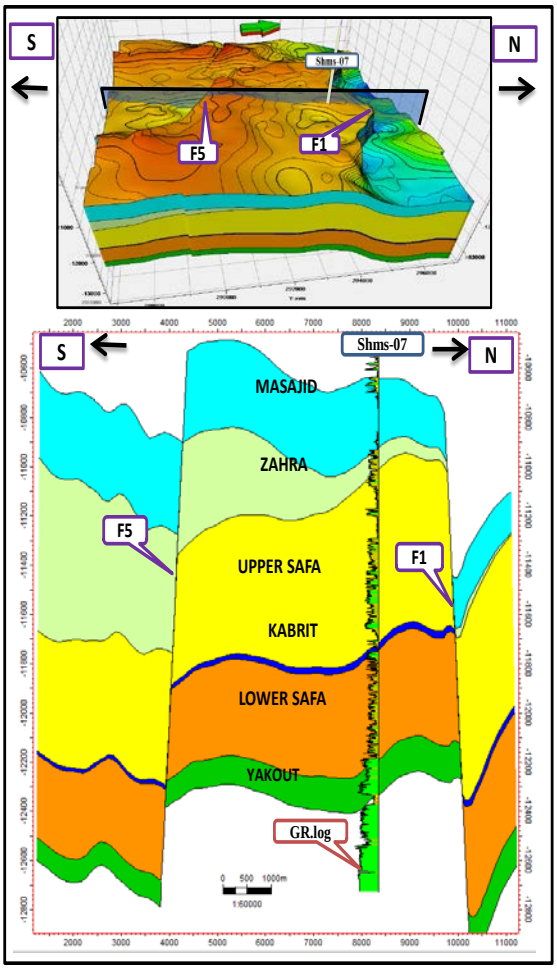


Fig.10): Structural cross section passing near Shms-07 well.

1.2 Lithofacies Maps:

The lithofacies maps reflect that the Upper Safa member is characterized by sandy shale facies in most of the studied wells changing to calcareous shale in the south and southeast directions. These facies reflect fluviomarine environment changing to shallow marine environment in the south and southeast part (Fig.11). Lower Safa facies map shows that the predominant facies is sandy shale which reflects fluviomarine conditions during sedimentation of this member (Fig.12).

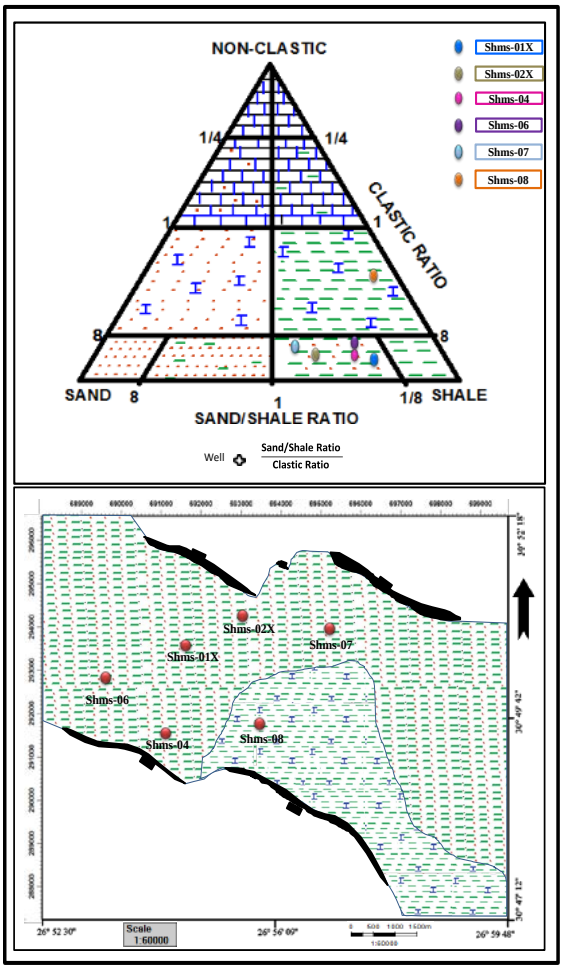


Fig.11): Facies map of the Upper Safa member in Shams filed.

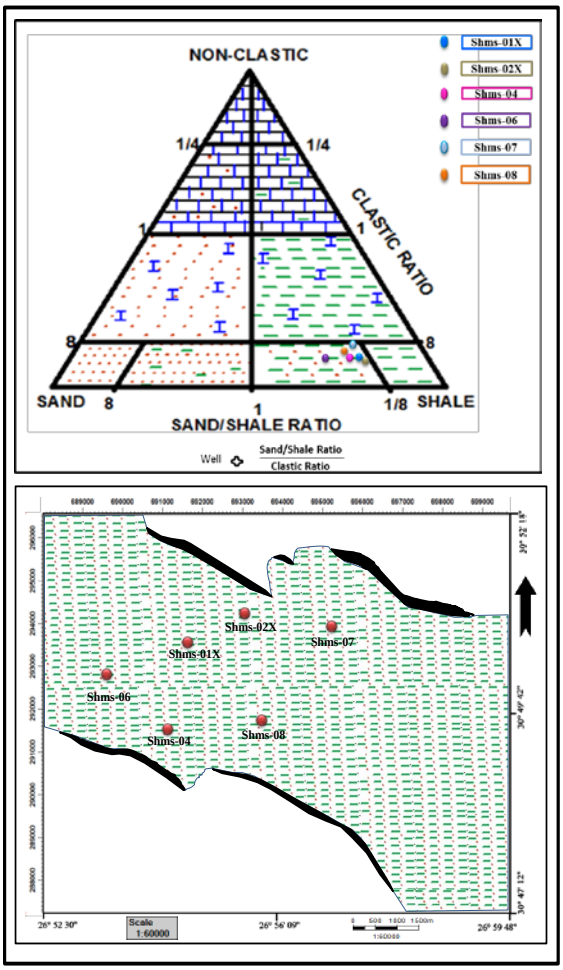


Fig.12): Facies map of the Lower Safa member in Shams filed.

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. 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 **(Poupon and Leveaux, 1971).**

Figure 13 shows the Neutron-Density cross-plots for Upper Safa reservoir in all our wells, it is observed that the majority of plotted points are located on sandstone line and in between sandstone and limestone lines with porosity ranging from 5% to 15%. This indicates that the reservoir is mainly sandstone with highly calcareous cement. The gas effect is observed where some points are shifted upwards above sandstone line. The neutron-density cross plot of the Lower Safa reservoir in our wells (Fig.14) shows that the plotted points are scattered between sandstone and limestone lines, with porosity ranging from 5% to 14%. It indicates that the lithology is sandstone with highly calcareous cement. Some distorted scattered points are observed towards dolomite line due to dolomitic cement, other points are shifted upward due to gas effects.

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 data for Upper Safa were only collected in Shms-06 and Shms-07 wells (Fig.15 and 16). The pressure analysis of Upper Safa illustrates average pressure reading (5230 psi and 5160psi) and gas gradient (0.11psi/ft and 0.15psi/ft) were observed in Shms-06 and Shms-07 wells respectively. The gas gradient (0.15psi/ft) and Water gradient (0.5psi/ft) were defined only in Shms-07 well, indicates a probable gas water contact at depth 12050/-11278ft TVDSS.

Figure 17 shows the analysis of pressure data for Lower Safa reservoir collected in Shms-06 well. The pressure readings in this well are scattered, so there is no sufficient data for Lower Safa reservoir to establish gas gradient or gas water contact and the average pressure is 5699psi/ft.

Based on the pressure readings and gradient data, it can be concluded that the hydrocarbon type of Safa Formation in Shams field is mainly Gas and it characterized by a gas expansion drive mechanism, as indicated by pressure decrease with production.

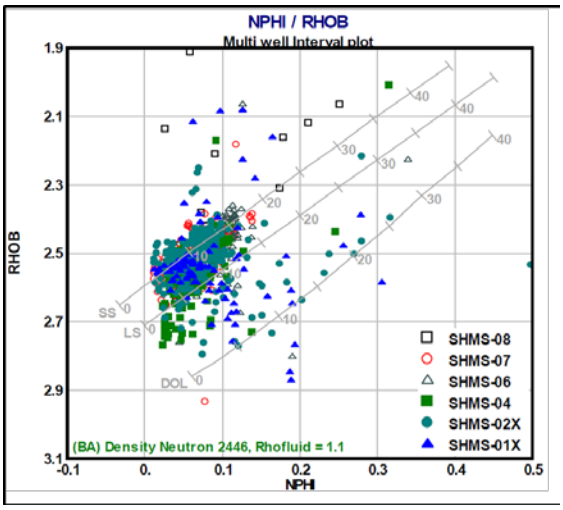


Fig.13): Neutron –Density cross-plot of the Upper Safa reservoir in Shams field.

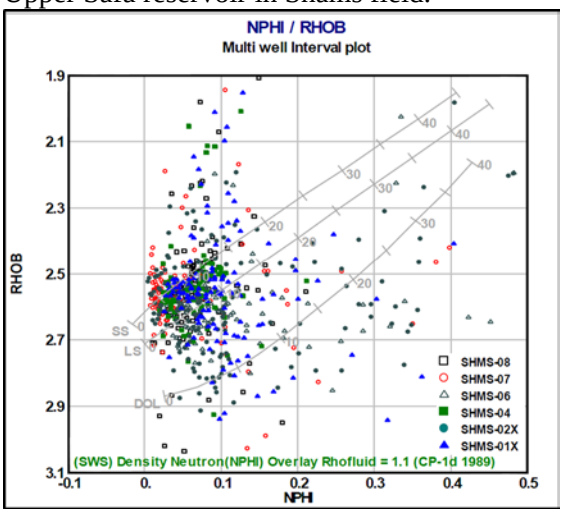


Fig.14): Neutron –Density cross-plot of the Lower Safa reservoir in Shams field.

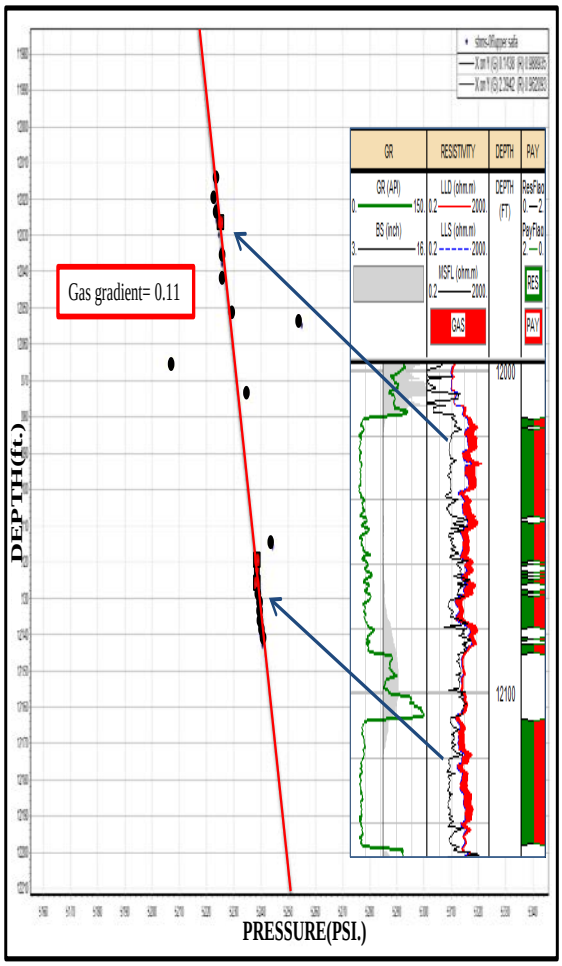


Fig.15): Analysis of the Upper Safa reservoir pressure data (RFT) in Shms-06 well.

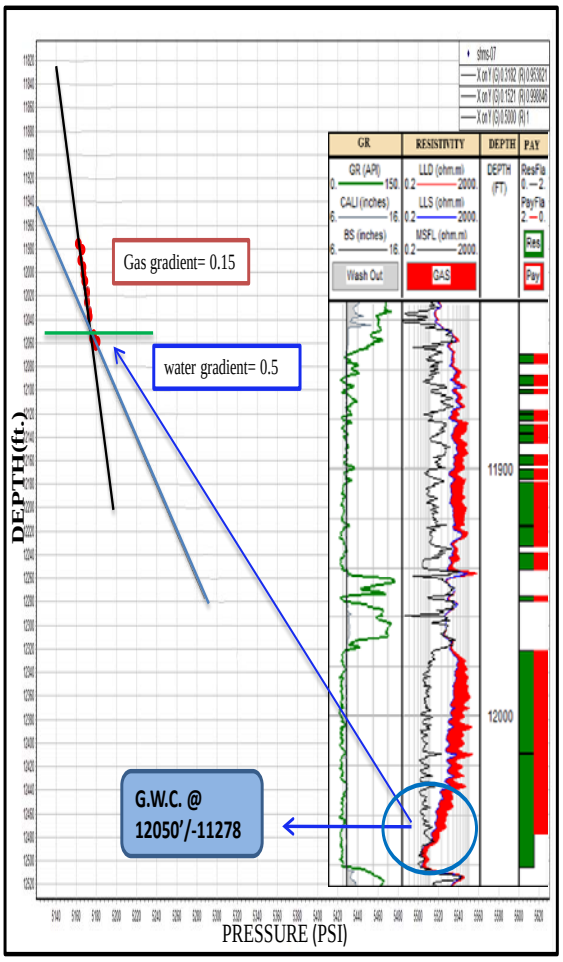


Fig.16): Analysis of the Upper Safa reservoir pressure data (RFT) in Shms-07 well.

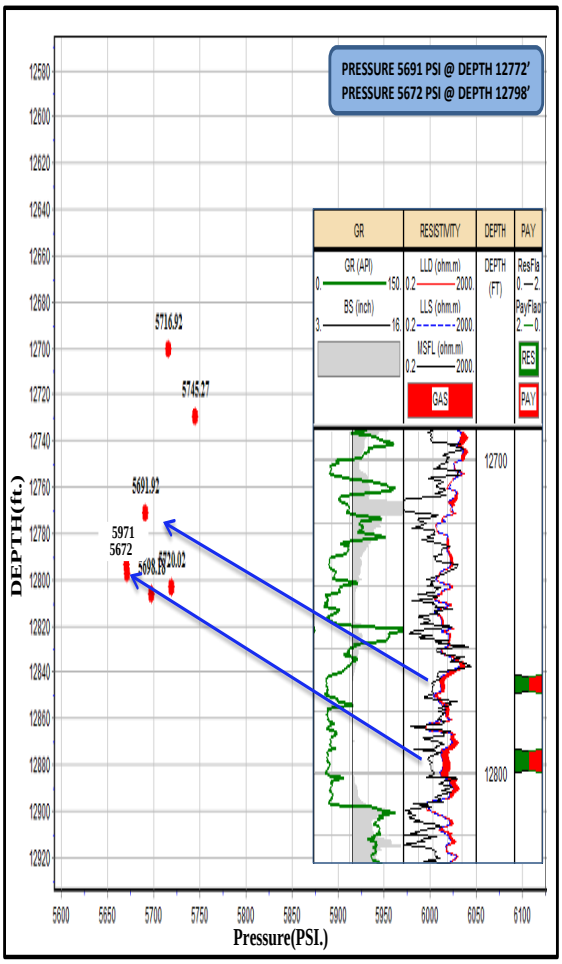


Fig.17): Analysis of the Lower Safa reservoir pressure data (RFT) in Shms-06 well.

1.3.3 Horizontal Variation of Petrophysical Characteristics:

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

1.3.3.1 Upper Safa reservoir maps:

The net pay distribution map (Fig.18) of the Upper Safa reservoir shows an increase towards the northeastern part of the study area, where it reaches 147ft in Shms-07 well. It decreases toward the south direction to reach 13ft in Shms-08 wells.

The effective porosity of the Upper Safa reservoir increases in the northeastern direction, and gradually decreases towards the south direction of the study area, where it reaches its

maximum value 11.0% in Shms-06 well. The minimum value 6.6% in Shms-01X well (Fig.19).

The water saturation distributions map of the Upper Safa reservoir in the study area (Fig.20) shows a remarkable increase towards the south part, where it reaches the maximum value 20.4% in Shms-08 well. It decreases in the northeastern part of the study area with a minimum value 10.6% in Shms-07 well.

The shale volume distribution map of the Upper Safa reservoir (Fig.21) shows that the shale volume content increases in the central part of the study area with the highest value 6.4% in Shms-01X well. It decreases in the west and east directions of the study area, where it reaches the minimum value 1.9% in Shms-08 well.

The hydrocarbon saturation map (Fig.22) of the Upper Safa reservoir illustrates an increase toward the central and northeastern part, where it reaches the maximum value 89.4% in Shms-07 well and the minimum value 79.6% in Shms-08 well.

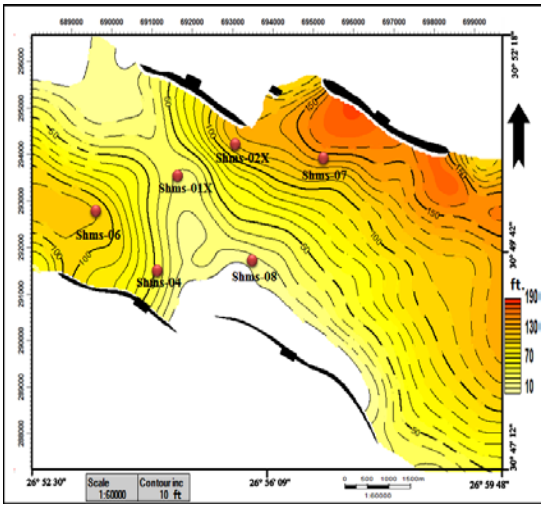


Fig.18): Net pay thickness map of the Upper Safa reservoir.

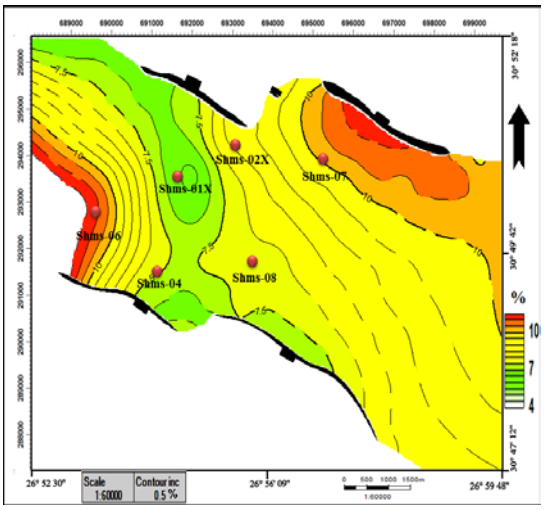


Fig.19): Effective porosity map of the Upper Safa reservoir.

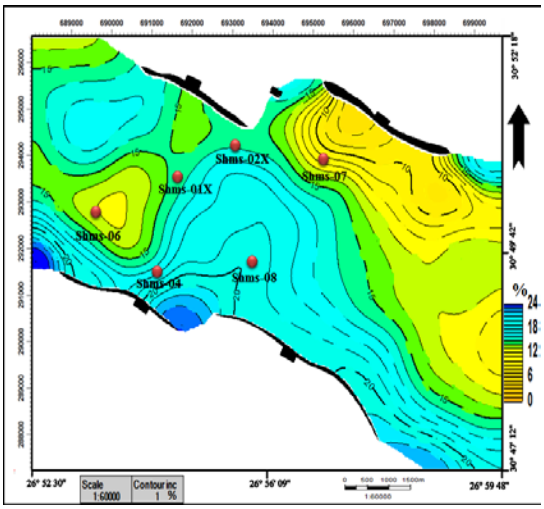


Fig.20): Water saturation map of the Upper Safa reservoir.

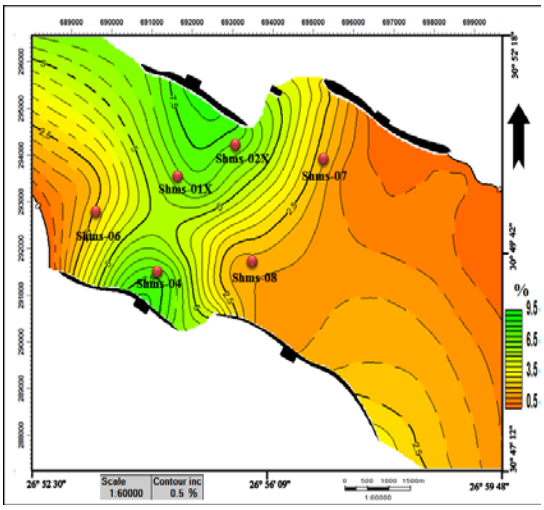


Fig.21): Shale volume map of the Upper Safa reservoir.

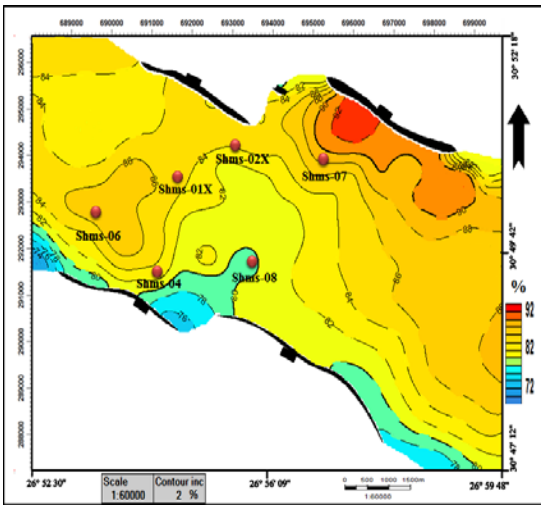


Fig.22): Hydrocarbon saturation map of the Upper Safa reservoir.

1.3.3.2 Lower Safa reservoir maps:

The net pay thickness distribution map of the Lower Safa reservoir (Fig.23) shows that the net pay thickness attains its least value 3ft in Shms -07, whereas its greatest value70 ft is recorded in Shms-01X well, the thickness of net pay in the Lower Safa increases gradually from the central part to the northwest and southeast directions, while it decreases in the northeast and west directions of the study area.

The effective porosity distribution map (Fig.24) shows a value of effective porosity 6.8% in Shms-02X well is the lowest value in our study area, while it reaches the highest value 8.3% in Shms-04 well, the effective porosity increases in the north and northwest direction. It decreases in the central part and southwest corner of the study area.

The water saturation distribution map (Fig.25) shows that the water saturation increases in the south and extend to southeast direction, while it decreases in the central part and northeast direction. The maximum value 27.4% occurs in Shms-08 well and the minimum value 17% occurs in Shms-1X well.

The shale volume distribution map (Fig.26) shows an increase in the south and southeast directions where it reaches its maximum value 9.3% in Shms-08 and Shms-01X while, it decreases to 1.7% towards the east and northeast directions in Shms-06 Shms-07 and Shms-02X wells.

The hydrocarbon saturation map (Fig.27) shows that the hydrocarbon saturation gets its highest value 83.1% at Shms-01X well and lowest value 72.6% in Shms-08 well. Hydrocarbon saturation increases in the north and northwestern part. It decreases in the southeast directions of the study area.

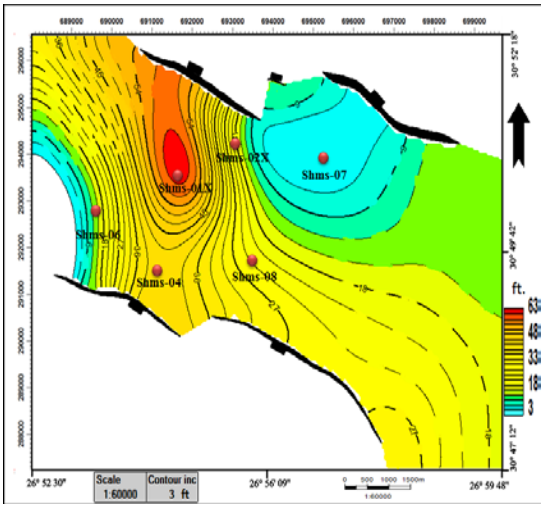


Fig. 23): Net pay thickness map of the Lower Safa reservoir.

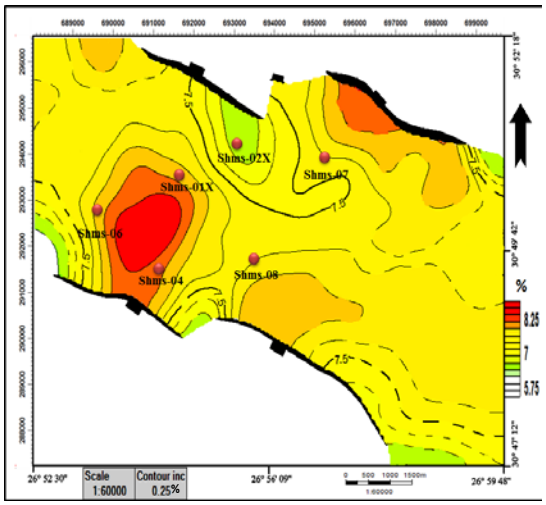


Fig.24): Effective porosity map of the Lower Safa reservoir.

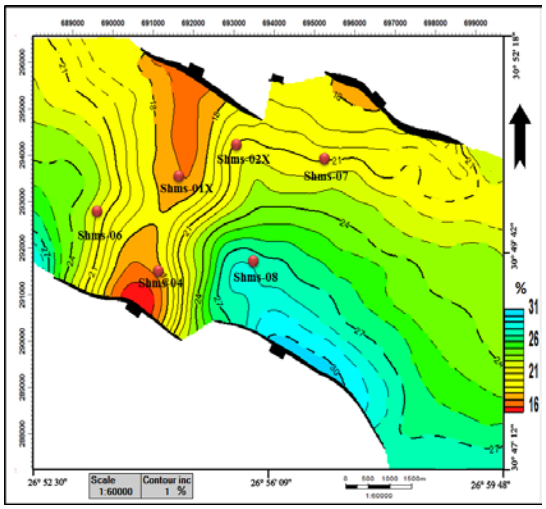


Fig.25): Water saturation map of the Lower Safa reservoir.

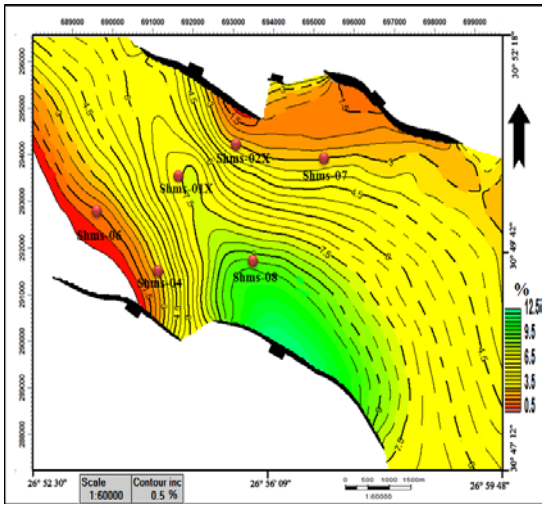


Fig.26): Shale volume map of the Lower Safa reservoir.

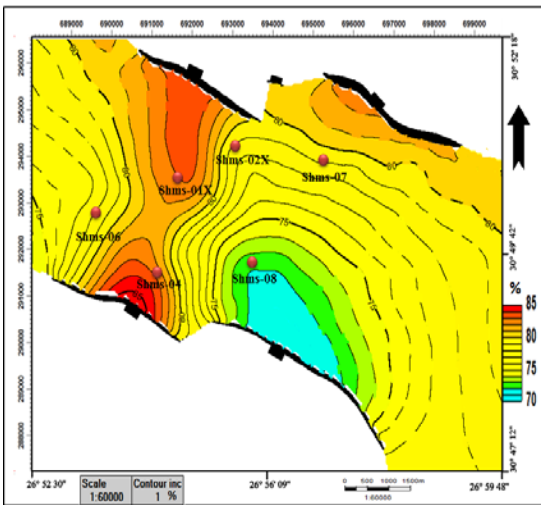


Fig.27): Hydrocarbon saturation map of the Lower Safa reservoir.

3. CONCLUSION

The Upper and Lower Safa reservoirs are comprehensively described and analyzed in this study area. The hydrocarbons are accumulated in the trap has the form of three-way closure structures or as a fault block structures. Some of the trapping structures could have possibly been charged by hydrocarbons.

Accordingly, by integrating the seismic interpretation and subsurface geological study together with the results of petrophysical parameters analysis, it can be concluded that the hydrocarbons potentiality of the Safa reservoirs was enhanced towards the north and northeastern parts of the study area. This was supported by the high structural position, good porosity, low shale content, low water saturation and a high percent of hydrocarbon saturation.

This encourages to drill more development and exploratory wells in north and northeastern parts of the study area to enhance productivity in the Shams field.

References

[1] A.N. Abu Shady, "Sedimentary Environments and Petrophysical Characteristics of the Khatatba Formation (Middle Jurassic), North Western Desert, Egypt", Ph.D. Thesis. Geo. Dep. Tanta Univ., Egypt, 2003, 133 p.

[2] A.S. Al Sharhan, and Abd E.A. El Gawad, "Geochemical Characterization of Potential Jurassic/Cretaceous Source Rocks in the

Shushan Basin, North Western Desert, Egypt". Jour Petrol. Geo., 2008, Vol. 31, No. 2, PP. 191–212.

[3] L. Cosentino, "Integrated Reservoir Studies". Ed. Ophrys, Paris, France, 2001, 336 p.

[4] J.C. Dolson, M.V. Shann, S.I. Matbouly, H. Hammouda, and R.M. Rashed, "Egypt in the 21st Century: Petrol. Potential in Offshore Trends". Geo Arabia, 2000, Vol. 6, pp. 211-230.

[5] EGPC (Egyptian General Petroleum Corporation), "Western Desert, oil and gas fields, a comprehensive overview". EGPC, Cairo, 1992, 431 p.

[6] A. El Awdan, F. Youssef, and A.R. Moustafa, "Effect of Mesozoic and Tertiary Deformations on Hydrocarbon Exploration in the Northern Western Desert, Egypt". In Am. Assoc. Petrol. Geol. Int. Meeting , 2002, (Abstract).

[7] E.M. El Shazly, "The geology of the Egyptian region", In Kanes, A.E.M., Stehli, F.G. (Eds.), The Ocean Basins and Margins. Plenum, New York, 1977, pp. 379-444.

[8] G. Hanter, "North Western Desert. In R. Said, (ed)., The Geology of Egypt, Rotterdam, The Netherlands, A. A. Balkema Publishers, 1990, PP. 293-319.

[9] Khalda Petroleum Company Internal Report, "Paleontological Studies for Qasr Field". 2001, PP.3-22.

[10] K. E. Peters, and M. R. Cassa, "Applied Source Rock Geochemistry. in: Magoon, L.B., Dow, W.G. (eds.) The Petroleum System-From Source to Trap". American Association of Petro. Geologists, 1994, Memoir 60, PP. 93-120.

[11] A. Poupon, and J. Leveaux, "Evaluation of Water Saturation in Shaly Parts of Northern Egypt". AAPG. 1971, Vol. 60, No.1. (Abstract).

[12] G. Stewart, and M.J. Wittmann, "Interpretation of Pressure Response of the Repeat Formation Tester", Presented at the SPE Fall Meetings, in Las Vegas, Nevada, 1979, SPE 8362, PP. 2-21.

[13] N. Sultan, and M. Abd EL Halim, "Tectonic Framework of Northern Western Desert, Egypt and Its Effect on Hydrocarbon Accumulations", Proc. 9th EGPC. Petrol. Expl. Prod. Conf., 1988, Vol. 2, PP.1-31.

[14] M.Y. Zein El Din, E.A. Abd El Gawad, H.M. El Shayb, and I.A. Haddad, "Geological Studies and Hydrocarbon Potentialities of the Mesozoic Rocks in Ras Kanayes Onshore Area, North Western Desert, Egypt", Annals of the Geological Survey of Egypt, 2001, Vol.24, pp. 115-134.