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Petrophysical Evaluation of Middle Jurassic Reservoirs, Shams Oil Field, North Western Desert, Egypt.

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Abstract: *The Western Desert is one of the most promising areas for hydrocarbon exploration and production in Egypt. The present work aims to evaluate the petrophysical reservoir characteristics and the lithology of Middle Jurassic Upper Safa reservoir (middle part of Khattatba Formation) in Shams oil field, North Western Desert, Egypt. Five wells (Shams-1x, Shams-2x, Shams-3, Shams-4 and Shams-8) were utilized for this study. They are analyzed for evaluating the different petrophysical parameters of the Middle Jurassic Upper Safa reservoir. The well log analysis of the Upper Safa reservoir, including data editing and data correction, are used in determination of lithology and porosity using density-neutron crossplots. The results of density-neutron cross plots revealed that, the lithology of Upper Safa reservoir is mainly sandstone with some calcareous cement. A weak effect of natural gas appears by shifting the plotted samples to the up-left of sand line. The porosity in the five wells ranges from 5% to 15% indicating fair porosity. Petrophysical parameters of the Upper Safa reservoir are illustrated in vertical litho-saturation crossplots to delineate the most effective sand zones in each well. Movable hydrocarbon increases mostly at the top and middle parts of the target reservoir in the studied wells. The iso-parametric maps of the Upper Safa reservoir show that, the northern and northwestern parts of Shams oil field are the most promising areas for future development.*
Keywords: *Middle Jurassic, Petrophysical Evaluation, Shams oil Field, North Western Desert.*

I. Introduction

The Western Desert is an important hydrocarbon producing region and has been intensely explored since the middle of the last century [1 & 2]. The study area is located in Shoushan Basin, Northern Western Desert, Egypt. It lies between latitudes 30° 48' - 30° 51' N and longitudes 26° 53' – 26° 57' E (Fig. 1). The northern part of the Western Desert consists of a number of sedimentary basins that received a thick succession of Mesozoic sediments. The sedimentary section in the northern part of the Western Desert can be divided into three sequences based on lithology, namely: the lower clastic unit from Cambrian to pre-Cenomanian, the middle carbonates from Cenomanian to Eocene and the upper clastic unit from Oligocene to Recent [3].

The Mesozoic sequence overlies unconformably Paleozoic rocks. The Mesozoic stratigraphic succession is much better understood than the Paleozoic one as it is encountered in all studied wells as indicated by [4, 5, 6, 7, 8, 9, 10& 11]. Figure (2) illustrates the simplified stratigraphic section in the Western Desert.

The Middle Jurassic sandstones of the Khatatba Formation are an attractive petroleum exploration target in the northern part of the Western Desert. [12] indicated that, Khatatba Formation at the eastern margin of Shushan basin is mainly composed of sands interbeded with overbank organic-rich shales and coals, reflecting fluvio-deltiac deposits of fluviatile and tidally influenced channel. It is overlain conformably by Upper Jurassic Masajid Formation. Among the key references dealing with the petroleum systems in the north Western Desert are: [13, 14, 15, 16, 17, 18, 19 & 20].

The structural setting of the North Western Desert has been discussed by many authors such as, [21, 3, 22, 23, 24& 25] and others.

The main objectives of this study are to determine the reservoir lithology and porosity using Density-Neutron crossplots, identify the different reservoir parameters characterizing the pay zones and construct iso-parametric maps from well log data to delineate the most effective sand zones and spot light on the promising locations for other further exploration.

II. Materials And Methods

The studied wells are: Shams-1X, Shams-2X, Shams-3, Shams-4 and Shams-8. The available well logs are density, neutron, gamma ray, resistivity, caliper, and sonic logs. The interpretation of lithology and porosity of the Upper Safa reservoir was undertaken using all the logs registered through a systematic approach, they were determined from logs using some chart types of neutron-density crossplots [26]. The neutron-density crossplots are commonly used to determine the lithology and accurately evaluate the porosity of the reservoir rocks. The effect of light hydrocarbons (natural gas) can be observed on the cross plot, where the plotted points tend to shift north-westerly from the sandstone line. Also, the effect of shale can be observed on the crossplot, where the shale effects tend to be in the lower-right quadrant of the crossplot [27].

The well log evaluation has been achieved using Interactive Petrophysics software (IP) version 4.2. The petrophysical parameters of the Upper Safa reservoir extracted from the well log data are used to display vertical litho-saturation crossplots of resulted petrophysical parameters to delineate the most effective sand zones in each well. These crossplots are used for the formation analysis which represents the vertical distribution of the rocks (lithology), fluids and porosity (total and effective porosity). This evaluation is useful to isolate zones for possible future testing. The results of well log analysis are used also to draw distribution maps for gross thickness, net sand, net pay thickness, total porosity, effective porosity, water saturation, shale volume, hydrocarbon saturation, irreducible hydrocarbon saturation and movable hydrocarbon saturation. The net pay thickness is calculated using 10% or more for effective porosity, 35% or less for shale volume and 50% or less for water saturation.

III. Results And Discussions

3.1 Determination Of Lithology And Porosity From Neutron-Density Crossplots

Figure (3) illustrates the neutron-density crossplots of the Upper Safa reservoir in the studied wells, it is observed that, the majority of plotted points are scattered very close to sandstone line in wells (Shams-1x, Shams-2x and Shams-3. In wells (Shams-4 and Shams-8) the plotted points scattered between sand and limestone Lines. The porosity values range from 5% to 15%. This indicates that, the reservoir is mainly sandstone with some calcareous cement and fair porosity. The effect of gas is weakly observed where some points are slightly shifted upward above sand line in wells (Shams-1x, Shams-2x, Shams-3 and Shams-8).

3.2 Petrophysical Evaluation

3.2.1 Vertical Litho-Saturation Crossplots

Corrected well logs data and derived reservoir parameters are plotted versus depth in the vertical litho-saturation crossplots showing the pay zones and hydrocarbon shows in the studied wells. Also the diagram illustrates the log package on the well from lift to right (first track gamma ray, resistivity, density / neutron, pay / reservoir flag, water / hydrocarbon saturation, porosity and the last track is lithology) (Figs. 4, 5 and 6). The analysis reflects the predominance of calcareous sandstone intercalated with shale streaks. Movable hydrocarbon is the most important parameter and has a wide vertical distribution in all wells. It increases mostly at the top and middle parts of Upper Safa reservoir. Therefore, the productivity is expected to be good in sandstone parts of the formation.

3.2.2 Reservoir Mapping

The log- derived petrophysical parameters are presented in contour maps to show their general distribution throughout the Upper Safa reservoir. The total thickness map of Upper Safa reservoir (Fig.7a) shows thickness increasing toward the north direction and decreasing toward east and southeast directions. The maximum thickness is 682ft at Shams-2X well. The minimum thickness is 662 ft at Shams-8 well. The Net sand distribution map (Fig.7b) shows general increasing toward north and north east direction, where it reaches 130ft in Shams-2x well. It decreases in southern and central area reaching 13ft in Shams-8 well.

The net pay thickness map (Fig.7c) reflects an increasing toward north and northeast directions and decreasing toward south and southeast directions. The maximum value 96 ft is recorded at Shams-2x well. The minimum value 18 ft is recorded at Shams-8 well. The total porosity (Fig.7d) increases toward northeast direction where it reaches 10.4% in Shams-3 well. It decreases toward south direction where it reaches 7.95% in Shams-8 well.

The effective porosity (Fig.7e) follows the same directions of total porosity recording maximum value (9.6%) in Shams-2x well and minimum value (7.7%) in Shams-8 well. The water saturation of Upper Safa reservoir increases to the east and northeast directions. It decreases to the west direction. It reaches 25 % at Shams-3 well, and attains the lowest value of 13.9 % at Shams-1x well (Fig. 7f).

Shale volume content increases in northwest direction, while it decreases in the southeast direction. The shale volume distribution map (Fig. 8g) shows that, the lowest value is 0.5 % at Shams-8 well and the greatest value is 7.9 % at Shams-1x well. (Fig. 8h) shows increasing in hydrocarbon saturation in the west and North West directions. It decreases toward north east direction of the study area. The hydrocarbon saturation attains a maximum value of 83.9 % at Shams-1x well and the minimum value is 74 % at Shams-3 well.

Irreducible and movable hydrocarbon saturation shows opposite directions (Figs. 8I & 8J). The Irreducible hydrocarbon saturation increases toward south and southeast direction reaching 56.2% in Shams-8 well. The movable hydrocarbon saturation increases toward north and northwest directions reaching the maximum value 52.5 % in Shams-1x well.

IV. Conclusion

The density-neutron crossplots of the Middle Jurassic Upper Safa reservoir illustrate that the lithology is mainly sandstone with some calcareous cement and weak natural gas effect appears in shifting some points to the up-ward of the sand line in the diagrams. The vertical litho-saturation crossplots of the resulted petrophysical parameters delineate the most effective sand zones in each well, Movable hydrocarbon is the most important parameter. It increases mostly at the top and middle parts of the formation. The hydrocarbon, irreducible hydrocarbon and movable hydrocarbon saturation distribution maps show a general improvement at the northern and northwestern parts of the study area. These parts are the most promising for future exploration and development.

V. Figures And Tables

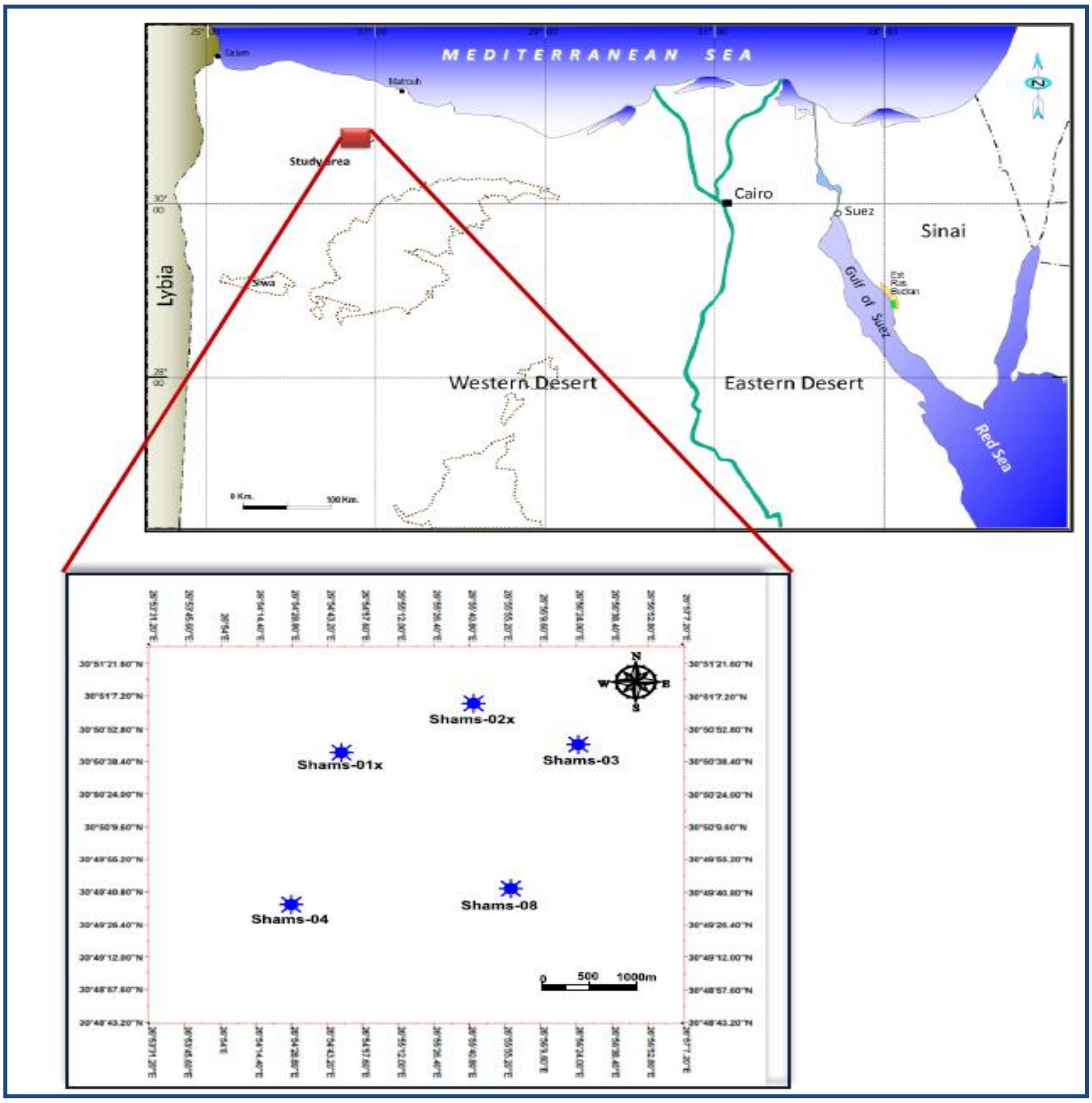

Fig. 1: Location map of the study area (Shams oil field), North Western Desert, Egypt.

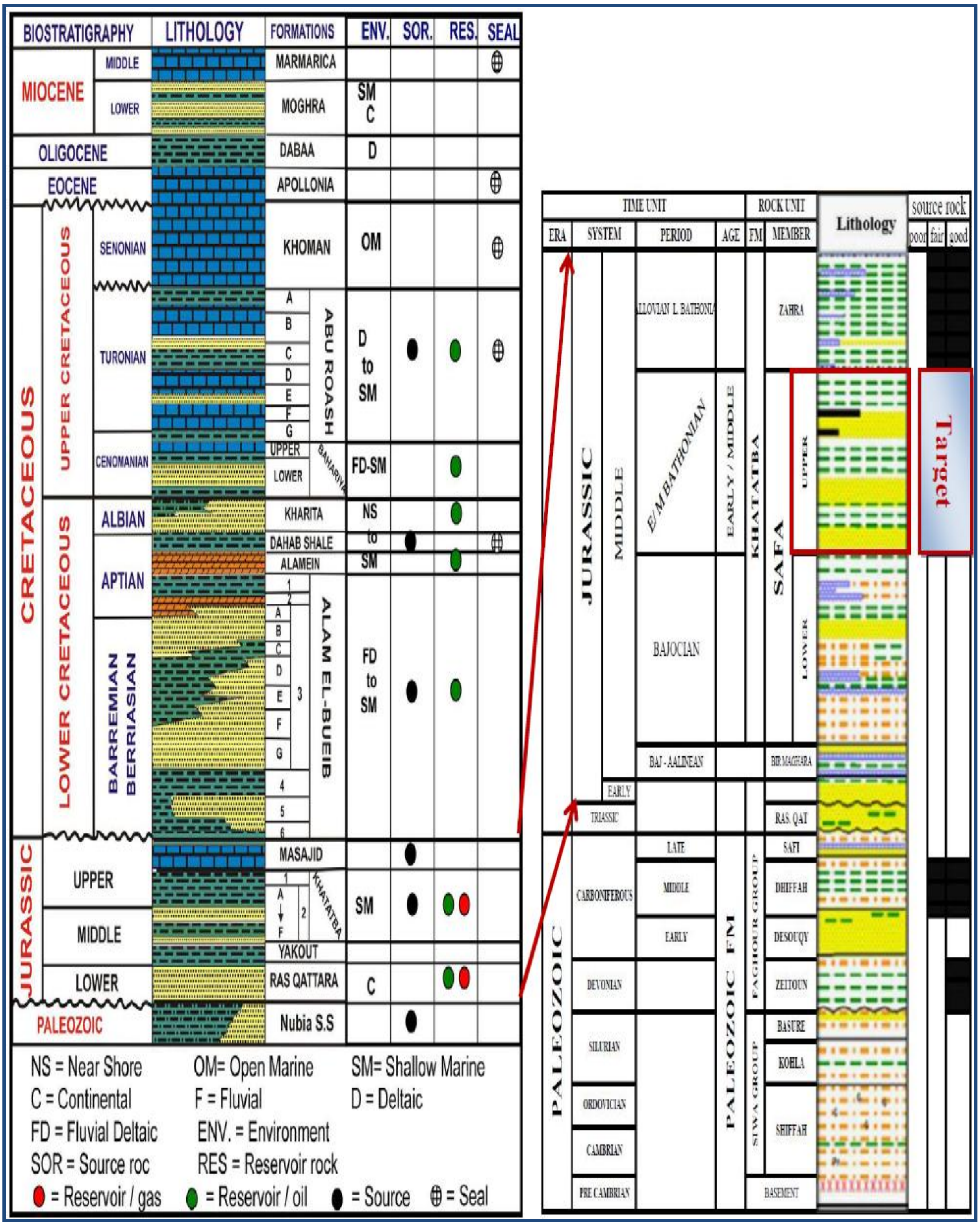

Fig. 2: Generalized litho stratigraphic column of the Western Desert, Egypt (modified after [10, 11 & 28]).

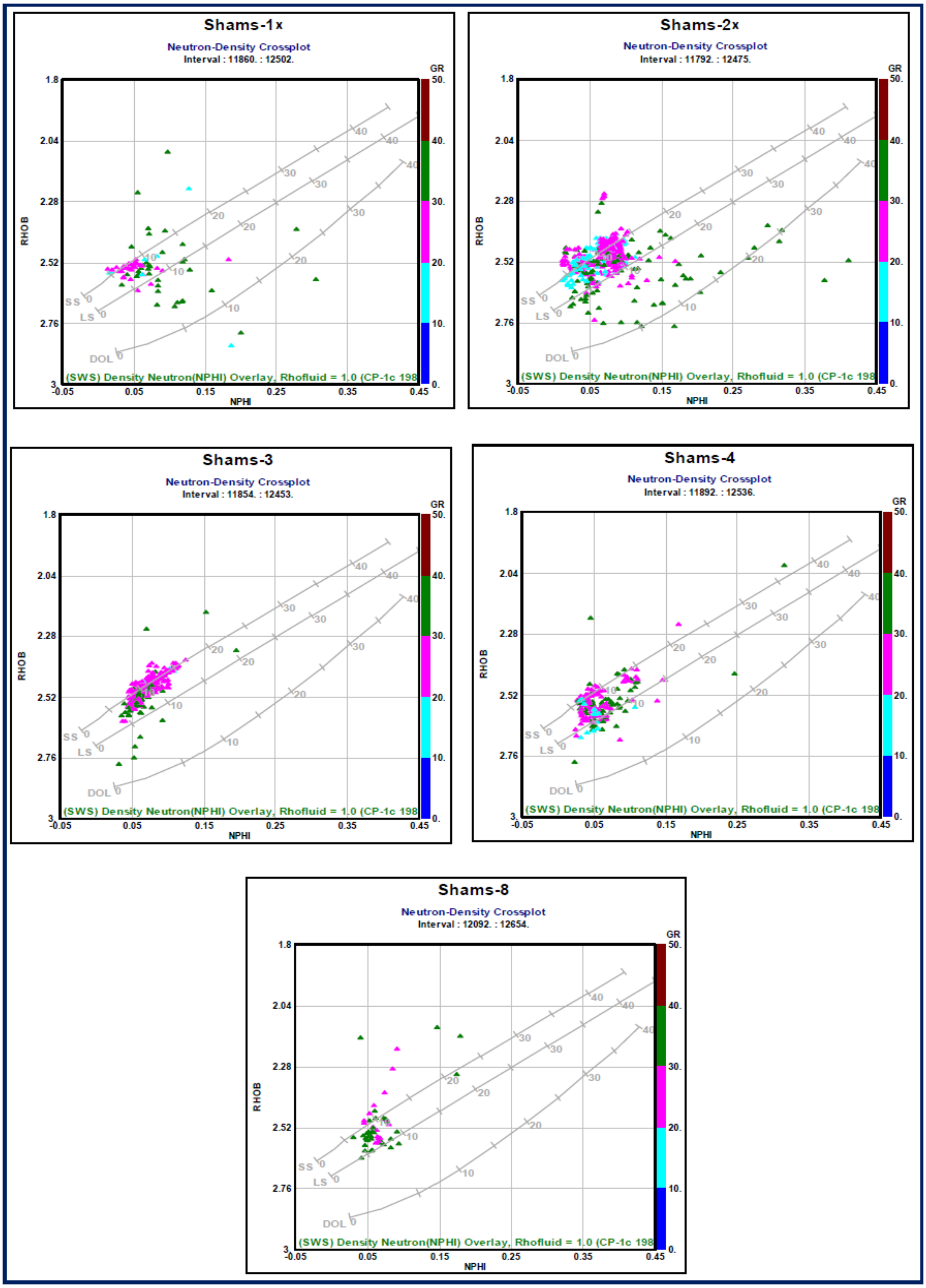

Fig. 3: Neutron-Density Crossplots for Upper Safa reservoir in Shams oil field. (Color of points refers to the GR value as shown in the right column color code)

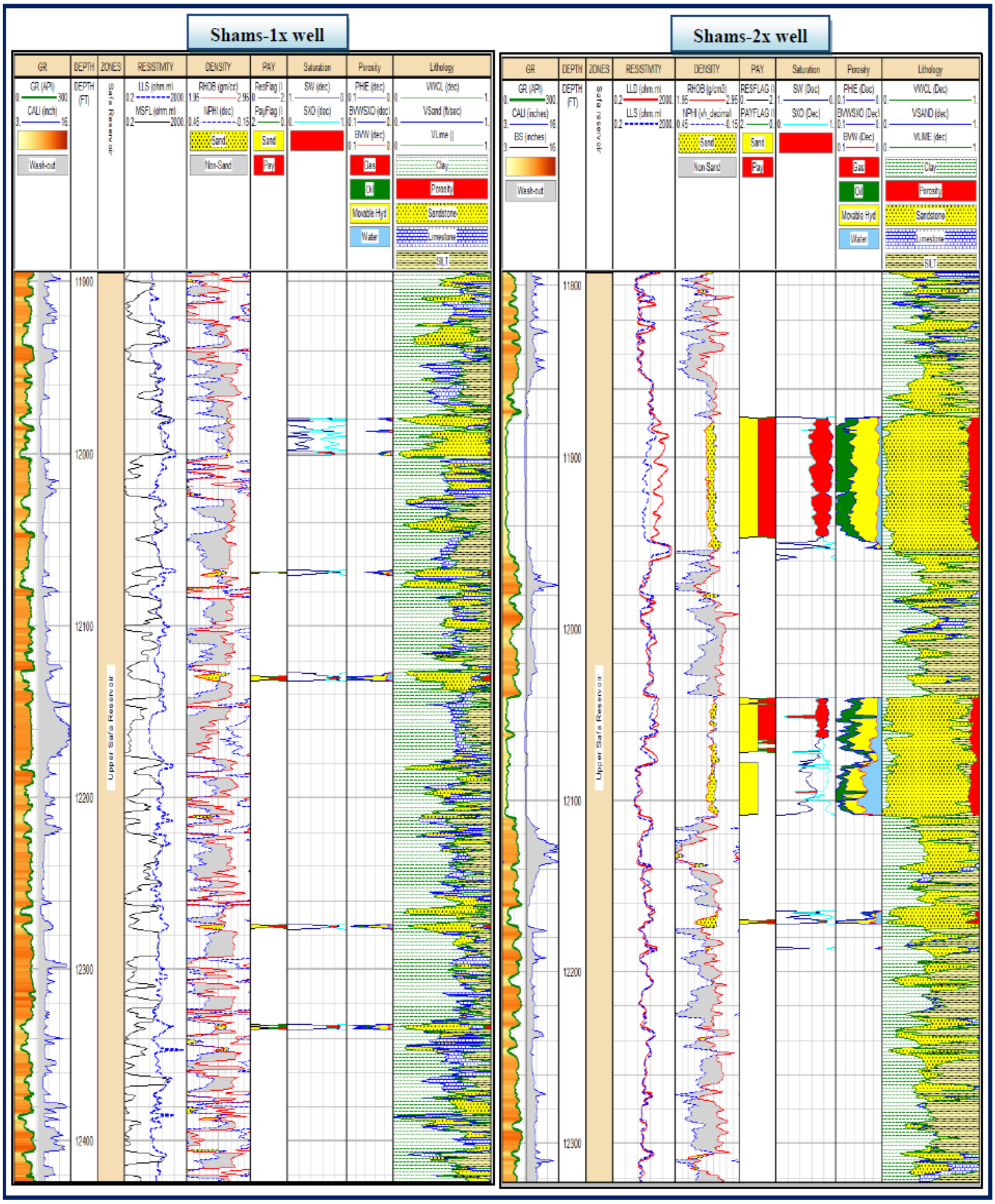

Fig. 4: Input data and interpreted results of Upper Safa reservoir in Shams-(1x & 2x) wells in the studied area.

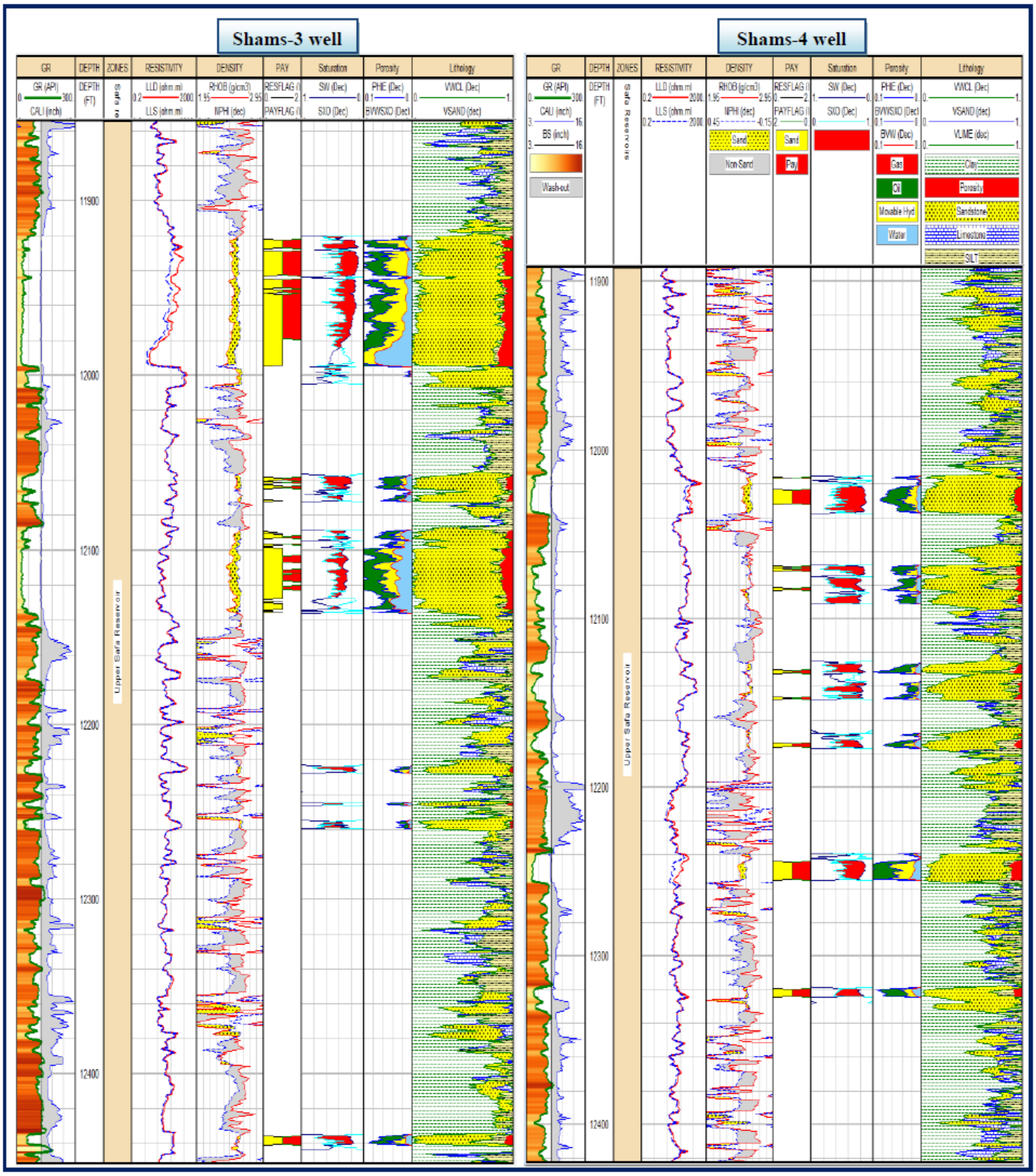

Fig. 5: Input data and interpreted results of Upper Safa reservoir in Shams-(3 & 4) wells in the studied area.

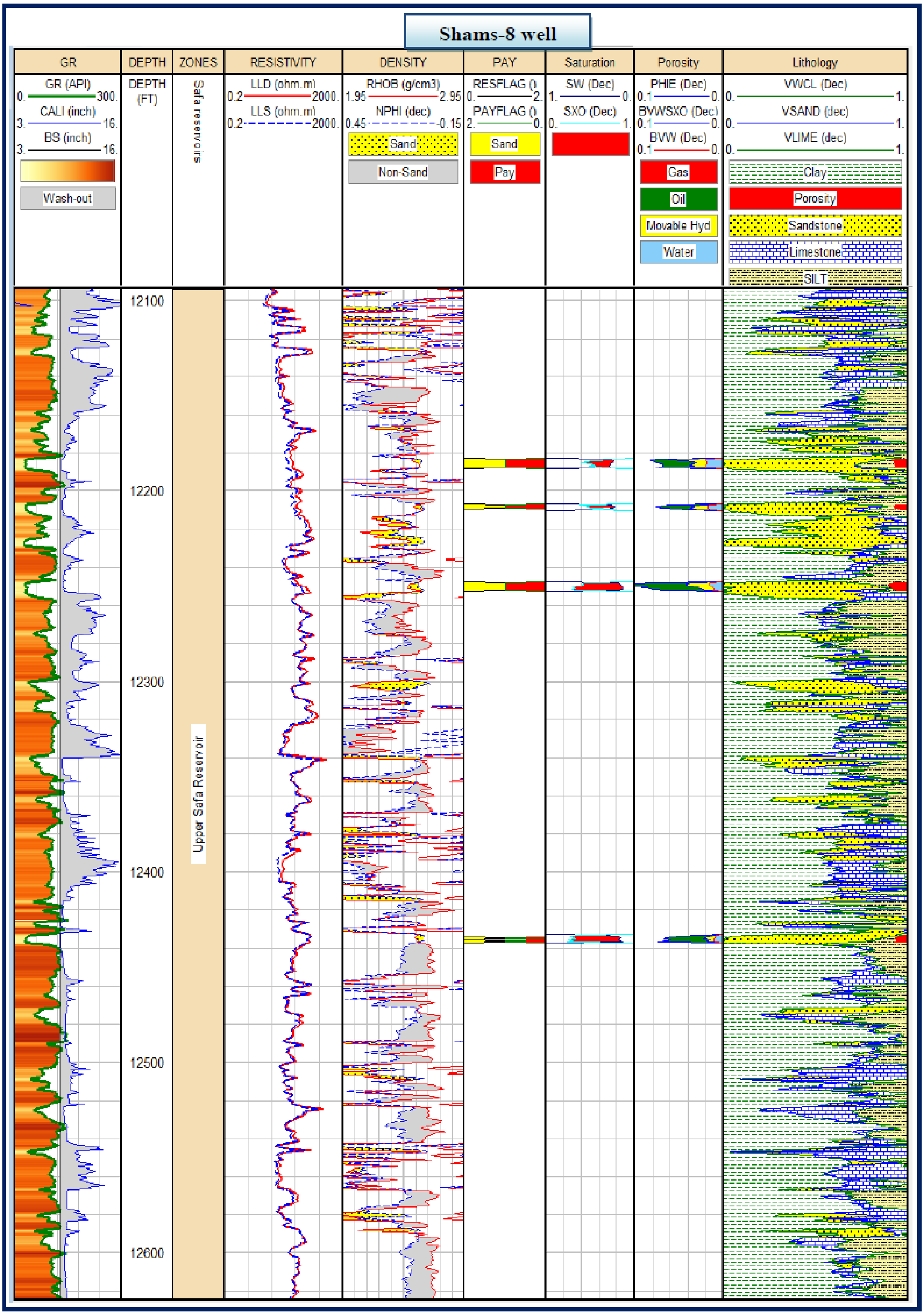

Fig. 6: Input data and interpreted results of Upper Safa reservoir in Shams-8 well in the studied area.

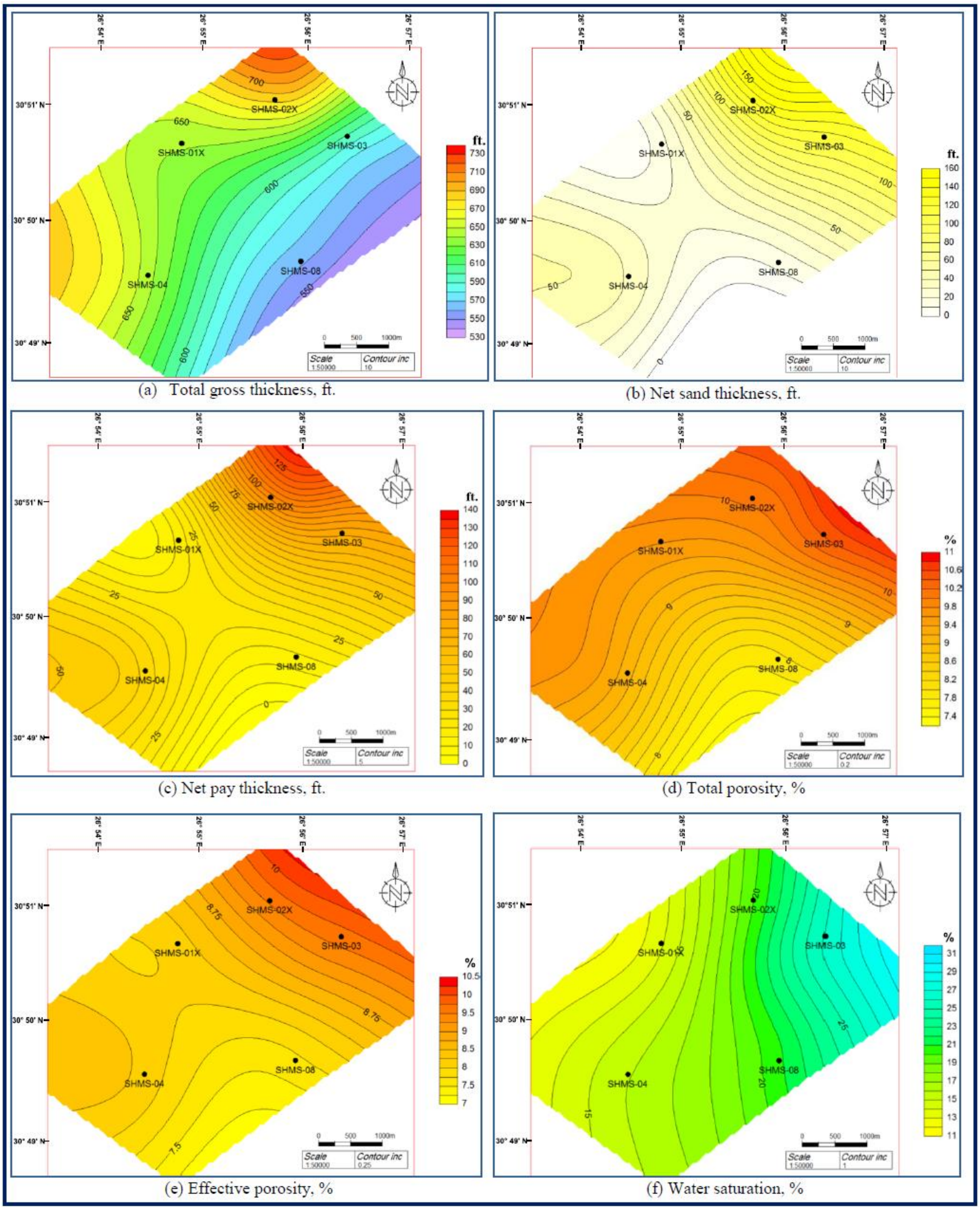

Fig. 7: Reservoir parameters of Upper Safa reservoir in Shams oil field.

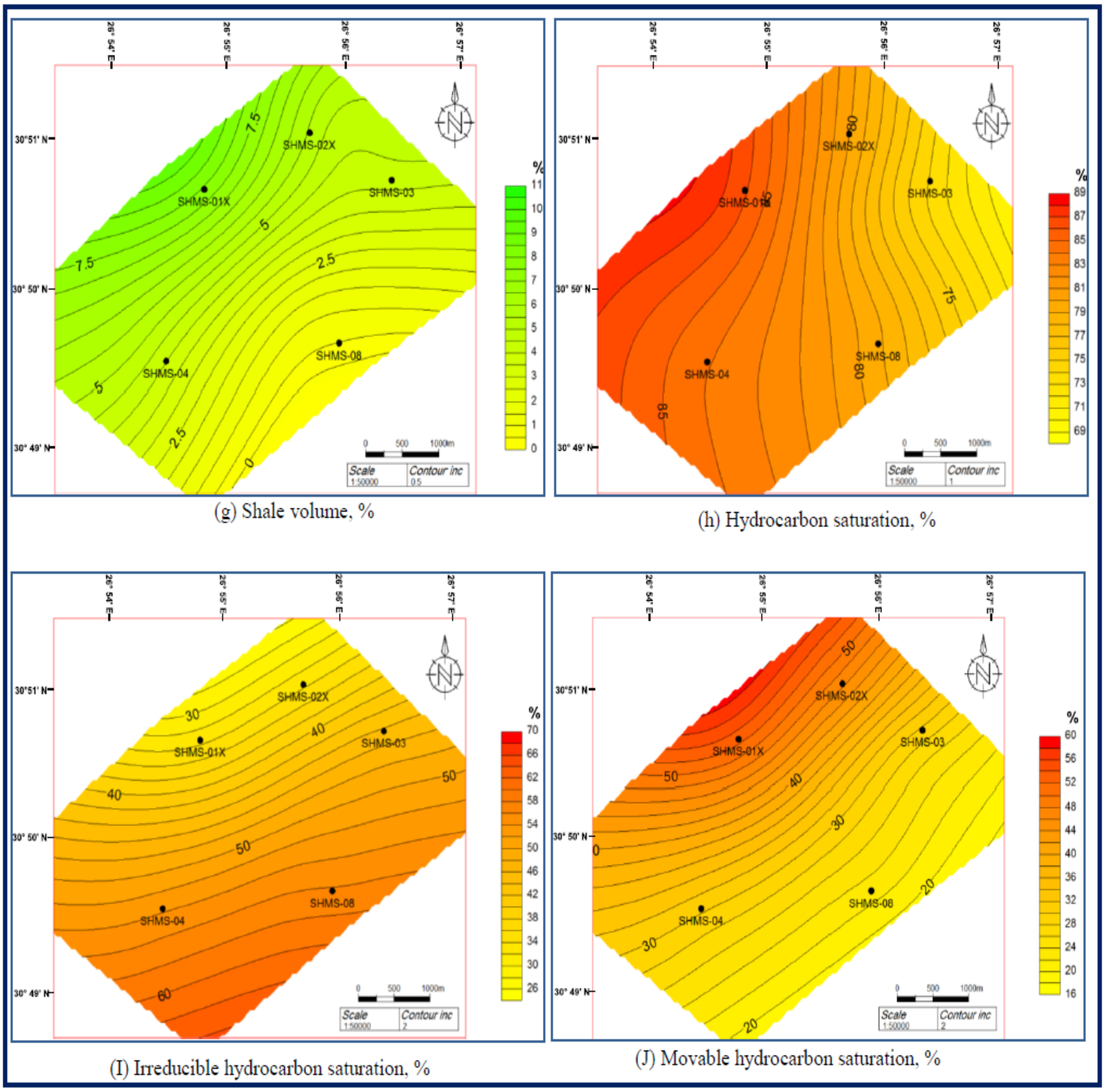

Fig. 8: Reservoir parameters of Upper Safa reservoir in Shams oil field.

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