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Study of reservoir quality changes of upper Sarvak formation in one of Persian Gulf fields

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Abstract

The purpose of this study, is assessment of petrophysical parameters of Sarvak reservoir in different points of field and compares them with each other, and thus determines the best areas in terms of hydrocarbon accumulation and generation. Lithology of this formation determine by use of three methods includes of: Density- Neutron Cross plots, M-N plot, and MID plot, mainly reflects the predominance of porous limestone. From positive characteristic of reservoir in this field is low shale volume and high effective porosity. Formation permeability changes is very dramatically, and in terms of quality, the permeability is variable from Low - moderate in North west to high and good in South and central of field. From the perspective of hydrocarbon accumulation, the best part of the field located in North West. Because calculated hydrocarbons saturation increase to North West of the field to an average of 46 percent. In this part, oil- water contact becomes deeper and located at a depth of 127 meters from the top of the formation. In this part, the formation divided into 5 separate members, that the upper member is the best in terms of production. Producing zone in central and southern part of the field, is limited to ten meters below the Lafan cap rock.

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Introduction

Petrophysics is knowledge to identify and determine the parameters of rock lithology and deals with behavioral characteristics associated with under-ground fluids. This knowledge is used to assessment reservoir properties of rocks and their fluids. Using Petrophysics can berealized static and dynamic reservoir properties and distribution of fluids in the well and its surroundings. Petrophysical properties of reservoir rocks such as porosity, permeability, fluid saturation and shale volume, are the main physical properties in relation to storage and transmission fluids in reservoirs.

Precise knowledge of these characteristics for each hydrocarbon reservoir, the development of productivity, planning and fore-casting future performance of oilfields is very important. In this study used Geology software, version 6.7.1, that is specialized software for petrophysical analysis and display them in numerical and graphical methods. Wells in this field are selected that have surrounded the entire field. A well in the North West, B well in the between center up to North, and C well located in the South. Mishrif member is equivalent to upper Sarvak with Cenomanian- Turonian age and part of Wasia group (south of Persian Gulf). Upper Sarvak spread throughout the Persian Gulf region, and created a wide Lithost-ratigraphic unit that limited by the two major discontinuity (Rezaei and Chehrazy, 2011).

During the Late Cenomanian and Turonian, upper Sarvak platform has suffered by uplift and erosion. This erosion is terminator and complement of deposition of Wasia group in Persian Gulf. Mishrif is recognized as a complex of Rudist reef. Back reef, near reef and fore reef facieses, come together in a carbonate shallow marine plateau, and sedimentation has been in a slow process (Rezaei and Chehrazy, 2011). This complex rudist reef is expanding 20 to 25 km, and covered by Lafan shale formation with Coniasian age. Lafan sequence has about 24 m thick in this field, and is a cap rock for Mishrifreservoir (upper part of Sarvak formation). The purpose of this study is assessment of petrophysical parameters of Sarvak reservoir in different points of field and compares them with each other, and thus determines the best areas in terms of hydrocarbon accumulation and generation.

Material and methods

Study area

Mishrif member is equivalent to upper Sarvak with Cenomanian- Turonian age and part of Wasia group (south of Persian Gulf). Upper Sarvak spread throughout the Persian Gulf region, and created a wide Lithostratigraphic unit that limited by the two major discontinuity (Rezaei and Chehrazy, 2011). During the Late Cenomanian and Turonian, upper Sarvak platform has suffered by uplift and erosion. This erosion is terminator and complement of deposition of Wasia group in Persian Gulf. Mishrif is recognized as a complex of Rudist reef. Back reef, near reef and fore reef facieses, come together in a carbonate shallow marine plateau, and sedimentation has been in a slow process (Rezaei and Chehrazy, 2011). This complex rudist reef is expanding 20 to 25 km, and covered by Lafan shale formation with Coniasian age. Lafan sequence has about 24 m thick in this field, and is a cap rock for Mishrifreservoir (upper part of Sarvak formation).

Lithology of study area

Lithology of this formation is shale and within thin layers of argillic limestone is also observed. The maximum thickness of this formation is in the West of Abu Dhabi about 190 meters (Rezaei and Chehrazy, 2011).

Location of study area

This field is located in the central part of the Persian Gulf, including an anticline with north-south trend. Salt dome Diapirism has played an important role in the formation and structure of this field and surrounding fields.

Results and discussions

Petrophysical parameters

Lithology

Lithology identification is an important step in the evaluation of reservoir properties, and can be isolated useful parts of the reservoir from non- useful parts (Ghasemolaskary, 2011). Available charts of field do not have peflog, FDC tools are used for determine formation density, that they have not the ability to measure photoelectric absorption. As a result of the lack of this log, Sonic logs (DT) and Neutron (NPHI) and Density (RHOB) used, neutron cross plot–density, the combination plot, MN cross Plot and MID cross Plot is used to determine the lithology. In Cross-plot of M - N, parameter M, obtained from the integration density and sonic measurement and parameter N from combination of neutron and density measurements too, and obeys the following relations:

$$M = \frac{\Delta tf - \Delta t}{\rho b - \rho f} \times 0.01 \quad (1)$$

$$N = \frac{\varphi Nf - \varphi N}{\rho b - \rho f} \quad (2)$$

MID cross Plot resulted from integrated neutron - density and neutron-sonic cross plot, has an advantage in terms of resolution than M-N cross Plot. All these cross plots indicate that they are the dominant limestones. The main points are recorded in neutron cross plot of three present wells represents the middle matrix line (calcite) and total porosity ranges between 15 to 30 percent.

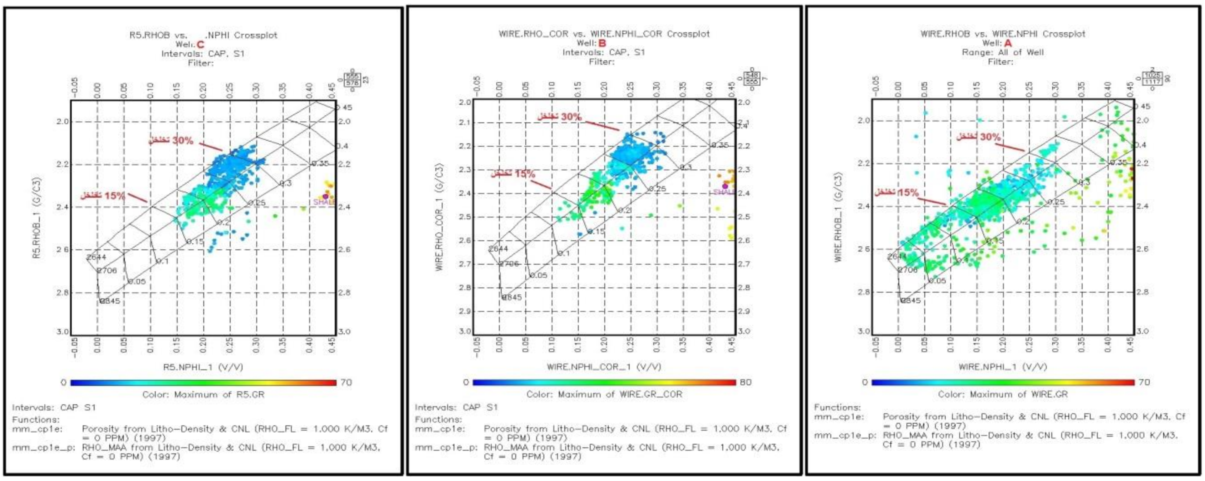

Fig. 1. Neutron-Density cross plot of upper Sarvak formation (from left to right, A,B,C well, respectively).

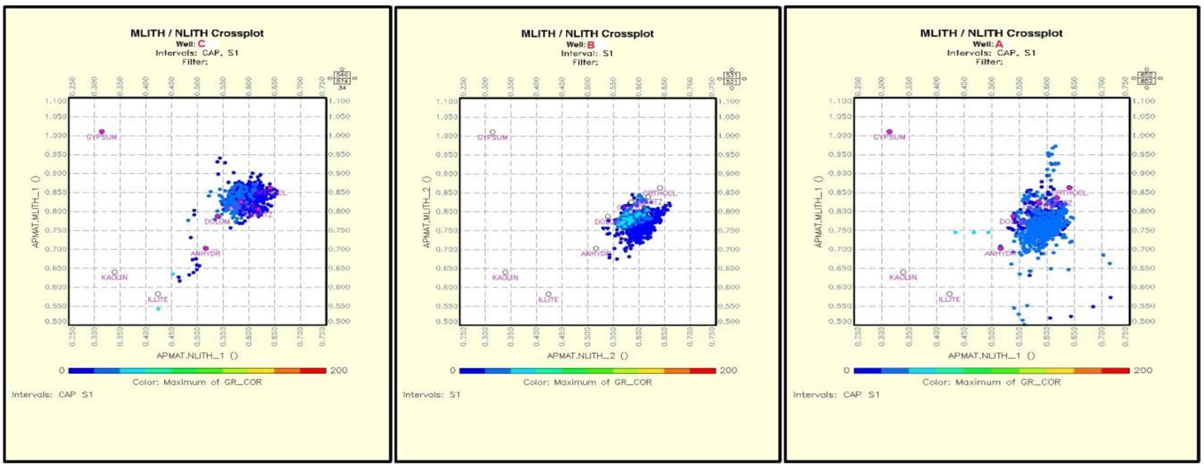

Fig. 2. M-N plot of upper Sarvak formation (from left to right, A, B,C well, respectively).

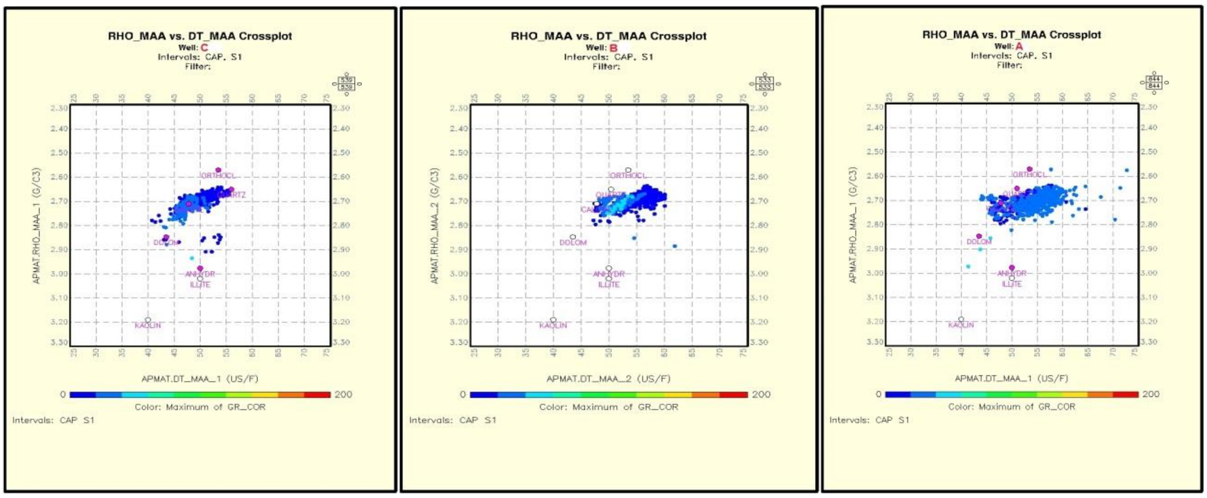

Fig. 3. MID plot of upper Sarvak formation (from left to right, A, B, C well, respectively).

Shale volume

Shale volume is the parameter that affecting other petrophysical parameters, and should be determined its rate before the calculation and use for determination of other parameters. In this studythe shale volume based on gamma logs and calculated using the following equation:

$$Vsh = \frac{(GR - GRmin)}{(GRmax - GRmin)} \qquad (3)$$

The result obtained in this relationship, represents a decrease of shale from the northern to the southern part of the field, so that the mean volume of shale calculated for wells A, B and C, is estimated, 15%, 11%, and 9% respectively. So the upper part of formation (under Lafan cap rock), is the cleanest part.

Porosity

Void and pores in the formation is a key factor in reservoir quality control that replaced by fluids (liquids and gases) and creates a reservoir. The oil reservoirs porosity is variable about 5 to 40 percent range, but most of them are between 10 and 30 percent porosity. Specialist well log curves to determine the porosity includes logs: Neutron, Density, andSonic that are extremely sensitive to changes in porosity, and studies and porosity measurements are based on the three-record set. In this study total porosity of the formation on Neutron and Density logs and effective porosity calculated with the impact of shale volume that measured valuesin the three wells shown in the table below:

Table 1. Average calculated porosity percent of upper Sarvak in the studied wells.

Well / Porosity	A	B	C
Total porosity	23.6	25.7	25
Effective porosity	18	21.8	20

Formation permeability

Permeability is a scale of the rock ability to transmit fluids during the specified area in time that is the most important parameter to measure the productivity of the reservoir. The most important clay minerals are Kaolinite, Illite, Smectite and Chlorite. Kaolin crystals tend to occupy voids in the form of sheet, but do not have much influence on the permeability of the rock. But Illite crystals are thin and long (hair-like) can be seen that fills pores pinch-points, and have significant impact on the permeability (Rezaei, 2011). Permeability of reservoir rocks varies from 0.1 to several thousand miliDarcy (Ghasemolaskary, 2011). In this study "Coates free fluid index"method, using the calculated effective porosity of the formation and irreducible water saturation, permeability is calculated for total formation.

$$k = [c \times \frac{\varphi^{2}(1 - SWirr)}{Swirr}]^{2} \quad (4)$$

In this equation, Swirr is irreducible water saturation, φ is effective porosity, $andcisacontractnumber.$

Calculated permeability represents an average of 52.5 mili Darcy for the entire formation, and maximum permeability, is for upper parts of the formation which reaches to 150 mili Darcy. Permeability in the North West decreased and reaches to an average of 7 miliDarcy. In general from quality, permeability is variable from good in central and southern parts to poor and moderate in western parts of field.

Fluid saturation

Reservoir fluids in Sarvak formation are oil and water in studied field. The water saturation due to the amount of shale has been determined from Indonesia method, which the relationship is given below:

$$\frac{1}{\sqrt{Rt}} = \left[\frac{Vsh^{\frac{1-Vsh}{2}}}{\sqrt{Rsh}} + \frac{\varphi^{\frac{m}{2}}}{\sqrt{aRw}}\right] Sw^{\frac{n}{2}} \quad (5)$$

Hydrocarbon saturation values and movable hydrocarbon volume is determined from the following relationship:

$$S_{hc} = 1 - S_w \quad (6)$$

$$Vol\_U_{oil} = Phie \times S_{hc} \quad (7)$$

Table 2. Hydrocarbon saturation values of upper Sarvak formation in studied wells.

S_{hc}	Max	Min	Mean
A	91%	0	46%
C	75%	0	18%
B	79%	0	28%

The valuesobtained showed an increase of hydrocarbon saturation in the North West of the field and relative reduce to the south.

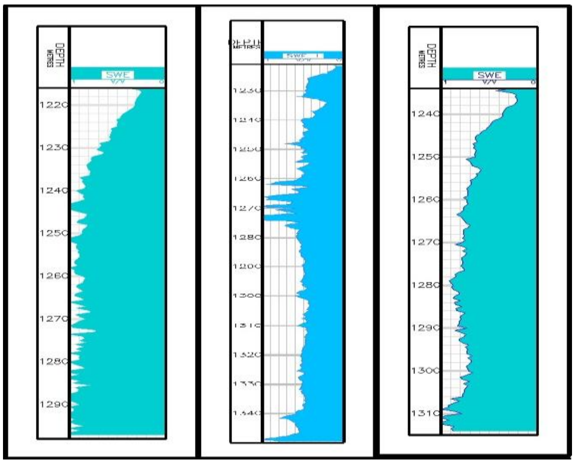

Fig. 4. Formation water saturation on the depth, from left to right, B,A,C wells, respectively.

Oil- water contact on water and hydrocarbon saturation in well A (North West) has a maximum depth (maximum of closure), and in depth of 1348 meters, located at 127 meters from the top of Sarvak formation.

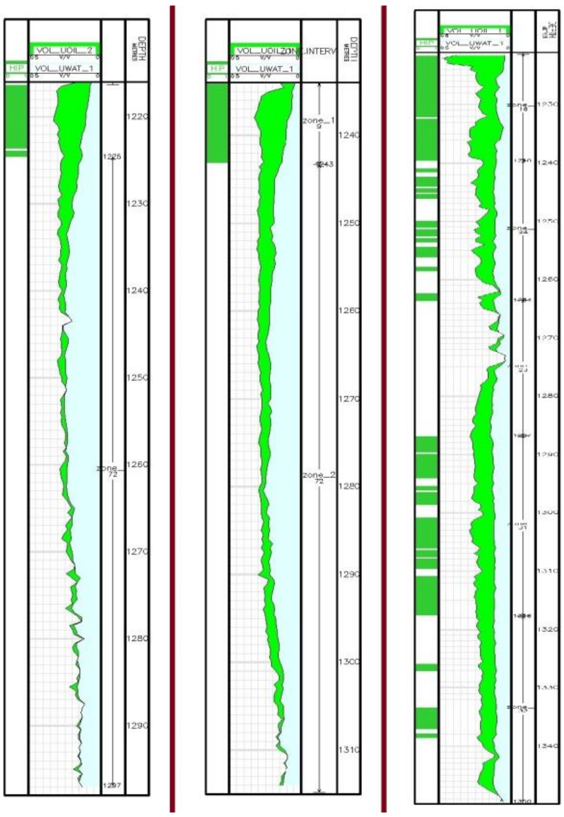

Fig. 5. Amounts of water and hydrocarbon and production zones, from left to right, B,C,A wells respectively.

Based on the final results of the assessment, Awell have the highest thickness of hydrocarbon production than other wells in the field. Sarvak formationin this well based on the well production is divided into five reservoir zones. Zone of number one in the first place with 18 m thick, and number four zone in the second place with a thickness of 31 m, have been determined as the best productive zone, respectively. Zone number three with the lowest effective porosity and highest water saturation is considered as the poorest regions in terms of hydrocarbon production.

Conclusion

A well have the highest thickness of hydrocarbon production than other wells and Productive zone in B and C wells (center to south) limited to 10 m in the upper part (the Lafancap rock) and in the lower part, the dominant reservoir fluid is water. Whatever move to the North and North West of the field, the amounts of saturated hydrocarbons are added and increase the production zone thickness, that this amount is maximumin the northwest of the field. According to the results, we can say that in this part of the field, Sarvak formation have the highest reservoir economic quality.So these areas can be an option for future development operations in the field. Permeability and porosity decreases towards the North West and the highest rate are in the southern and central part of the field, that it shows from quality, Good permeability and porosity.

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