

## Determining Reservoir Potential in the Yaran Oil Field

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### Abstract

Sarvak Formation as the oil reservoir with the most hydrocarbon potential in Yaran oil field is of special importance. The present research was conducted to study the reservoir parameters of this Formation. For this purpose, petro-physical crude data was first prepared and using the Geolog<sup>6.7</sup> software, a petro physical plot was drawn. Afterward, petro-physical properties of reservoir were done by modeling and using cross plots and logs, including porosity, permeability, lithology type, shale volume, water saturation and fractures analysis were investigated. Finally, with the adaptation of petro-physical parameters and other geological assessments from drilling cores, reservoir zoning and reservoir quality was analyzed. The obtained results showed that in the studied well there is a depth of 2600 to 2693 m of hydrocarbon potential friends. Effective porosity of the Sarvak Formation varies from 10 to 15%. Moreover, all of the investigated methods present of the prevailing lithology Carbonate, which can be on some outcrops of the shale layers, which has led to a decrease in reservoir quality in other zones.

**Keywords:** Yaran oil field, Sarvak Formation, reservoir potential, petro-physics.

### Introduction

Yaran oil field is located 130 km west of Ahwaz on Iran-Iraq border with Iraq and has a common oil field. Sarvak Formation is known as the main reservoir with the highest hydrocarbon potential in the Southern Yaran oil field. It consists of carbonates with large heterogeneity in reservoir rocks. Therefore, the investigating porosity and saturation of fluids and permeability is very important in reservoir studies (Pickett, 1966). The present research was conducted for studying the reservoir parameters of the submerged section of this formation in exploratory well No.1. Since the Sarvak Formation is one of the most important reservoir horizons in many hydrocarbon fields of southwest of Iran, several studies have been conducted in its exploration and characterization. Cai-neng et al. (2008) conducted a study on petro physical assessment of carbonate reservoirs, the results of which include empirical methods and relationships used to evaluate carbonate reservoirs (Ameen et al. 2010). Petro-physical assessment of Sarvak and Ilam Reservoir horizons in one of the western

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regions of Iran led to the zoning of reservoir in the studied area. Zamanezhad et al. (2007), performed; petro-physical evaluation and comparison of reservoir changes in Sarvak and Kazhdumi Formations in the Azadegan oil field by zoning the reservoir and reported variations reservoir trend in the studied field. (Hajikazemi et al. 2010).

Another research aimed at assessing reservoir quality based on petrographic and geochemical characteristics of the upper part of Sarvak Formation in Bangestan anticline (Aliabadi et al. 2011). The results of this study can be used to determine the reservoir expansion and zonation of the reservoir. Stratigraphic formations of the Fars, Khuzestan and Lorestan regions, presented sections of the model of different formations, especially the Sarvak Formation (James and Wynd 1965). The formations of the Bangestan and Gorpi and Tarbur groups in the wells of Azadegan, Kooshk, Darkhvin, Khorramshahr, Togo and Abadan plain, and evaluated the position of the sedimentary series of the middle and upper Cretaceous on a carbonate ramp at the margin of the continental shelf (Keyvani 1993). Taati (2000) studied the stratigraphy of the sequence and sedimentary environment of the Bangestan Group in the Zagros range. This author proposed a carbonate ramp for the lower Albian sediments (equivalent to the cartilage), and for the upper Albian sediments up to Turonian. Moreover, he proposed a carbonated boundary platform that leads to a basin within the platform. In Sarvak Formation, three sedimentary sequences are detected. And investigated stratigraphic formations of Sarvak and Ilam in the Bangestan anticline and Parsi group (Alishvandi et al. 2010; Ghabeishavi et al. 2010). According to these authors, during the Cenomanian, the Bangestan anticline was located on the margin of the basin within the platform and at the same time, Pars oil field in the basin was in the platform. Using the Strontium isotope dating method, they estimated the age of the upper sediments of the Sarvak Formation as Cenomanian to the beginning of the Turonian. The reservoir characteristics of Sarvak Formation in Hendijan oilfield with sedimentary studied, sedimentation observation and petro-physical assessment (Urmia and Bashari 2008). In this study, Sarvak Formation is divided into 4 main zones and the sedimentary environment model of Sarvak Formation is a carbonate ramp type platform. Honarmand and Madahi (2011) investigated the relationship between sedimentary facies with the expansion of the diagenetic processes and reservoir quality in the upper part of the Sarvak Formation in the Azadegan oil field. During this research, four sedimentary facies were identified, which were deposited in deep open seaboard, rocky or carbonate dam and channel, and represents sedimentation in a carbonate ramp. Zare Reisabadi et al. (2017) studied the orientations of borehole breakouts as a function of depth in oil wells A and B in Lali oilfield; in the southwest of Iran. Borehole breakouts were detected from FMI logs. Mehrabi et al. (2014) investigated the distribution of the flow unit and the Cretaceous carbonate storage model of Sarvak Formation in the oil field of Abteymur, Dezful. In this study, Sarvak Formation was considered to be the main reservoir of hydrocarbon production in the studied oil field. Moreover, the sedimentary environments were introduced as carbonate platform. Khanjani et al. (2014) investigated the types of reservoir rock in Sarvak Formation in the south-east of the Persian Gulf. Six micro facies were detected in a sedimentary environment of the homo cline ramp. In studying the reservoir properties of the Sarvak Formation, four types of reservoir rock were identified in terms of reservoir quality. In the middle ramp facade, due to the upward particle shrinkage, the reservoir quality also increases. To avoid inaccurate estimations caused by the foregoing assumption due to the lack of laboratory results in petro-physical evaluation which may lead to significant errors in the

calculation of the water and hydrocarbon saturation, Time Domain Analysis (TDA) method was applied to detect hydrocarbon typing (Rastegarnia et al. 2018). In another study, Ezati et al. (2018) investigated of lateral continuity of micro-fractures in the Sarvak Formation.

## **Material and methods**

In the first phase of this study, geology and history of the studied area, especially stratigraphy and structural properties, were explored. After formation fluid data of all formations were studied using the extracted cores. In the second phase, to evaluate reservoir quality of Sarvak Formation, The logs of an exploratory well was studied. For this purpose, set of numerical data Delis or Las formats were extracted. We used parameters including Gamma-ray, Caliper, Sonic, Resistivity, Density and Neutron Log for petro-physical modeling and interpret them using. Geo-Log. In the next step, we for determined their porosity-permeability, lithology, shale volume and degree of saturation for to model border contact oil and water. In this research, petro-physical raw logs in the form of LAS (Ahmadi, 2015), were imported to Geo-Log software and for petro-physical and geological evaluations were performed. Quality control and data correction phase included; linguistic adaptation, data synchronization, deep matching, and data error correction were performed. In the analysis and interpretation stage, considering the advantages of probabilistic petro-physical evaluation, the ability of the Multimin module in the Geo-Log software to design a suitable model was considered. After the above steps, the results were interpreted and based on the results of the petro-physical zoning of the reservoir.

### *Geological setting*

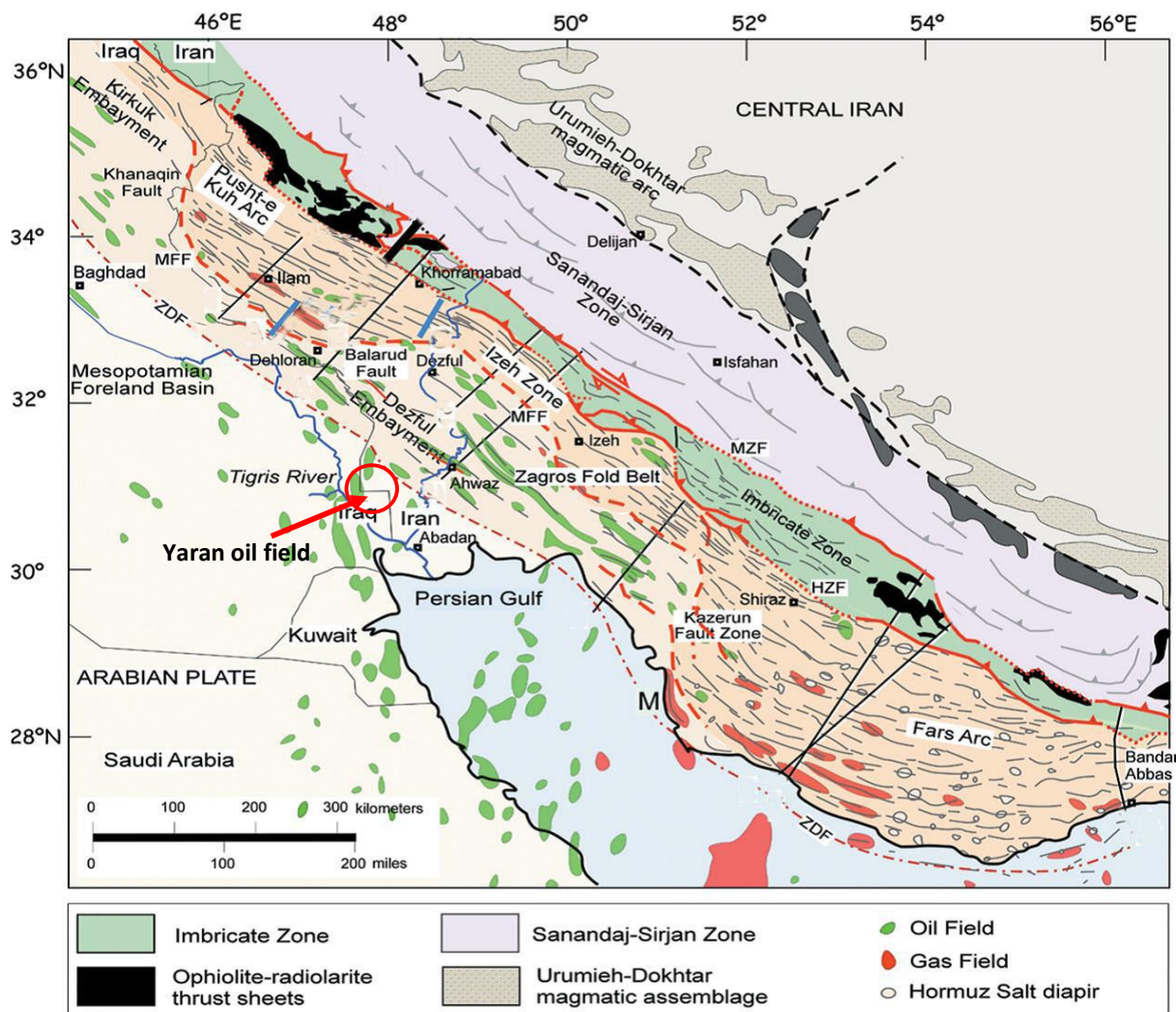
South Yaran oil field in north Dezful sub-zone of Abadan plain and to the border of Iran and Iraq and 80 km of south west Azadegan oil field located. In structural dividing of the folded belt and trusted of Zagros. Abadan plain is a under structural Zagros folded belt that construct the west south end of falling in the north of Dezful. The process of the structures of this area follow the south-north process that is form Zagros old processes (Wen et al., 2015). The structural properties of the Yaran oil field that located on this area is not separated from the structural properties of the structural breadth of Abadan plain. Anticlines located on this structural area are not influenced by Zagros fold and all of them are Geophysical and without anticline outcrop in the surface (Motiei, 1994).

All structures of Azadegan, Yaran and Majnoon show the south-north process of the Arabian plate, this geology structure (Yaran anticline) with the direction of south-north in the west of anticlines of Darkhoein, Jofeir and Susangerd and located on the next to the east structure of Majnoon. At Yaran oil field of Agajari Formations Gachsaran, Asmari, Abadeh, Jahrom, Gurpi, Tarboor, Ilam, lafan, Sarvak, Kazhdomi, Daryan, Gadvan, Fahlian has been documented. The main reservoir of the Yaran oil field is Sarvak carbonate Formation (Cenomanian) Sarvak Formation was in other fields located on Abadan plain and has a suitable storage face (Figure1). Sarvak Formation in terms of lithology consists of pure limestone (containing oil at some depths) and with some shale layers, which at some intervals are located at the depths of a very small of chert noodles,

and this section is composed with sediments of the Sarvak Formation. At the section of the studied type, it is considered equivalent (Motiei 1994). This part of formation in the studied well includes about 639 m thickness and deep distance of 2576 to 3215 m. The upper border of Sarvak Formation at this cutting with limestone sediments related to Ilam-Lafan Formation is uncontinuous in the deep of 2576 m. James et al. (1965) in Sarvak Formation has determined nine biologic zones that in the falling of Dezful, only six biologic zone expand that respectively from up to down include:

- 1- Gathered zone of Trokolina- Orbitolina.
- 2- Gathered zone of pro-Aloeolina-Alga.
- 3- Appearance of *fowo slaltensis*.
- 4- Biologic zone with some rudists.
- 5- Aloeolind.
- 6- Biologic zone with *Eligstejina* face.

The sedimentary facies of the upper part of Sarvak Formation in the studied field mainly related to Low deep environment. Enchinus and algae fragments, immediate mineral consist of calcite, dolomite, anhydrite and clay minerals fragments and beads along or secondary that include more organic materials, and finally, Matrix or background that was limestone and dolomite samples have been constructed from tiny and without shape or half-shape dolomite crystals.



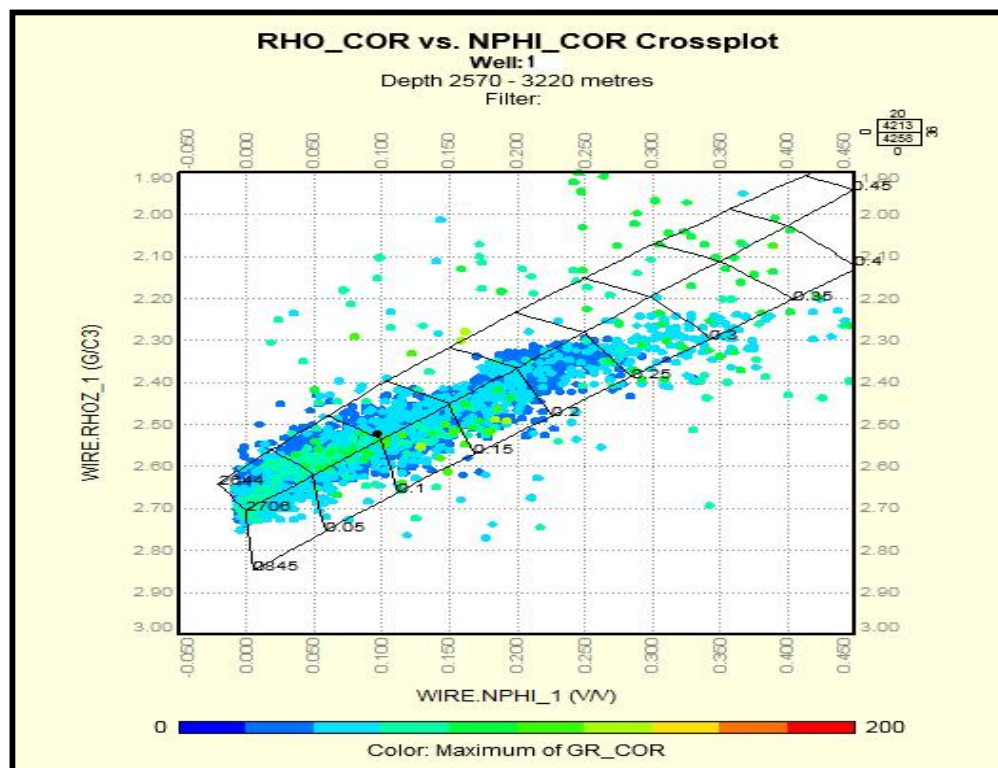
**Figure 1.** Situation of Yaran oil field in Zagros folded belt under the structural breadth of Abadan plain.

### *Applying cross plots to gain lithology and porosity*

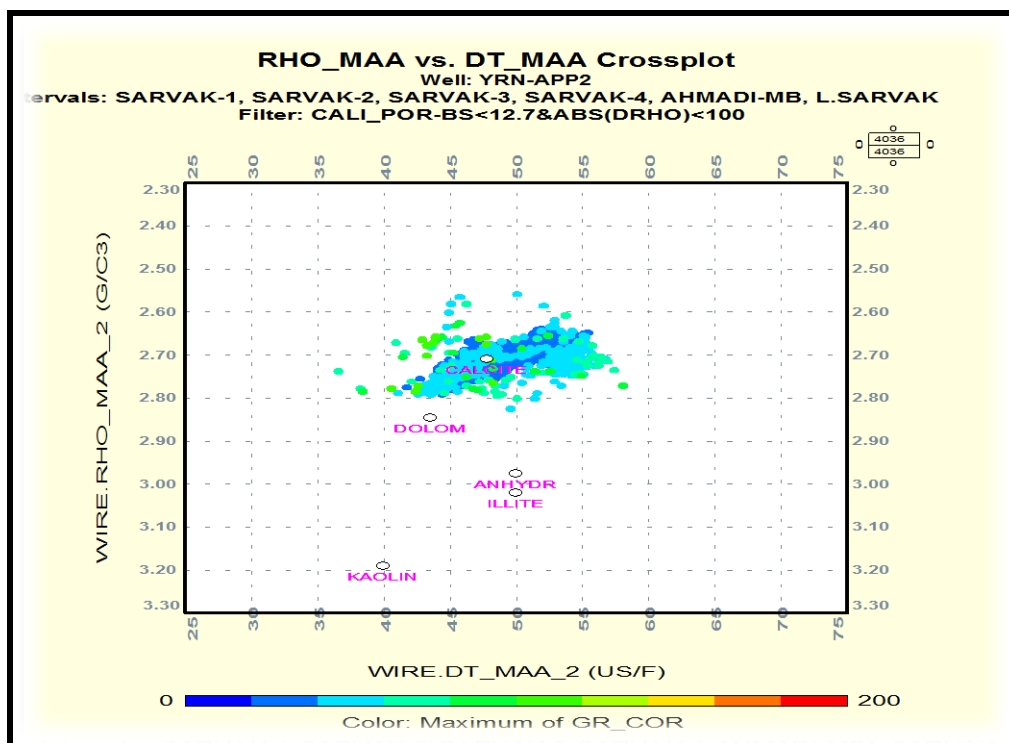
One of the main good design is the determination of lithology and porosity (Noroozi, 2006). Of course in this background, interfering of geology data is very important for interpretation. In quantity analyzing the designs, there are several reasons for the necessity of recognizing the lithology, one of these reasons is that porosity tools are needed for calculating porosity to lithology. The cross plots natural gamma has been indicated in the form of colorful indexes. Cross plots include density-neutron, sound-neutron, sound-density in addition to determining lithology have usage for determining the porosity. Porosity is not accurate without lithology data. Here, three cross plat density-neutron, sound-neutron and density-sound has been used. Density-Neutron cross plot: In the Density-Neutron cross plot used for calculating lithology and porosity, limestone formations, dolomite and sandstone and distinguish the existence of anhydrite, salt and gas, of course, porosity estimation in this log is better than lithology estimation. Points that are in the left and above are indicating the gas formation (Jong, 2005). The more blue spectrum, it means that gamma will reduce and layers are clean from shale and vice versa, the more red spectrum, gamma and shale layers will increase. This cross plat is for studied well (Figure 2). As seen in these figures, due to gather the limestone points, generally carbonate will be distinguished. Obtained porosity from this cross plat that is known as Bateman-Konen method, will be read from the written number on the lithology lines that are from 50 to 15%. In cross plot figure 2 as seen this cross plat is based on neutron and design the colorful spectrum PEF. The most part of dispersions are in calcite area with the green spectrum, the green spectrum shows the lithology with PEF and is about 5, and In fact density-neutron cross plat and PEF confirm each other. Separation of the lithology is less than the previous state, so its resolution of lithology estimation is very low and moreover, Smallest error in the time of sound and matrix density creates much error in porosity and lithology calculation, of course, the strong point of this method is high resolution, vapping distinguishing.

### *Reservoir zoning*

After imposing environmental corrections for doing applications, Interpretation of good zoning will do. Since, the well in the different deeps has different lithology and it is observed that some logs according to phenomena like washout that exist at different deeps, the quality of their respond changes. For separating zones, we must see the whole logs and we should see that in which part, all or most logs show a certain pick that indicates that in this area, the kind of lithology and fluid has changed; we can consider that part as a zone, because lithology has changed. According to down interpretation from Sarvak Formation in the exploratory well of Yaran oil field generally divide into two part of Reservoir and un Reservoir, the reservoir part of Sarvak Formation in this well is from 2701 to 2703 m. Based on the behavior of petro-physical graphs (special resistance, neutron, density), this output has a suitable quality and Hydro carbonic potential. And then reservoir potential of Sarvak Formation in this well has been confirmed. From 2697 m to the end of this formation in this well (320 m) due to lack of useful and good porosity and increased saturation of water, reservoir properties will decrease that construct a un reservoir zone (Ahmadi, 2015).



**Figure 2.** Density-neutron cross plot for well No.1 of Yaran oil field



**Figure 3.** Sound-density cross plot for determining lithology of Sarvak Formation



## Results and discussion

Determination of the shale volume: there are different methods for calculating the percentage of shale in formation. At some cases, with the use of one design or two or more design can calculate the shale volume. In this study, CGR is used for calculating the shale volume (Poupon and Leveaux 1971). Generally, the calculated shale volume decrease in this formation, but according to this middle shale layers, the existence of shale causes that at some parts, the reservoir quality decrease (Jerry Lucia, 2002). Since shale have porosities that exist water in empty places. Porosity in shale is too much, but porosity is non-useful, so in evolutions the shale volume should be corrected.

The determination of oil-water contact: Oil-water contact is the lowest deep in a reservoir that water saturation is 100% the zones that are saturated from water up to 100% are zones that are below the primary oil-water contact. At some reservoirs, the primary contact is clear and we can calculate it, but at some reservoirs, oil-water contact is gradual (Rezaei and Chehrazi, 2006).

Porosity collation: The porosity percentage in reservoir formation with the use of well logs, which should be driven, calculates. This quantity usually calculates with sound graphs, neutron or special weight graph or with each other. The fractures of reservoir stone in the limestone reservoir of Iran and also the existence shale layers and sandy limestone with different cement degree cause a different porosity in a well with other well in a little distance from it or even as twice as it. It should be considered that real porosity obtains from experimental studies on drilling cores.

In this study, based on Multimin that is done according to synchronic equations, porosity calculation also does with the use of porosity cross plots (density, neutron, sound). The whole porosity mean calculated in reservoir zone 13% and effective porosity (PHIE) is 12%. As seen, the whole and effective porosity are equal and this is for sake of Law shale volume and inherent porosity of carbonate particles.

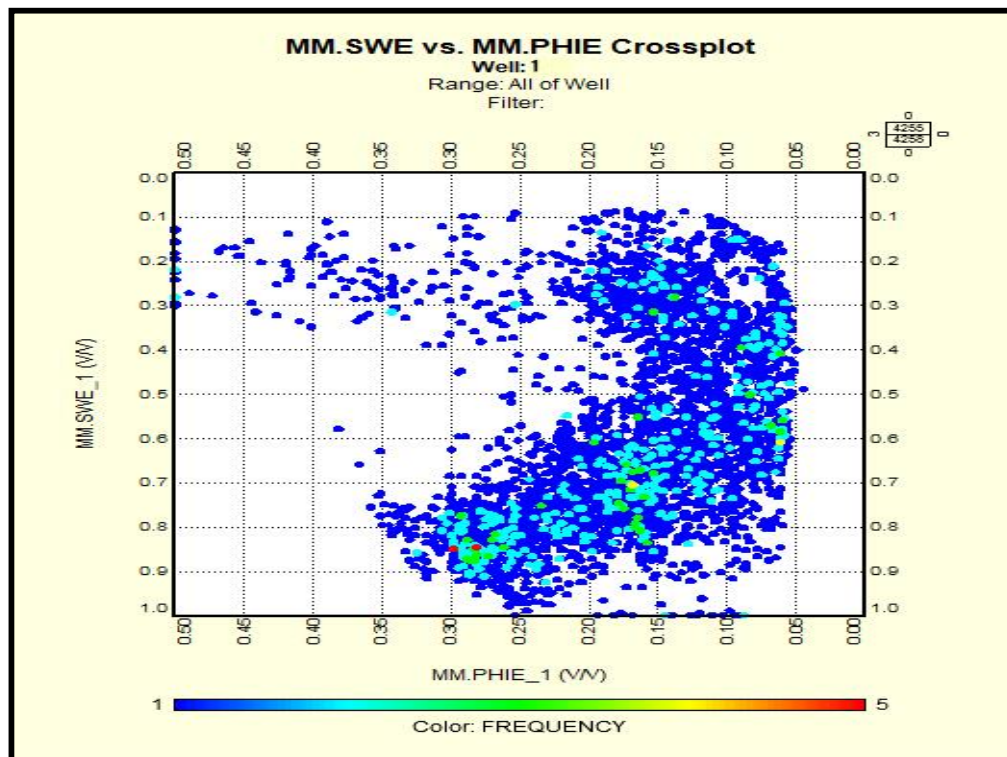
The caculation of water saturation amount: In this study, with considering the existence of shale as an effective factor in increasing water saturation and based on factors of shale resistance, the porosity degree of formation, cement coefficient (m) Archi constant (a) and the resistance of the deep part of the formation, water saturation degree has calculated, there are several methods for calculating water saturation is a parameter that must be estimated with the use of resistance logs data. In the petro-physical study of the Yaran oil field, Sarvak reservoir, to achieve a good equation for calculating the amount of water saturation over Archi, Indonesia, dual water and Waksman-smith methods that there is a possibility for applying those in Geo-log software, studies have done. (Bateman1987). Since, Archi equation is just for organizing so, due to the existence of shale layers in Sarvak Formation, the usage of this method for calculating water saturation had been by passed (Figure 4).The calculation of Bulk volume water: Bulk volume water (BVW) in formation is the product of water saturation ( $S_w$ ) in formation porosity ( $\phi$ ) if calculated amounts of BVW in the different deep of a formation equals with constant amount or very near to constant, Indicating that this zone is related to one rock and in water saturation is swirl:

$$BVW = S_w \cdot \phi \quad (1)$$

When a zone is swirl, waters in ( $S_w$ ) intact zone due to impose the mensch power by stone beads is not able to more. So the production of hydrocarbon in zones located on swirl performs without water the formation that is not located on swirl shows different amounts of BVW. Here the calculated amount for the whole water volume is 90%. The water amount that a formation can

conserve by capillarity depending on the size of ingredients that particle size is also a stone fabric. With reducing the particles in pressure capillarity BVW and capillarity will increase. So, we can use the BVW amounts in carbonate stones as a general guide for distinguishing reservoir distances from distances with shale.

Plot CGR is against NPHI: In distances with shale GR, NPHI (Q), each responds to the presence of shale and then in these distances, plot points will appear like a liner graph (with considering this point that GR respond to shale. And  $\phi_N$ , in addition to the presence of shale, responds to saturated (Fig.5). In reservoir layers that the percentage of clay in them is low, plot points the from process of liner graph will exist (Rezaei and Chehrazi, 2006; Schlumberger, 2009). The calculation of hydrocarbon storage: The calculation of hydrocarbon volume by log data is very important. Note that accurate numbers for storage degree don't depend on log data, but also, size and shape of reservoir according to seismic data or gathered data from other methods that are independent of graphs will determine. In this study, despite resembling the lithology combination of Sarvak reservoir, due to analyzing the kernel with different amounts of cement coefficient, different petrophysical models obtain for different amounts of m for each well. The evaluation results of reservoir Designs and separation of reservoir part and non-reservoir of Sarvak Formation for well. One Yaran oil field is shown in figure 6 respectively.



**Figure 4.** Cross-plot of effective porosity against effective water saturation for Sarvak Formation.

### *Interpretation and zoning*

For separating zones, we should see all of the logs and should see in which part, all or most logs show a certain process and changes in logs pattern indicates that in this place, the kind of lithology

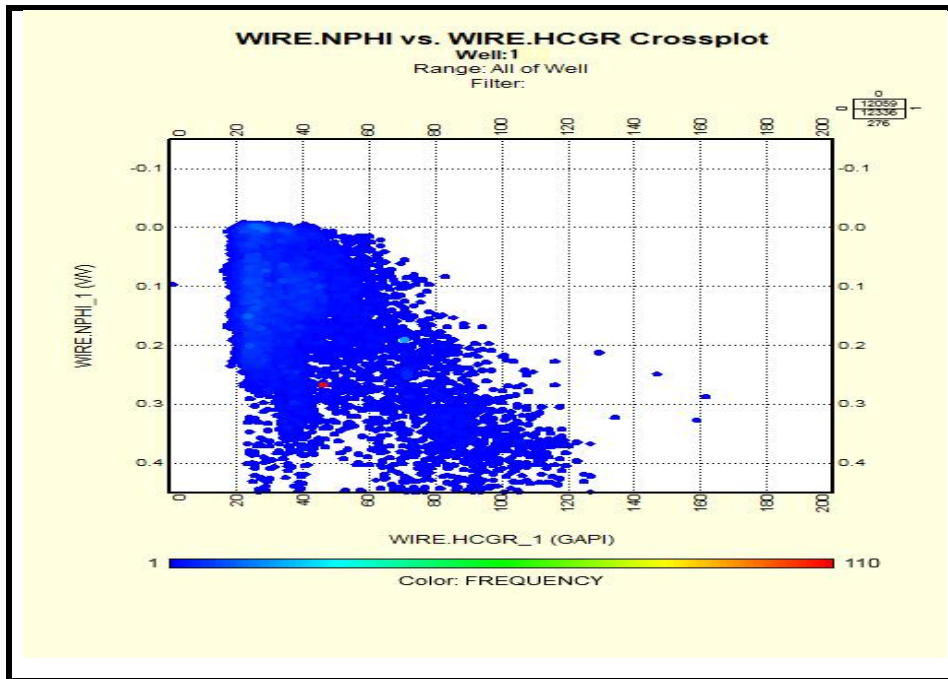


and fluid has changed. In this study, according to the process of logs pattern changes, below zones will determine and petro physically describe:

1- In the deep of 2701-2603 m generally, in a deep stance based on porosity average effective degree (12 to 13%), water saturation (21%), shale volume about less than 5% and lithology from limestone with a little amount of shale construct the reservoir part in Sarvak Formation in oil field.

2- In the deep of 2732-2797 m at this output is also influenced by the deep of logs, but this part of the reservoir has a different situation with the upper part of the reservoir. At this output, the reservoir conditions in porosity and hydrocarbon potential have become weaker and the degree of water saturation get 10 %, notably, from the deep of 2701 to 3200 m doesn't practically have potential reservoir of hydrocarbon production.

3- From the deep of 2732-2854 m most part of Sarvak Formation at this output is from limestone along with shale. As seen in the interpreted graph the degree of reading the resistance Log is near to one that means that the layer is watery.



**Figure 5.** CGR cross-plot against NPHI for well one Yaran oil field: In distances with shale, shale process line indicates the rising of neutron porosity degree and is the amount of Gamma-ray, otherwise, with raising the shale, the porosity will also rise, but this porosity is microscopy.

4- In the deep of 2854-2978 m at this output a concentrated part of limestone with zero porosity exist that doesn't generally have reservoir properties.

5- In the deep of 2878-2965 m at this output, reservoir properties in porosity than upper layer is different, but for sake of being low in porosity than upper layer is different, but for sake of being low resistivity and water saturation about 78% of hydrocarbon. As a result, there is no possibility of hydrocarbon production.

6- In the deep of 2965-3012 m at this output a concentrated lime part with non-porosity that does not generally have reservoir properties.

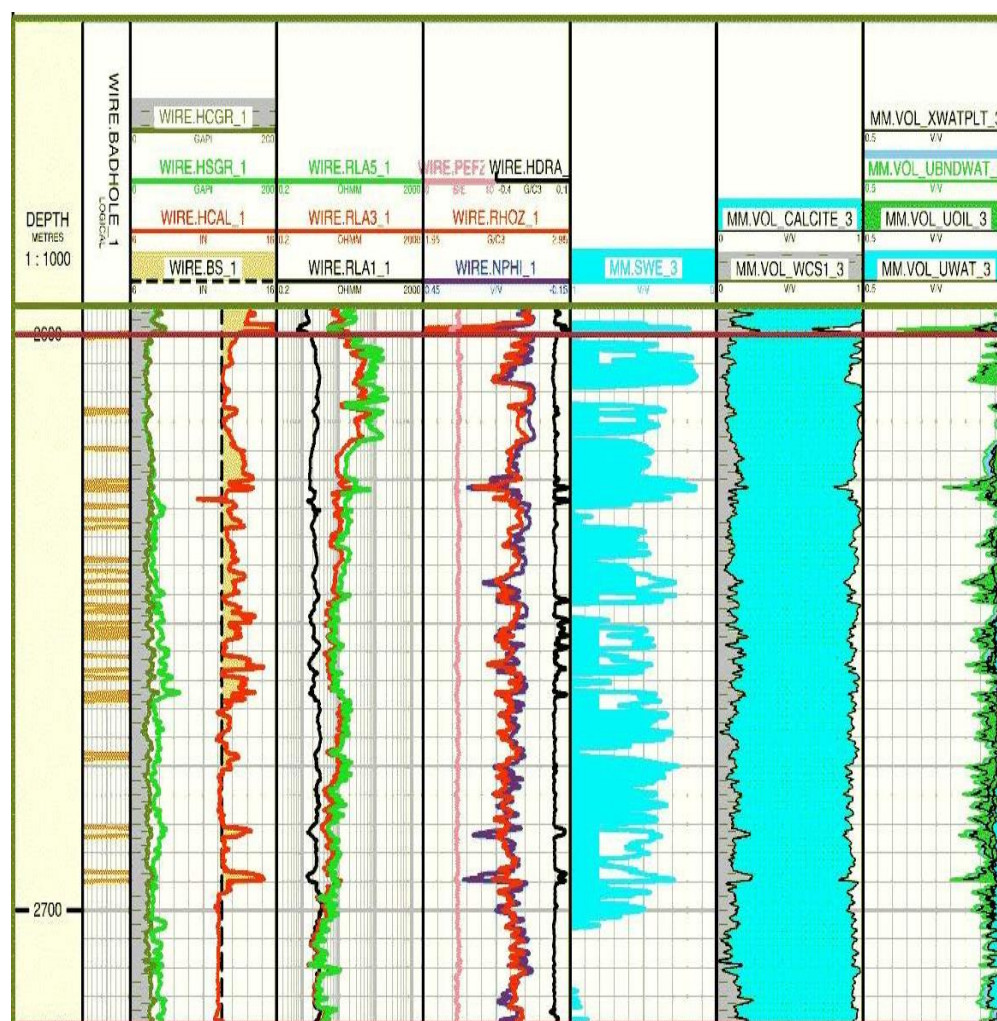
7- In the deep of 3012-3169 m the most part of lithology is limestone and shale. At this output, shale volume is 20% and there is no hydrocarbon potential.

8- In the deep of 3169 m to the Bottom of the well, at this output, a concentrated lime part with zero porosity exists that generally doesn't have reservoir properties.

9- If we want to divide Sarvak Formation at this field into different petro physical zones, we can consider two certain zones:

a- The deep of 2603 to 2701 m based on the behavior of reservoir properties zone petro-physical Logs are at this formation. Generally, we can say that the least deep of 2701m that the degree of water saturation begins to increase.

b-From the deep of 2701 to 3200 m that is the Bottom of the well we consider it as secondary petro-physical zone that doesn't have reservoir properties.



**Figure 6.** Full set evaluation results of reservoir designs and the separation well No.1 of Sarvak Formation

## Conclusion

Based on interpretation results, from deep of 2603 to 2701 m has Hydrocarbon potential, and the mean of useful porosity in studied reservoir interval from Sarvak Formation is about 12%. The

lithology of Sarvak Formation with different methods is estimated, all of methods show carbonate with over limestone lithology, and that is distinguishable from the part of shale layers. Sarvak Formation has a low mean of shale volume that is less than 5%, and according to this point that the whole porosity and useful porosity are equal; we can find the low shale volume. The Lowing of the shale volume is due to the sediment of the formation in a high energy environment. The porosity changes are not too much but base to being low shale volume, most these porosities is useful, good porosity in this field is influenced by the sedimentary environment. By active surface layer that is on the clay minerals, the whole resistance will decrease. So, the existences of clay in this reservoir cause to decrease the rock resistance and increase in calculating the water saturation.

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