RESERVOIR PETROPHYSICS AND HYDROCARBON POTENTIALITIES OF THE SAB'ATAYN FORMATION (UPPER JURASSIC) IN ALIF OIL FIELD, MARIB SHABWA BASIN, REPUBLIC OF YEMEN.

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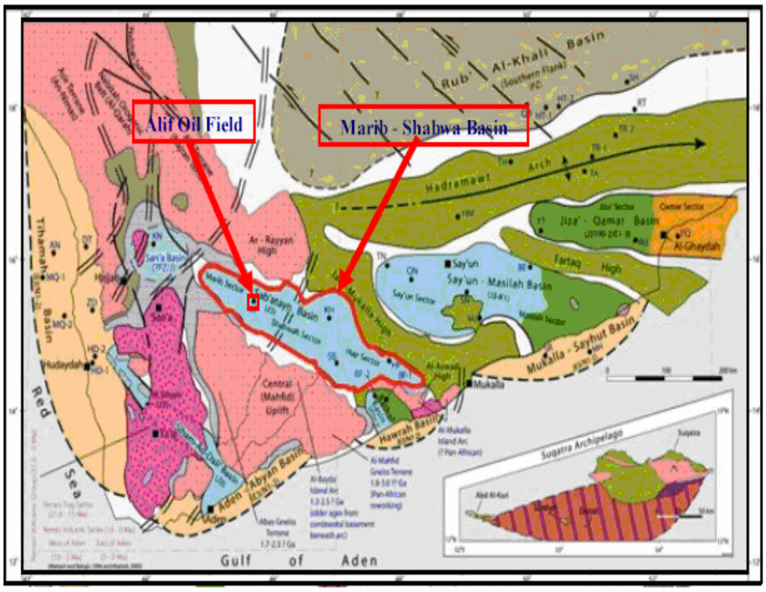
ABSTRACT

Reservoir characterization plays a critical role in appraising the economic success of reservoir management and development methods. The main objective of this work is to evaluate the Upper Jurassic petroleum reservoirs in Marib region by integrating a variety of the state-of-the-art computer packages as follows: To evaluate and calculate measurable quantities such as shale volumes, porosity and fluid saturations by using computer software. The comprehensive petrophysical analysis of Sab'atayn Formation indicate that Alif Member is the main reservoir in the study area with 15.5% mean value total porosity and less than 23% and more than 85% hydrocarbon saturation. Vertical evaluation for the encountered reservoirs were done by construction of lithosaturation cross plot for the studied wells, so Alif Member can be dived into three productive units composed of sandstone separated by shale beds. Cross plotting techniques is also used to identify the lithology of the reservoirs in the studied area. As well as such horizontal evaluation were done by construction of distribution maps for the studied wells to locate the best places for the further exploration and development of Alif reservoir in Alif Oil Filed.

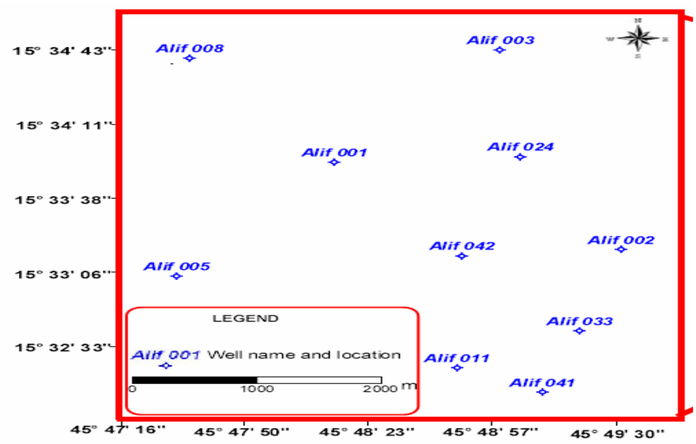
Keywords: Petrophysics, Reservoir Evaluation, Sandstone Reservoir, Yemen

INTRODUCTION

The Marib – Shabwa Basin is one of thirteen basins in Yemen, it lies in Marib, Shabwa and part of Al-Jawf Governorate. This basin is considered as one of the most important basins because it contains many productive blocks. It is located between 14° 40' — 16° 30' N and 44° 40' — 48° 30' E and it has a NW-SE general direction. It extends southward from Aljawf to Shabwa Governorate (Fig.1). The studied area involves ten oil wells located between 15° 32' 0.91" - 15° 34' 59.91" N and (45° 47' 16" - 45° 49' 48.42" E) within Alif Oil Field which located between 16° 15' 00" - 16° 00' 55"N and 44° 55' 0 - 46° 00' 33"E. The Alif Oil Field is bounded on the west by the Main field and from south by the Mawza field and Gabal Nuqum field. East of Alif Oil Field lies Al-Shura field and Asaad Al-Kamil field and north of Alif Oil Field lies Raydan field.



(A)



(B)

(Fig. 1): (A) Location map showing the study area and oil fields

(B) Base map of the studied wells in the Alif oil field.

Materials and Methods

For the purposes of the present study, ten drilled boreholes have been selected from Marib block in Alif Oil Field (Fig.1B). The Alif Member is encountered in all wells, as well as the Seen Member is also present except in Alif 003 well while the Yah Member is found in the northern wells; Alif 001, Alif 005, and Alif 008 and disappeared in the southern part of the study area. The collected data from these wells encompass well logs, core samples, and geological information. The collected data have been supplied by the Yemen Safir Exploration and Production Operation Company (SEPOC). These data -base have been analyzed using the following methods: review of previous researches conducted on the study area, determining geological and stratigraphical setting in the study area, correcting and analyzing the available geophysical data using computer software (Interactive Petrophisecis (IP) in order to elucidate the reservoir petrophysics, and evaluation of the study area by Construction of structure contour maps, petrophysical parameters maps, isopach maps and lithofacies maps for the hydrocarbon reservoir evaluation.

Many studies were done on the Mareb Shabwa basin such as; Beydoun, (1964), Beydoun, (1968), El-Anbaawy, and Al-Thour,. (1989) Redfern, et al (1995) Beydoun, (1997), Brannan, Sahota, Berry, (1999), Al-Atesh, (2000), Al-Matary, (2003), Abbas, (2004), Al-Areeq, (2004),

Lithostratigraphy of Sab'atayn Formation

The Stratigraphy of Marib-Shabwa basin is composed of the Middle Jurassic to Cretaceous sequences lying above the basement rocks. Our target in this work is Sab'atayn Formation which is composed of different members which have been identified and characterized in the surface and subsurface area. Surface exposures in the Shabwa-sector have been described by Beydoun (1964) and Beydoun and Greenwood (I968). They subdivided it into: Leyadim Member, which consists of bituminous shale and limestone: Ayad composed mainly of salt, whereas the younger Maqah is represented by turbidities. In the Marib-sector, the subsurface Sab'atayn succession is made up of the Yah, Seen, Alif, and Safir Members. The Safir Member exhibits an alternation of halite, sandstone and shale.

The Sab'atayn Formation is represented from base to topas Safir, Alif, Seen and Yah Members in most of the studied wells, while the Yah Member is absent in Alif 002, Alif 011, Alif 033 and Alif 041 wells which may be due to faulting. Stratigraphic correlation charts were constructed along five profiles extending N-S, NE-SW, NW-SE, W-E and W-SE based on the available subsurface borehole data (Figs.3to 7). As well as isopach maps were constructed using variant thicknesses of variant members of the Upper Jurassic Sab'atayn Formation in the study area (Table.1). Thickness of the Sab'atayn Formation in the study area shown in the isopach map (Fig. 8) which illustrates that the maximum thickness is 2771 feet at Alif 003 well while the minimum thickness reaches ٢٢٠٠ feet at Alif 005 well. This map shows that the thickness increases from the west (2240 feet) towards the east (2480 feet), northeastern (2760 feet) and southeastern (2600 feet) at Alif 011 well then decreased in same direction from Alif 011 well toward Alif 041(2400 feet). Beydoun et al., (1998) subdivided the Sab'atayn Formation from base to top in Marib-Shabwa Basin into the following members:

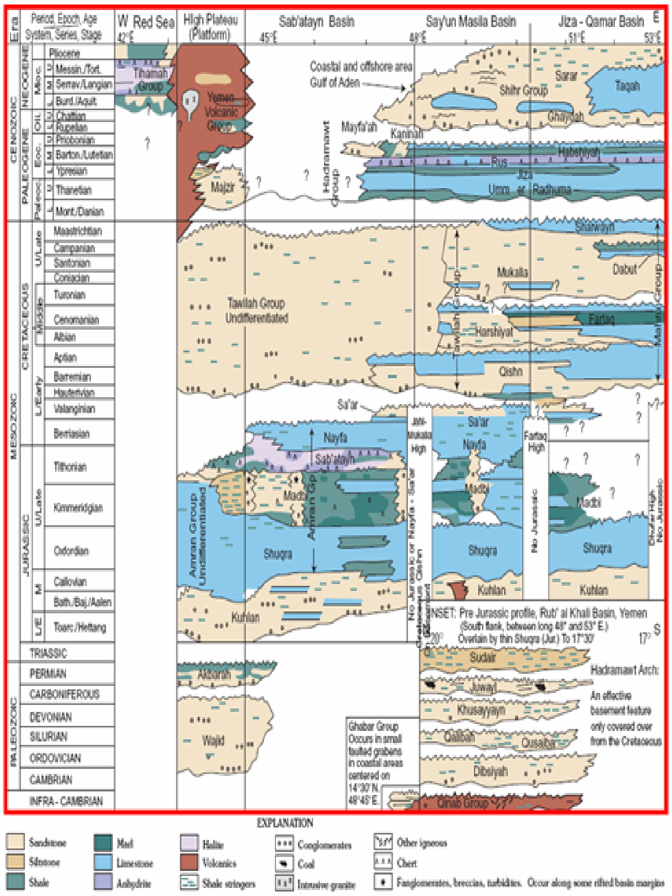
Yah Member

Yemen Hunt Oil Company YHOC (Schlumberger,1992), introduced a name of this unit as Yah Formation, and emended to Yah of Sab'atayn Formation by Yemen Stratigraphic Commission (in Beydoun,1997). It is composed mainly of sandstone with intercalations of mudstone/shale, locally with limestone and halite. It is Early Tithonian in age. In general, the Yah Member disconformably overlies the Lam member of the Madbi Formation at the type section and is conformably overlain by the Seen Member. Locally, the Yah Member is present throughout the Marib al-Jawf sector of the Marib-Shabwa Basin, and pinching out southeasterly direction towards the end of the Shabwa sector. (Beydoun. et al. , 1998). The thickness of Yah Member in the study area reaches its maximum value of 252 feet Alif 003 well while the minimum value is 67 feet at Alif 001 well (Table 1).

Seen Member

It was known as Seen Formation by Yemen Hunt Oil Company YHOC (Schlumberger,1992), and emended to the Seen of the Sab'atayn Formation by Yemen Stratigraphic Commission (Beydoun,1997). and is made up of interbeded sandstones and shales/mudstones. Sandstones dominate the upper part and mudstones the lower one. Thin beds of anhydrite occur within the subordinate shales of upper part. It is Early to Middle Tithonian in age. In general, the Seen Member is conformably underlain by the Yah Member and is overlain by the Alif Member . Locally the Seen Member is present throughout the Marib al-Jawf sector of the

Marib-Shabwa Basin, and pinches out southeastwards in southwestern side of the Shabwa sector. (Beydoun. et al. , 1998). Thickness of the Seen in the study area is shown in the isopach map (Fig. 9) which illustrates that the maximum thickness is 438 feet at Alif 011 well while the minimum value reaches 155 feet at Alif 003 well (Table. 1). This map shows that the thickness increases from northeastern (170 FT), north (210 feet) and south (290 feet) parts toward the center around Alif 001 well (330 feet).



(Fig. 2): Phanerozoic lithostratigraphy, correlations, and spatial stratigraphic distributions for Yemen (After Beydoun et al., 1998)

Alif Member

The Alif was formerly known as Alif Formation by Yemen Hunt Oil Company YHOC (Schlumberger,1992), and emended to Alif of Sabatayn Formation by Yemen Stratigraphic Commission (Beydoun,1997). and mainly consists of sandstones with subordinate interbeded shales/mudstones, local anhydrites and dolomitic limestones. It is Middle-Late Tithonian in age. In general, the Alif Member conformably overlies the Seen Member and is non-conformably overlain by the Safir Member . Locally Alif Member is widely present in the eastern part of the Marib al-Jawf sector and extends into the western part of the Shabwa sector of the Marib-Shabwa Basin, but is generally absent in the westernmost part of the basin west of Sirwah - 1(lat .15 45 long . 44 58). (Beydoun. et al.1998) It is the principal reservoir in the YHOC concession area. Alif Member comprises over 90% of recoverable oil in the Marib-Shabwa Basin (JNOC, 2000). The isopach map the Alif Member (Fig. 10) illustrates that the maximum thickness is 553 feet at Alif 003 well while the minimum thickness reaches 377 feet at Alif 008 well (Table. 1). This map shows that the thickness increases from northwestern (3٨٠ feet) and southeastern (470 feet) parts toward center (505 feet) at Alif 042 well also thickness decreases from northeastern (550 feet) and south (530 feet) parts toward the center (505 feet) at Alif 042 well.

Safir Member

Yemen Hunt Oil Company YHOC (Schlumberger, 1992) suggested the Safir Formation as a name for this unit, but Yemen Stratigraphic Commission (Beydoun, 1997) emended it to Safir Member of Sab'atayn Formation. It is predominantly a thick halite which is subdivided into five units by intervals of interbedded shale and minor sandstone. It is Late Tithonian in age. (Beydoun. et al. , 1998). The Safir Member constitutes an excellent seal to the underlyng Alif reservoir and contain within them some potential good local reservoir – seal pairs in the intra evaporate clastics and the evaporates. (Beydoun et al. , 1998). The Thickness of Safer Member in the study area is shown in the isopach map (Fig. 11). It illustrates that the maximum thickness is 1874 feet at Alif 002 well, while the minimum thickness reaches the values of 1395 feet at Alif 005 well (Table. 1). This map shows that the thickness increases from west 1420 feet toward east 1860 feet part also the thickness increases from south (1540 feet) toward east (1860 feet) part of the study area.

(Table 1) Summary of the elevation of top and bottom of Sab'atayn Formation in the studied wells.

Alif 042	Alif 041	Alif 033	Alif 024	Alif 011	Alif 008	Alif 005	Alif 003	Alif 002	Alif 001	Wells	
-439	-574	-563	-205	-432	-726	-698	-561	-449	-415	Top	Safir
-2289	-2102	-2303	-2052	-2096	-2387	-2093	-2372	-2323	-1943	Bottom	

1850	1528	1740	1847	1664	1661	1395	1811	1874	1528	Thickness	
-2289	-2102	-2303	-2052	-2096	-2387	-2093	-2372	-2323	-1943	Top	Alif
-2794	-2616	-2766	-2593	-2630	-2764	-2527	-2925	-2792	-2364	Bottom	
505	514	463	541	534	377	434	708	469	421	Thickness	
-2794	-2616	-2766	-2593	-2630	-2764	-2527	-2925	-2792	-2364	Top	Seen
????	-2928	-3026	-2857	-3068	-3068	-2805	-3080	-2995	-2707	Bottom	
????	312	260	264	438	304	278	*ABS	203	343	Thickness	
????	ABS	ABS	ABS	ABS	-3068	-2805	-3080	*ABS	-2707	Top	Yah

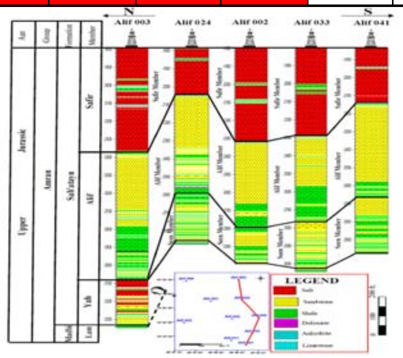


Figure (3): Geologic cross section along the profile (N-S)

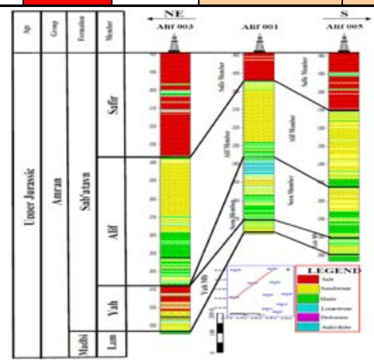


Figure (4): Geologic cross section along the profile (NE-SW).

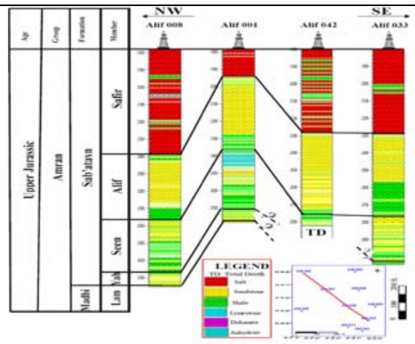


Figure (5): Geologic cross section along the profile (NW-SE)

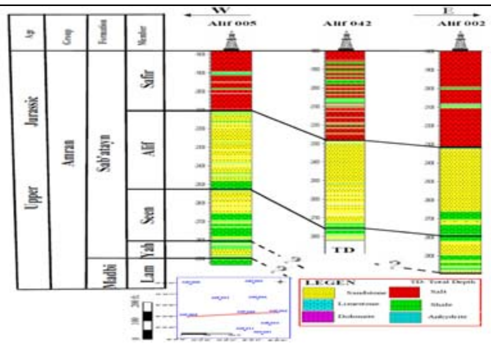


Figure (6) Geologic cross section along the profile (W-E)

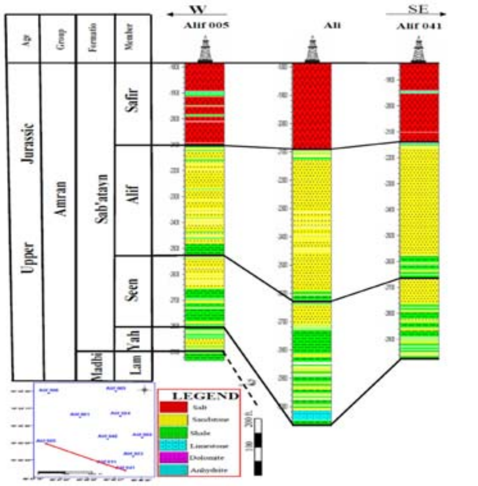


Figure (7): Geologic cross section along the profile (W-SE)

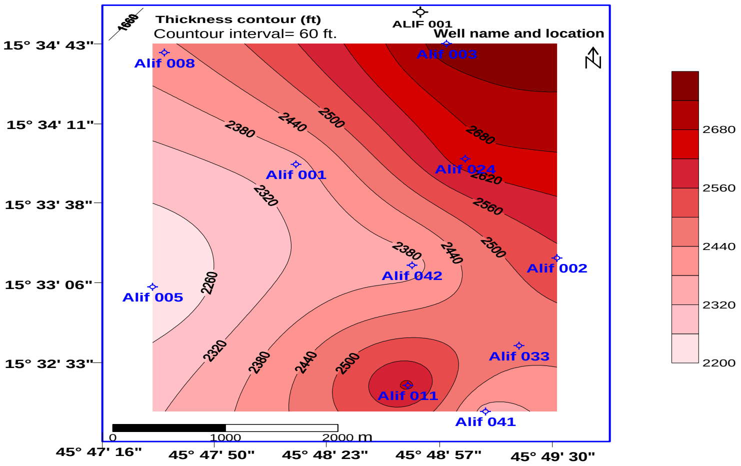


Figure (8): Isopach map of the Sab'atayn Formation.

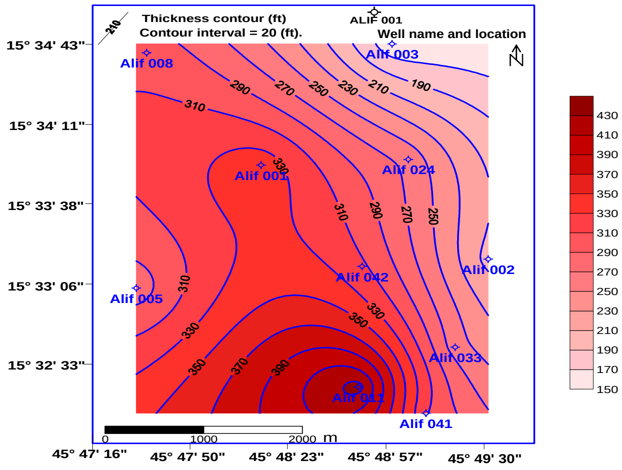


Figure (9): Isopach map of the Seen Member.

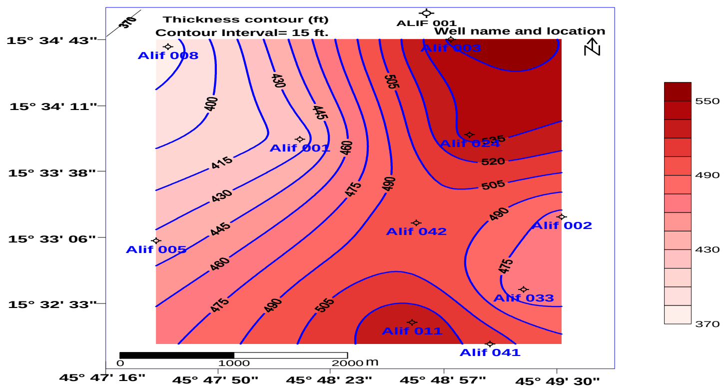


Figure (10): Isopach map of the Alif Member.

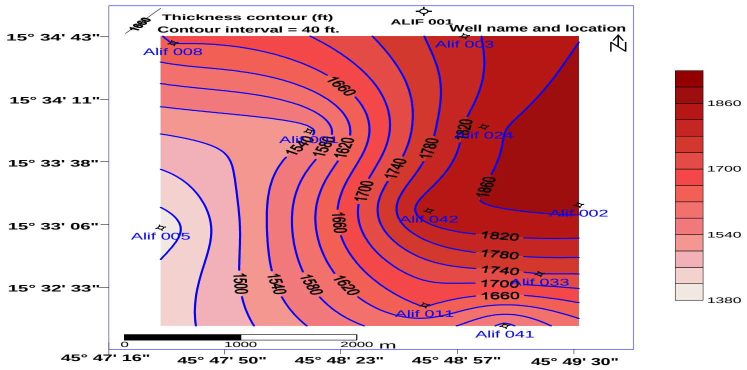
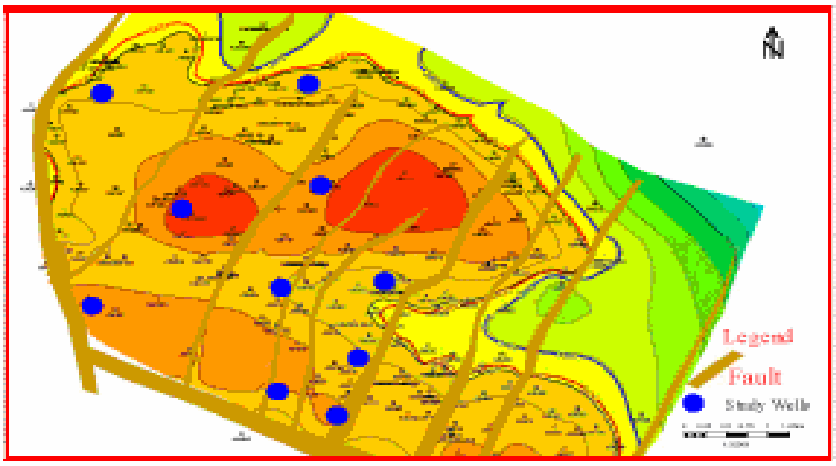


Figure (11): Isopach map of the Safir Member

Structure Configuration

The Structure contour map for the top of Alif Member in Alif Field indicates that the dominant Structure in the area is double plunging anticline. affected by several parallel faults of northeastern southwestern trend (**Al-Zubairi, 1999)** (Fig. 12).



(Fig. 12) Structure contour map for the top of Alif Member in Oil Alif Field. (after Safir Company 2007).

Well log analysis

Well log analysis is the most important task for any well after drilling, to detect the reservoir rocks among the all drilled formations (Pirson, 1963). It is one of the most useful and important tools available to the petroleum geologist. Besides their traditional use in exploration to correlate zones and to assist with structure and isopach mapping, logs help to define physical rock characteristics such as lithology, porosity, pore geometry, and water saturation etc.. In this study, the goal of the evaluation of reservoir properties is the estimation of hydrocarbons in the porous zones encountered in the Upper Jurassic Saba'tayn Formation (Alif, Seen, and Yah Members) in Alif oil field in Marib — Shabwa Basin penetrated by ten wells in the study area using a computer programs named as Interactive Petrophisecis^{TM} (IP). Saba'tayn Formation was subjected to a comprehensive formation evaluation process. The results of well log interpretation for Saba'tayn Formation (Alif, Seen, and Yah s) in Alif oil field are presented in three forms; a)Reservoir parameters determination, b) litho-saturation cross-plots, … and

c) Reservoir distribution maps.

Determination of petrophysical reservoir parameters

In this study, well log interpretation has been done by for determination and calculation of the reservoir properties including shale volume, porosity, water saturation, and other properties within the user-defined zones.

Table (2): Reservoir petrophysical parameters

Parameters	Wells / Members	Alif 001	Alif 002	Alif 003	Alif 005	Alif 008	Alif 011	Alif 024	Alif 033	Alif 041	Alif 042
Volume of Shale (Vsh)%	Alif Mb	28.1	27.7	43.4	29.5	29.3	20.5	16.8	37.6	22.4	15.8
	Seen Mb	33.6	34	*ABS	55.4	63.3	43.4	38.2	18.3	35.5	???
	Yah Mb	36.8	ABS	8.3	31.7	36.8	ABS	ABS	ABS	ABS	???
Total porosity (Phit)%	Alif Mb	17.1	19.6	22.6	20.9	15	14.3	12.9	14.3	13.8	15.2
	Seen Mb	14.9	10.9	ABS	10.9	11.1	8.6	10	13.6	11.6	???
	Yah Mb	11.6	ABS	30.6	9.3	9.7	ABS	ABS	ABS	ABS	???
Effective porosity (Phie)%	Alif Mb	11.1	19.8	11.9	9.4	11.4	12.7	11.9	9.9	12.9	14.7
	Seen Mb	4.2	7.9	ABS	6.6	3.4	5.3	7.7	11.5	4.2	???
	Yah Mb	3.7	ABS	29.6	7.7	5.1	ABS	ABS	ABS	ABS	???
Water Saturation (Sw)%	Alif Mb	11.2	24.1	41.1	12.8	35.8	14.4	17.7	32.2	12.3	28.6
	Seen Mb	26	53.1	ABS	94	63.3	63.3	45.3	59.5	58.1	???
	Yah Mb	38.6	ABS	10.8	94.9	77	ABS	ABS	ABS	ABS	???
Hydrocarbon Saturation (Sh)%	Alif Mb	88.8	75.9	58.9	87.2	64.2	85.6	82.3	67.8	87.7	71.4
	Seen Mb	74	46.9	ABS	6	36.7	36.7	54.7	40.5	41.9	???
	Yah Mb	61.4	ABS	89.2	5.1	23	ABS	ABS	ABS	ABS	???

Litho-saturation cross-plots

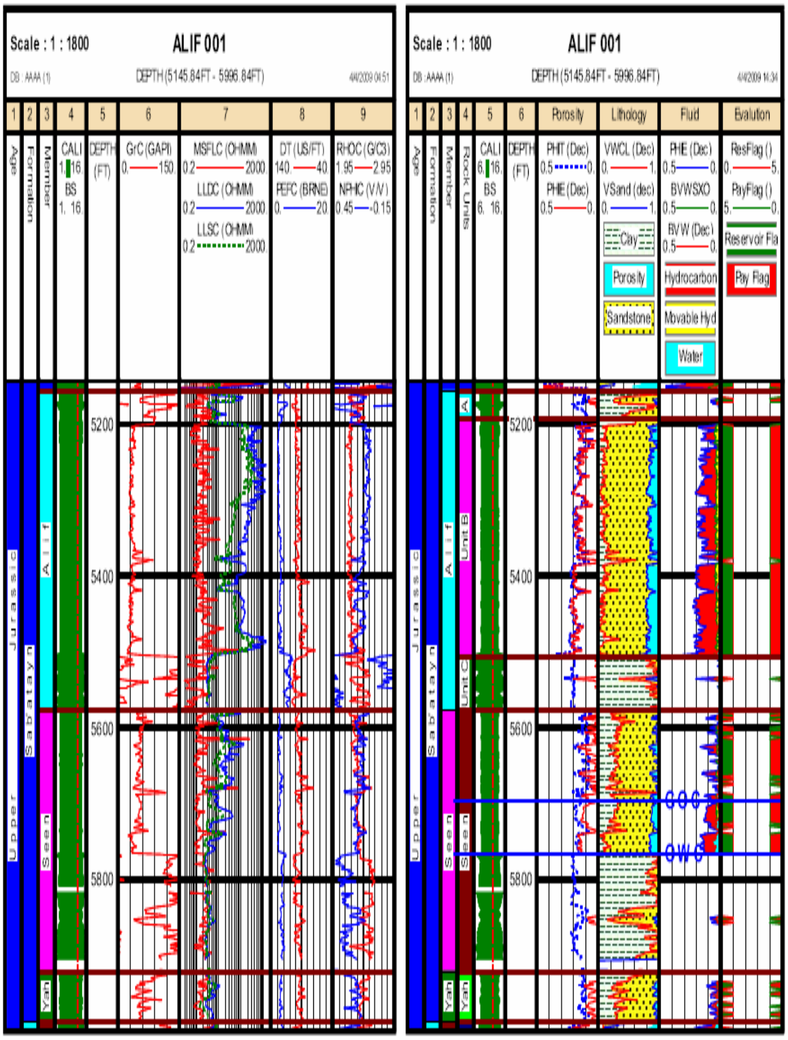
The Sab'atayn Formation can be evaluated through studying the vertical distribution of petrophysical parameters based on the results of well log analysis. In all stratigraphic units, the rock characteristics change is in somewhat the same manner from one part to another of the basin, especially for Alif reservoir. The vertical distribution of petrophysical parameters and lithology is presented in the form of litho-saturation crossplots. It consists of one track including the vertical distribution of the rock types (lithology) and fluids in effective porosity. Also the other diagram represents the total percentage of the rocks and fluids. This evaluation of reservoir potential will be useful to isolate zones for possible future testing.

Reservoir zonation

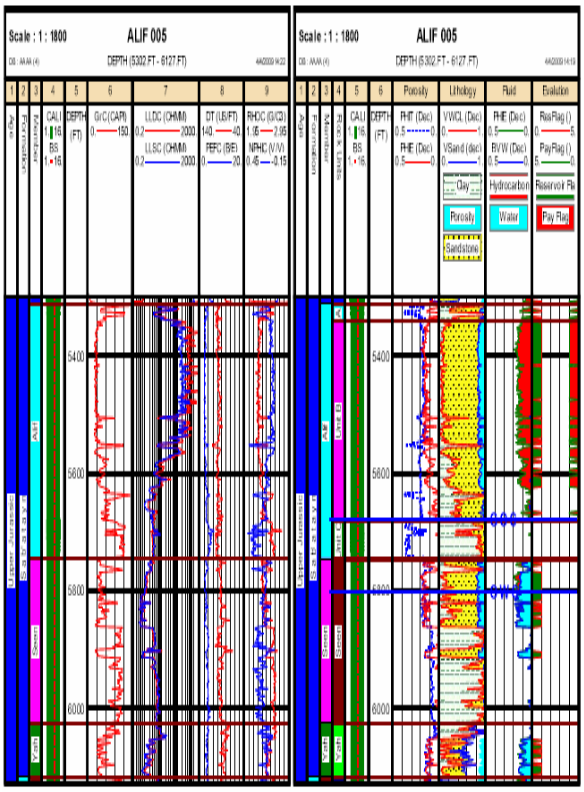
From log analysis and interpretation the Alif Member can be divided into three units, a thick unit of sandstone(313 ft, 339 ft, 260 ft, 324 ft, 464 ft, 488 ft, 252 ft, 427 ft, 389 ft and 423 ft thickness) (Unit B) overland by a relative thin unit of shale (37 ft, 30 ft, 31 ft, 30 ft, 33 ft, 19 ft, 18 ft, 7 ft,20 ft and 15 ft thickness) (Unit A) and underlined by a moderate thickness of shale(71 ft, 86 ft, 116 ft, 37 ft, 34 ft 188 ft, 80 ft, 299 ft and 67 ft).While (Unit C) for wells Alif 001, Alif 005, Alif 008, Alif 002, Alif 011, Alif 024, Alif 033, Alif 041, Alif 003, , Alif 042 respectively (Figs. 13, 14 and 15). The fluid saturation of the Alif , Seen and Yah can be detected from the log response. for example Gas zone and Oil zone (GOC) can be easily recognized from the relation between the neutron and density logs. Oil zone and Water zone (OWC) is also detected as a resolution from the response of resistivity logs (Figs. 13, 14 and 15).

Neutron-density crossplots

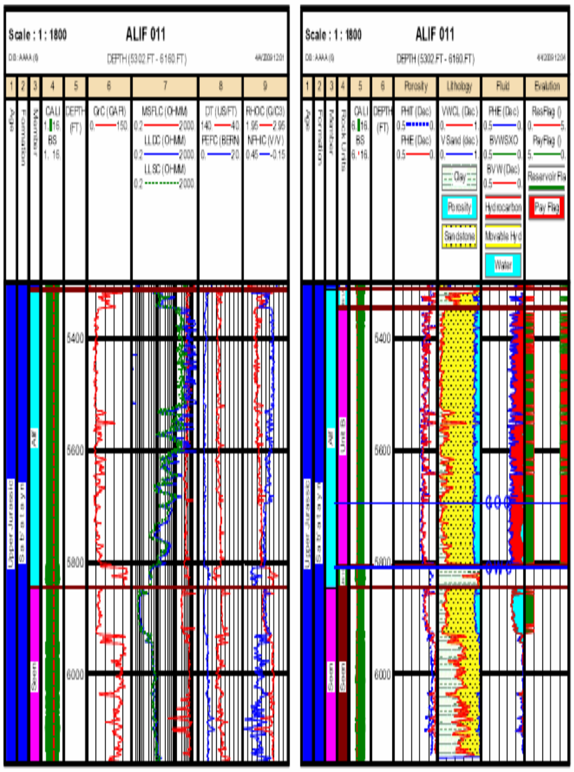
The neutron-density crossplot of the Alif Member shows that the majority of points overlie the sandstone line and some points around sandstone line and limestone lines in addition to the gas effect pulled up the plotted data to the upper left hand side of the plot. For Seen Member it overlies the sandstone line and around limestone line and dolomite line in addition to the clay effect that pulled down the plotted data to the right bellow hand side of the plot. While for Yah Member, it overlies sandstone line and around sandstone line and line limestone (Fig. 16A).



(Fig. 13) Lithosaturation crossplots for Alif 001 well.



(Fig. 14) Lithosaturation crossplots for Alif 005 well



(Fig. 15) Lithosaturation crossplots for Alif 011 well

Mineral identification crossplots (M-N)

The M-N cross-plots of the Alif, Seen and Yah members of the wells (Fig. 16B).reveals the dominance of quartz sandstone, in which the points are frequently located in the shale area but with lesser carbonate, beside shifting some plotted points toward the gas zone

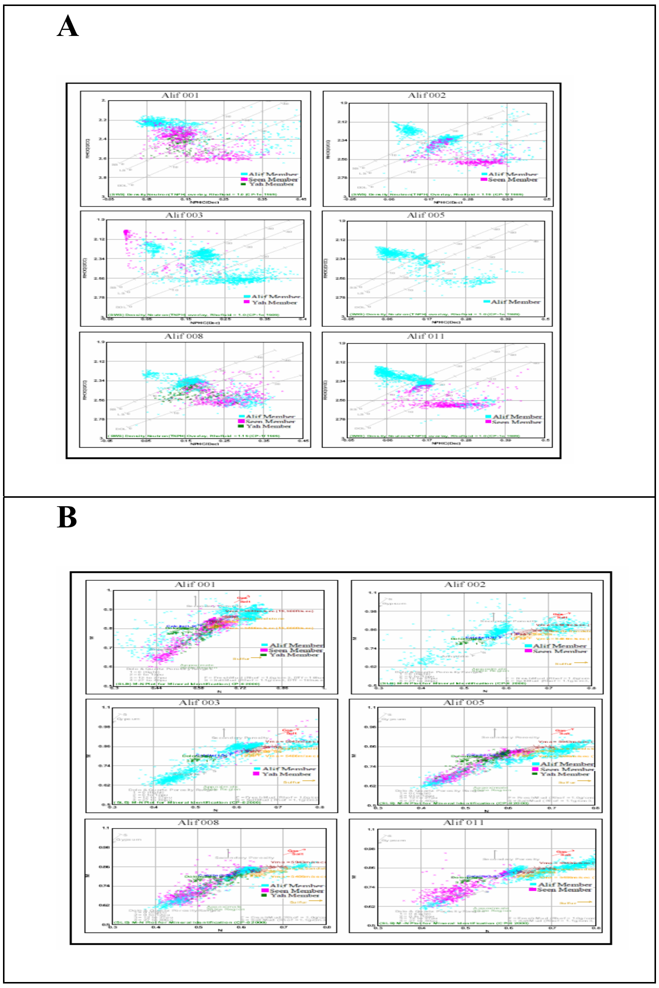
Shale volume (Vsh) distribution Map

The shale volume contour map of the Alif Member (Fig. 17A) shows distribution of shale content, the minimum value is 15.6 % at Alif 042 well while the maximum value is 43.4 % at Alif 003 well. Generally the shale content distribution decreases from east towards the southwestern part of the study area and increases towards north and southeastern parts. The shale volume contour map of the Seen Member (Fig. 18A) shows that the minimum value is 18.3 % at Alif 033 well and the maximum value is 63.3 % in Alif 008 well. The shale content distribution increases from southeastern part towards the northwestern and western parts of the study area. While the shale volume of Yah Member shows that the minimum value is 8.3 % in Alif 003 well to maximum value of 37 % at Alif 008 well and Alif 001 well (Fig. 19A).

Total and effective porosity distribution maps

Total porosity distribution map of the Alif Member (Fig. 17C) shows that the porosity values varies from 12.9 % at Alif 024 well to 22.6 % at Alif 003 well. This map shows an increase in the total porosity from central area towards northeastern, and western parts of the study area. While stabilize from central area towards southeastern part. While the effective porosity distribution map of the Alif Member (Fig.17B) shows that minimum value is 9.4 % at Alif 005 well and the maximum value is 19.8% at Alif 002 well. Generally the effective porosity increases from the west toward east part of the study area. The total porosity distribution map of the Seen Member (Fig 17 C) shows that the minimum value is

8.6 % at Alif 011 well and the maximum value is 14.9 % at Alif 001 well. Generally the total porosity decreases from central and southeastern parts towards the northeastern and the southwestern, and stabilize from central area towards the southeastern parts of the study area. The total porosity decreases toward south and east parts of the study area.



(Fig16) A: Neutron Density Crossplot & B: M-N crossplot

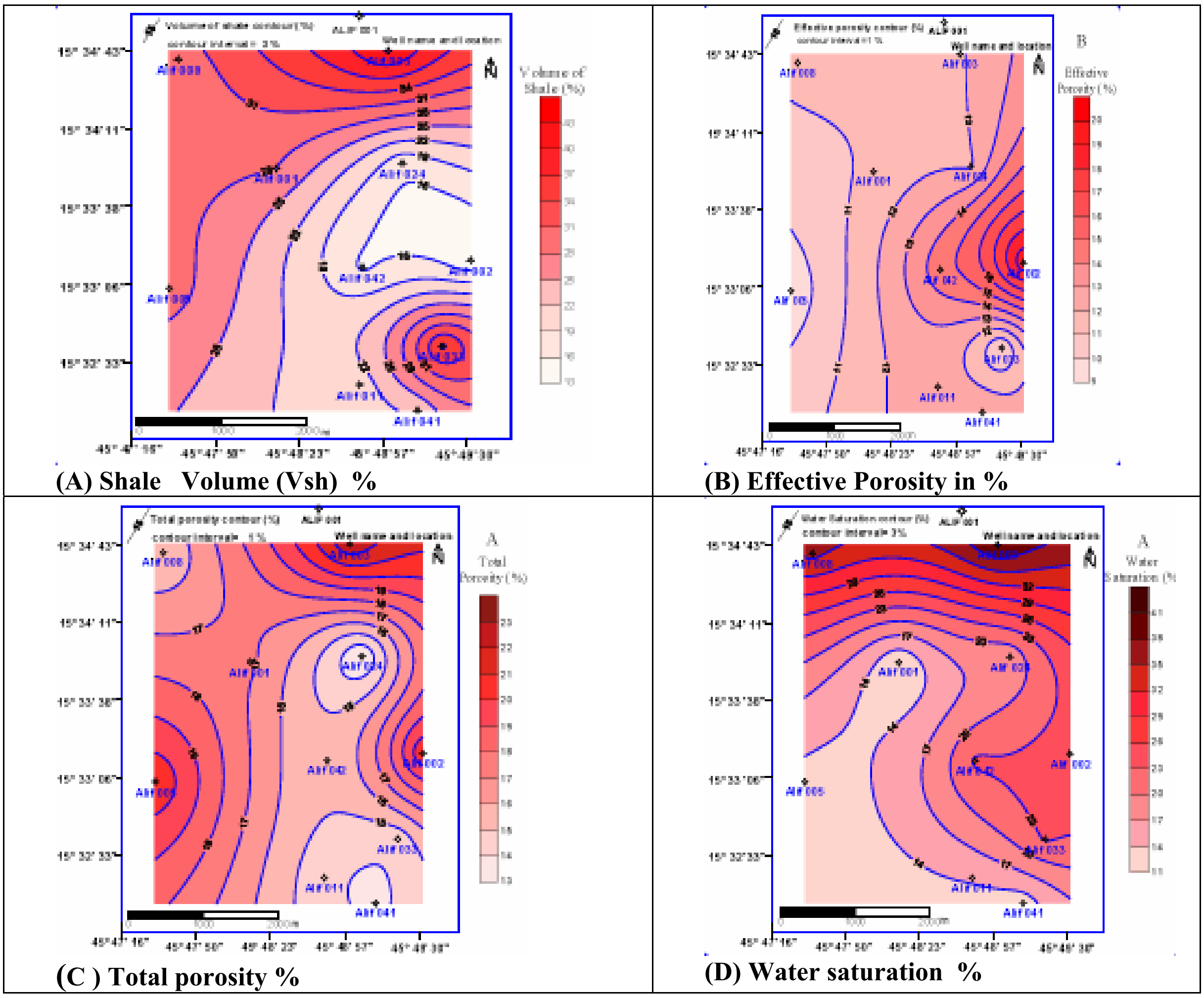
The effective porosity distribution map of Seen Member (Fig. 18B) shows minimum value of (3.4 %) in Alif 008 well and maximum value of (11.5 %) in Alif 033 well. This map shows that the effective porosity increases from northwestern toward southeastern, and stabilize from central area toward south, west and north parts of the study area. The total porosity of the Yah Member shows variation in porosity values from 9.4 % at Alif 005 well to 30.6 % at Alif 003 well (Fig. 19C). While the effective porosity of the Yah shows minimum value of 3.7 % at Alif 001 well and maximum value of 29.6 % at Alif 003 well (Fig. 19B)

Water Saturation Distribution Map

The water saturation map of Alif Member (Fig. 17D) shows variation in water saturation values from 11.3 % at Alif 001 well to 41.1 % at Alif 003 well. Generally the water saturation distribution increase from central-western toward the east, north, northeastern and northwestern parts of the study area. The water saturation distribution stabilize from central area toward west and southwestern. While the water saturation map of Seen Member (Fig. 18D) shows variation in water saturation values from 26 % at Alif 001 well to 94 % at Alif 005 well. This map shows that the water saturation distribution increasing from central area toward southwestern part of the study area. The water saturation of the Yah Member shows variation in water saturation values from 9.5 % at Alif 005 well to 76 % at Alif 008 well. While the hydrocarbon saturation shows variation in their values from 24 % at Alif 008 well to 91.5 % at Alif 005 well (Fig. 19D)

Net-Reservoir And Net-Pay Thickness Distribution Maps

The net reservoir thickness distribution map of the Alif Member (Fig. 17E) shows a considerable reservoir thickness restricted to the northeastern and central parts of the area and stabilizes from central area toward southeastern, south parts of the study area. with a maximum recorded value of 486 ft at the Alif 024 well. The thickness decreases gradually northwestern and southeastern wards, recording the minimum reservoir thickness of 240 ft at the Alif 001 well. In contrast, the net pay thickness distribution map of the Alif Member (Fig. 17F) shows as similar distribution pattern for net reservoir thickness distribution map of the Alif but with lower magnitude. the minimum net-pay thickness is recorded value of 198 ft at the Alif 003 well, while the maximum net-pay thickness is recorded value of 465 ft at Alif 024 well. The distribution pattern points to the northeastern and central parts of the Alif as promising sites for further hydrocarbon exploration. The net reservoir thickness distribution map of the Seen Member (Fig. 18E) shows that the reservoir thickness increases from the northeastern part toward the southwestern and southeastern parts of the study area. The maximum value is 123 ft at the Alif 041 well, and it decreases towards northeastern, to 11 ft at the Alif 024 well. The net-pay thickness distribution map of the Seen Member (Fig.18F) demonstrates that the net-pay thickness increases toward the central part of the study area, recording the maximum value of 58 ft at Alif 001 well and tends to decrease east ward, which reaches zero at the Alif 002 well. While The net reservoir thickness of the Yah shows variation in the reservoir thickness values minimum value of 2 ft at the Alif 003 well while the maximum value is (28 ft) at the Alif 005 well (Fig. 19E). The net-pay thickness of the Yah shows variation in the net-pay thickness values minimum value of zero ft at the Alif 005 well to maximum value of 3 ft at the Alif 001 well (Fig. 19F).

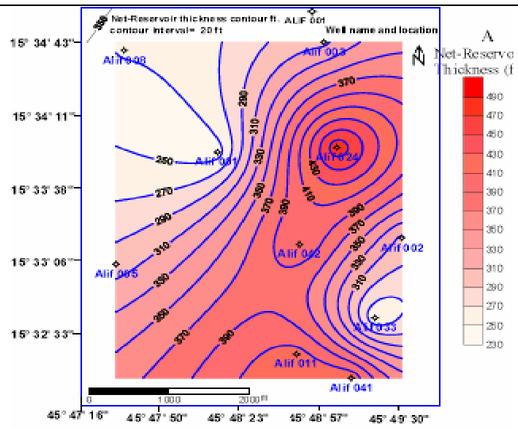


(A) Shale Volume (Vsh) %

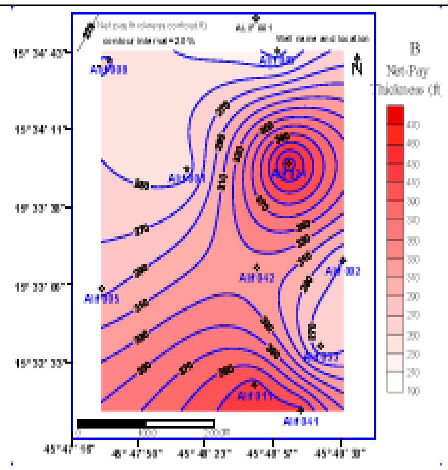
(B) Effective Porosity in %

(C) Total porosity %

(D) Water saturation %

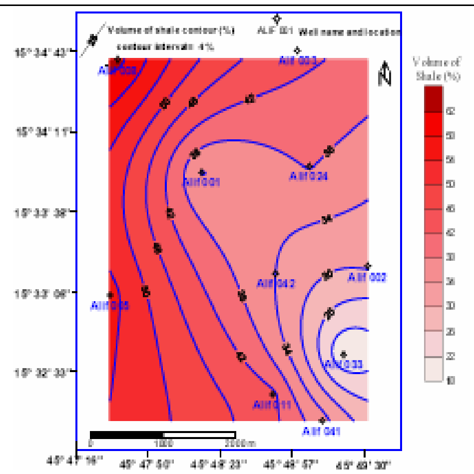


(E) Net reservoir thickness

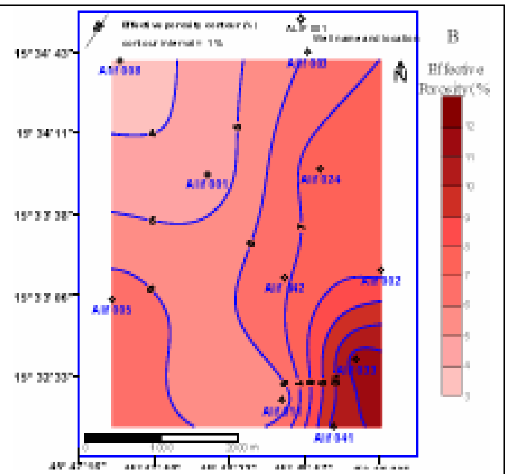


(F) Net pay

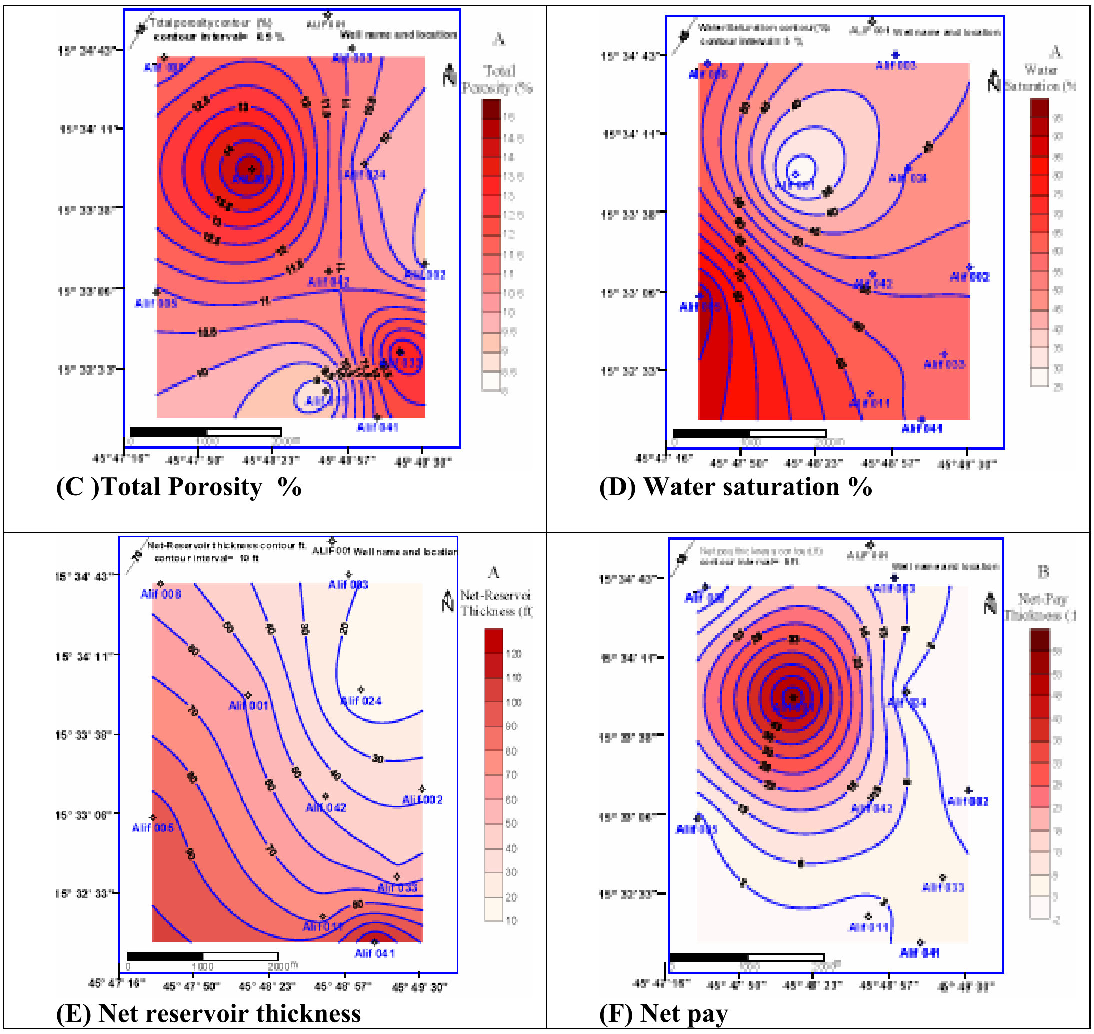
(Fig. 17) Distribution maps for Alif Member in the study area.



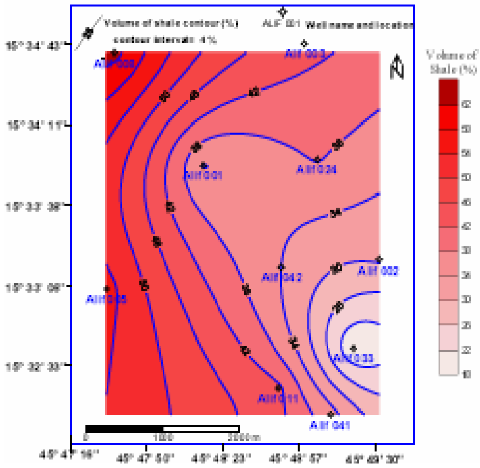
(A) Shale Volume (Vsh) %



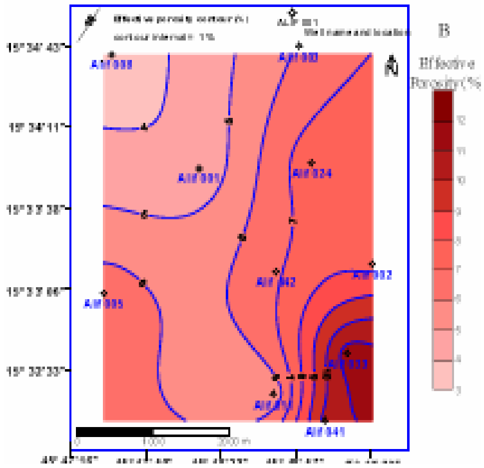
(B) Effective Porosity in %



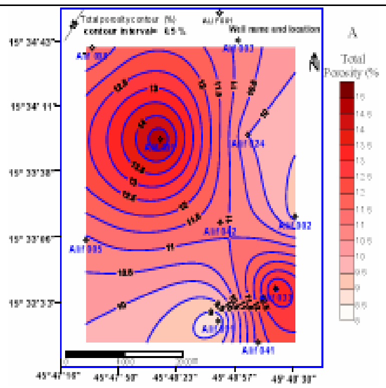
(Fig. 18) Distribution maps for Seen Member in the study area.



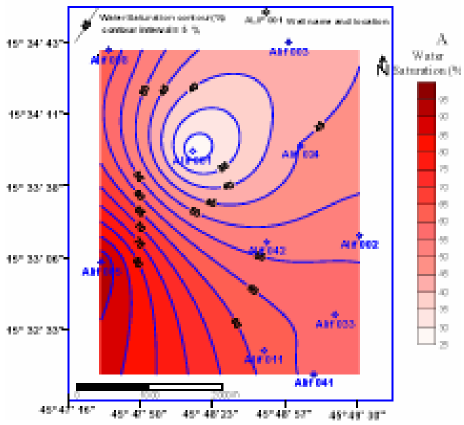
(A) Shale volume %



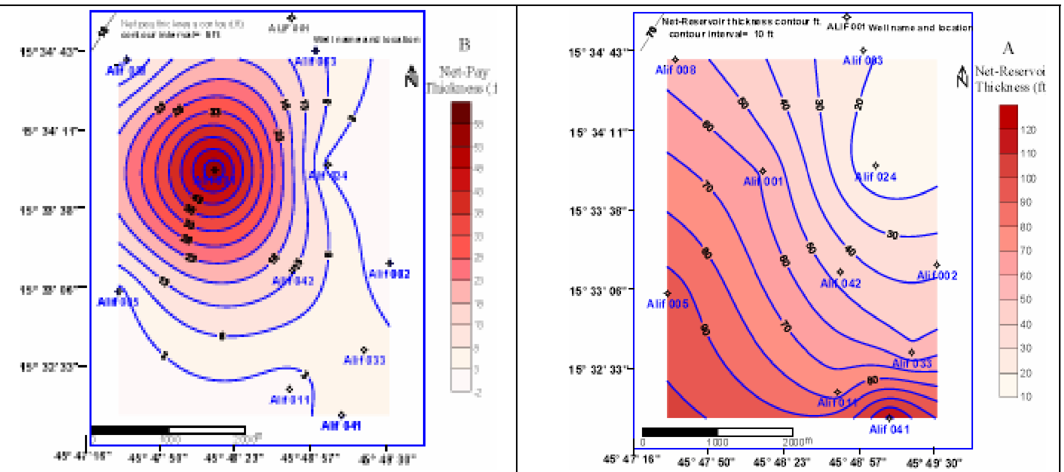
(B) Effective porosity %



(C)Total porosity %



(D) Water saturation %

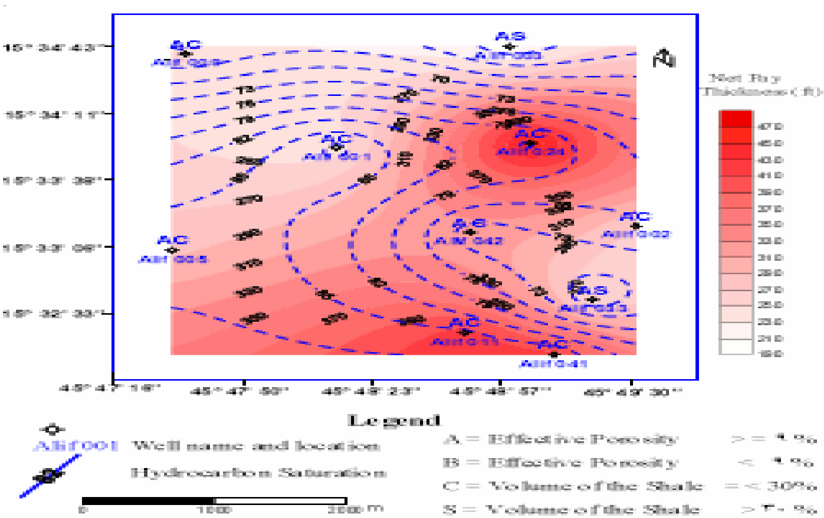


(E) Net reservoir thickness (E) Net pay

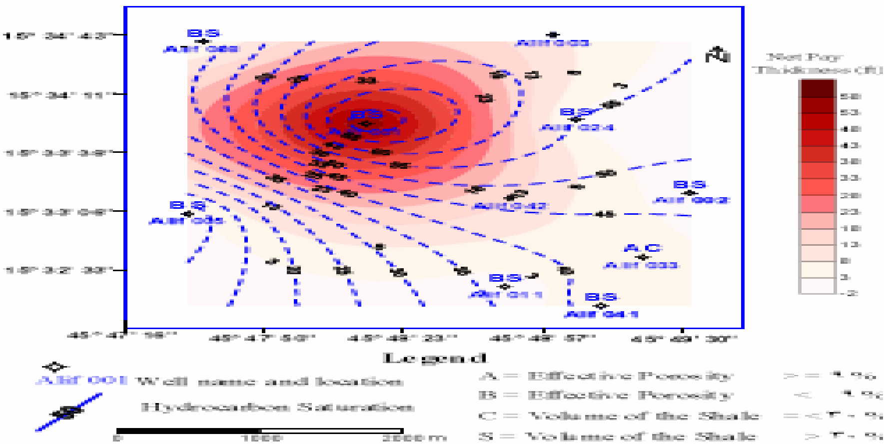
(Fig. 19) Distribution maps for Yah Member in the study area.

Reservoir potentiality

The hydrocarbon potentialities of the study area can be discussed by integrating the lithological, petrophysical, fluid parameters and hydrocarbon generation factors affecting the investigated area which are achieved from the comprehensive analyses processes. Consequently, two lease maps are constructed for the studied members (Alif and Seen). These maps are based on pay zone thickness, hydrocarbon saturation, some reservoir petrophysical parameters such as effective porosity and volume of shale. These maps are helpful for the future developing of the study area and a guide for the future exploration plan. For the Alif Member it was found that the central and southern parts of the area, particularly at the Alif 024 and Alif 041 wells are promising sites for future hydrocarbon exploration These sites have high hydrocarbon saturation of 82.2 % to 87.6 %, low shale contents, high effective porosity and maximum pay thickness of 415.5 to 464.5 ft (Fig. 20). The Inspection of the Potential maps of the Seen Member (Fig. 21) reveal that the study area is not promising sites for future hydrocarbon exploration These sites have low hydrocarbon saturation up to 6 %, high shale contents, low effective porosity and minimum pay thickness between zero to 58 ft. thickness.



(Fig. 20) Hydrocarbon potential map of the Alif reservoir.



(Fig. 21) Hydrocarbon potential map of the Seen reservoir.

CONCLUSIONS

- The subsurface Upper Jurassic Sab'atayn Formation is subdivided into four members named from base to top as; Yah Member, Seen Member, Alif Member, and Safir members
- The dominant structure in the area is a double plunging anticline which is affected by several parallel NE-SW faults
- The mean value of the total porosity of the Alif Member in Alif Oil field is 16.6%, for the Seen Member is 11.45% while for the Yah Member is 10.2%. The mean value of the effective porosity for Alif Member is 12.57% and for Seen Member is 6.35% while for Yah Member is 5.5%.
- The mean value of the shale volume V_{sh} of Alif Member in Alif Oil field is 24.1%. for Seen Member is 40.1% while for Yah Member is 35.1%.

- The mean value of water saturation S_w of Alif Member in Alif Oil field is 23%. for Seen Member is 59.1% while for Yah Member is 55.3%.
- Alif Member is the main reservoir in the study area as it has the most considerable reservoir properties. It can be divided into three units, a thick unit (A) about 450ft of sandstone, (Unit B) about 30 ft and finally unit (C) about 120ft.
- The separation between Neutron and Density logs in most of the wells indicates that the Alif Member is also gas bearing zone.
- The central and southern parts of the study area, particularly around the Alif 024 and Alif 041 wells are promising sites for future hydrocarbon exploration These sites have high hydrocarbon saturation (82.2 % to 87.6 %), low shale contents, high effective porosity and maximum pay thickness (415.5 ft to 464.5 ft).

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