Evaluation of Upper Tahara Sand as a Secondary Target for Hydrocarbon Production Wafa Field, -block169a, Ghadames Basin-Libya ZOG_2_5

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Abstract

Considering the importance of petrophysical analysis and integrated advanced applications of electrical logs and techniques that may give way to a more in-depth investigation of the possibility of accumulation of Hydrocarbon with commercial quantities after appraisal and development schemes of well drilling operations, and in

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light of this principle, this paper dealt with the study of Tahara Fm. sand (Wafa Field, NC169a Block, South Western Libya) considering the formation as a secondary target for production of Oil and focus on key issues link to adopt more investigation and intense the potential toward this task. Tahara Fm. (Middle Devonian age) Consists of sand layer (divided into upper and lower units) interbedded with little Shale layers, with Gross Thickness ranges from 142 to 180 feet. Five wells from Wafa Field (A2, A3, A34, A36 & A45 NC169a) were selected for this study (Fig.3). Those wells were drilled targeting the production of Hydrocarbon from Aouinet Ouenine F3 Sand Fm. and cut the Tahara Sand (formation of interest) deploying some Wireline logs and planning for cutting a sidewall cores for this bed in future. Logging data were analyzed in terms of petrophysical characteristics of the sand using Tech Log software 2015, and the reserve was estimated upon the analysis results. The upper unit of Tahara sand has fair to good quality reservoir than lower unit ,where the total porosity in upper unit is about 12 % , the net pay thickness is about 17 feet and water saturation in upper sand reaches 34%. Reserve estimation results showed 6940711.768 MMSTB (Oil in Place) and oil recovery of about 2024374.266 MMSTB

1. Introduction

Libya is located on the Mediterranean of the African shield; and it is a major oil producer in the African continent, oil and gas where discovered in Libya during late fifties, several tectonic activities and events formed the present major structural and tectonic features including Caledonian and Hercynian orogeny's of Paleozoic time, during cretaceous to middle tertiary (Oligocene through Miocene) times[2]. These events caused uplift, subsidence, tilting, and faulting within the basins. As the result of tectonic movements, Libya was subdivided into five major

sedimentary basins; these are Sirt Basin, Murzuq Basin, Al Kufra Basin, Ghadames Basin, and offshore Basin.

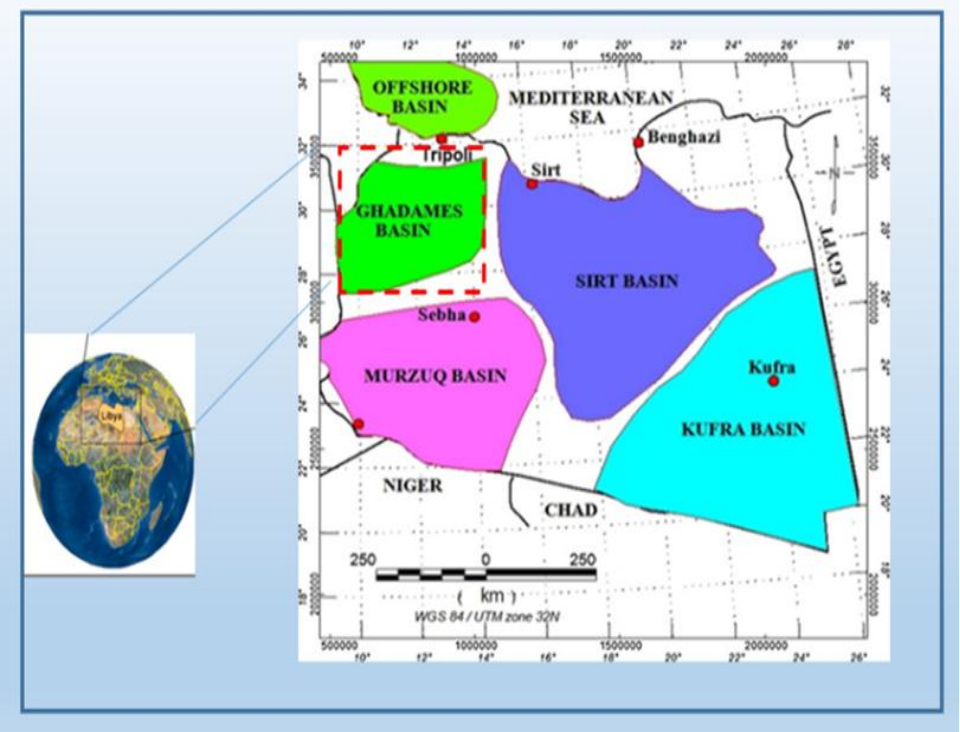


Fig.1: The Ghadames Basin location map in Libya North Africa shield (K.M.Abdunaser 2015)

Ghadames, Murzuq, and Kufra Basins are of Paleozoic age. However, Sirt and Sabratah Basins are of Mesozoic-Cenozoic ages. Both Sirt and Sabratah Basins were extended to offshore into the Mediterranean Sea, Sirte Basin has been explored more extensively than other basins and that accounts for about 80-85% of known recoverable oil reserves, while 3% are located in the Murzuq Basin 3% in Ghadames Basin and 5% offshore Basin[1]

The aim of study is to investigate the possibility of adopting more deep handling of Tahara sand in Wafa Field- Ghadames Basin as a secondary target of hydrocarbon production from the area in order to facilitate the identification of drilling locations and target intervals during the continued development of the field.

2. Stratigraphy

Ghadames Basin contains up to 20,000 feet (Fig.2), of Paleozoic and Mesozoic sediments, the Paleozoic section being separated from the Mesozoic deposits by a major regional unconformity of Hercynian (Permian-Carboniferous) age. Erosion patterns and the topography that developed on the surface of this regional unconformity have had a direct influence on the petroleum systems within the basin. These factors controlled the preservation of Paleozoic hydrocarbons, communication between source and higher reservoirs, and long-distance migration within the Triassic reservoirs.

The basin contains a variety of structural and stratigraphic traps in reservoirs of late Silurian and early Devonian age. Migration occurred along conduits within a sequence of deltaic sediments. In the south, where these seals become ineffective, oil has spread into middle and upper Devonian Reservoirs[2]

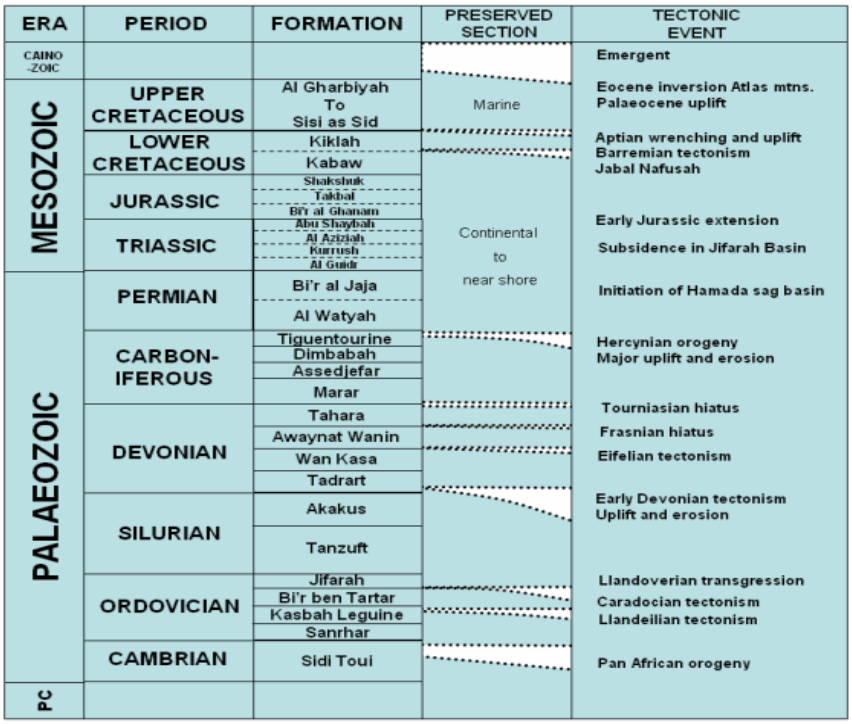


Fig.2: Typical Stratigraphic column of Ghadames Basin

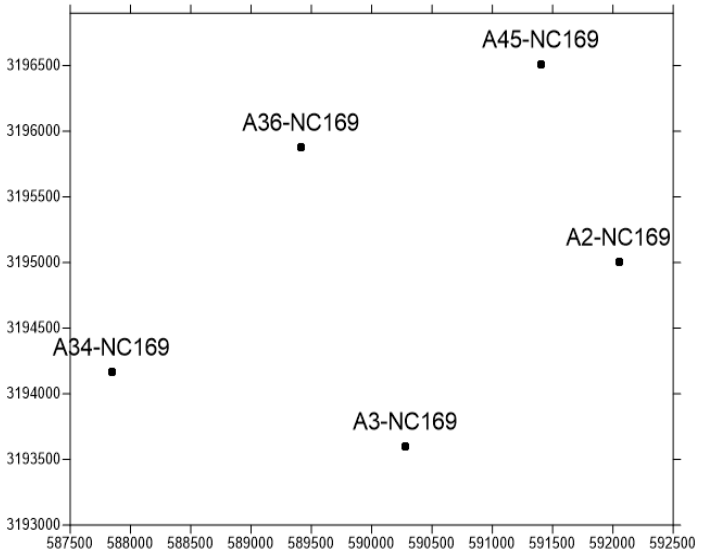


Fig.3: Location map of selected wells in Wafa Field

2.1 Tahara Formation:

In the subsurface of the Ghadames Basin, the uppermost Devonian is represented by sandy and shaly facies with frequent lateral variation in lithology. The type section is in the Wadi Tahara. The unit was first described by Massa and Moreau-Benoit (1976) as a 50-70m thick succession of fine-grained sandstone with frequent ferruginous levels, interbedded with shales. (Seidl and Rohlich 1984) pointed out that this formation should be included in the Aouinet Ouenine Group, because it originally was a part of that unit. According to Bellini and Massa (1980). The deposition of this unit took place in a deltaic environment, under substantial continental influence as indicated by the presence of lycophytic debris. (E1-Rwemi 1991) reported the presence of minor amounts of pyrite and Glauconitic as indicators of very slow sedimentation[3].

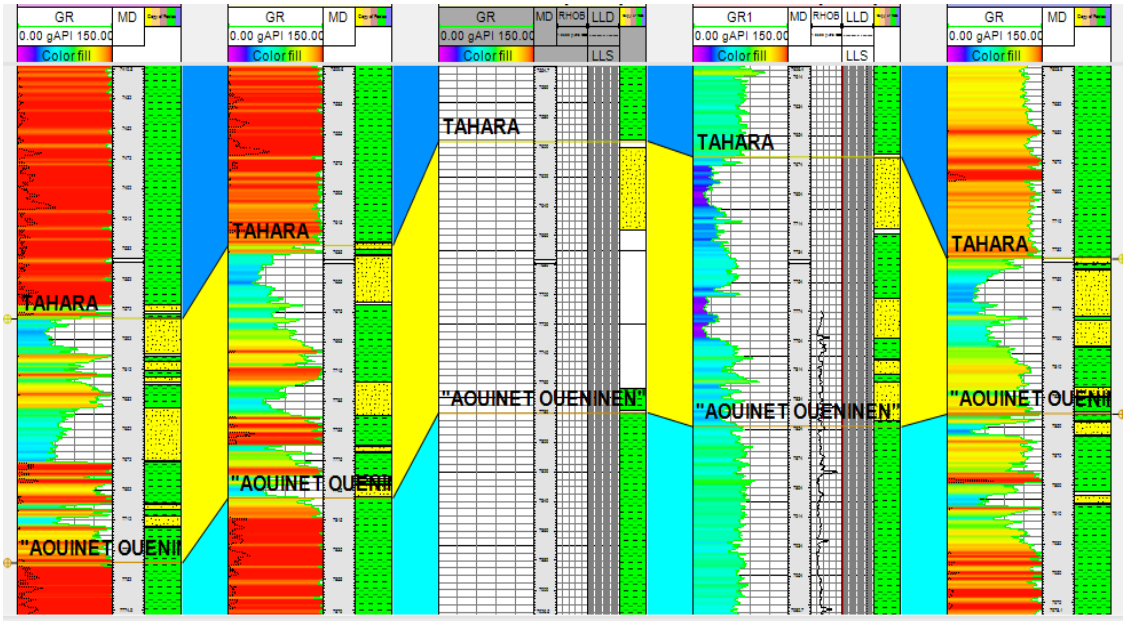


**Fig.4: well correction of Tahara Formation By GR Log **

3. Petrophysicalanalysis

Petrophysical analysis is one of methods used for the Formation evaluation, by using the well logging and core results. wireline logs recordings which was applied continuously recording of a geophysical parameter along a borehole, these value of the measurement is plotted continuously against depth in the well. Fig.4 illustrates the well correction of Tahara formation in study area.

3.1 Well A2 NC169a Analysis:

The Upper Tahara sand bed was penetrated in this well at a depth of 7584 feet, the thickness of sand bed was 50 feet, and the thickness of Tahara formation is 150 feet. The porosity values ranging between (18.9% and 22.4%), Net-Pay thickness of 13.5 feet and average water saturation was 17.1% (Fig.5 & table -1).

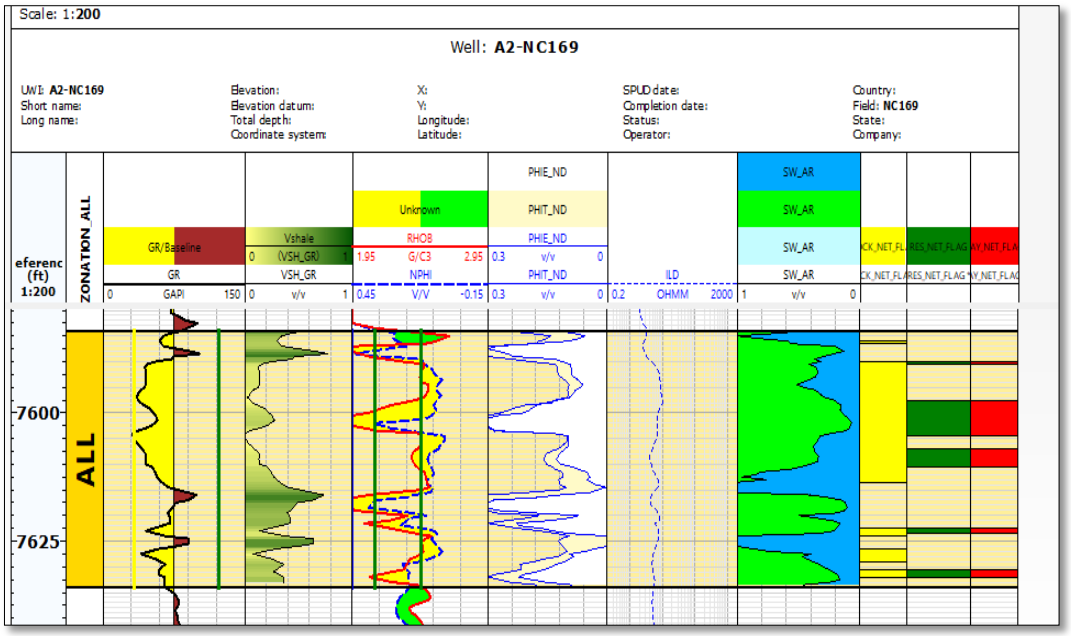


Fig.5: Log analysis plot of well A2-NC169a. (By TechLog 2015)

Table - 1 : The analysis results of well A2-NC169a

A2-NC169 A2	A2-NC169 A2	A2-NC169 A2
ALL	ALL	ALL
ROCK	RES	PAY
7584.000	7584.000	7584.000
7634.000	7634.000	7634.000
ft	ft	ft
50.000	50.000	50.000
29.500	13.500	13.500
20.500	36.500	36.500
0.000	0.000	0.000
0.590	0.270	0.270
0.590	0.270	0.270
1.034	0.469	0.469
4.035	2.751	2.751
3.002	2.281	2.281
0.155	0.170	0.170
0.137	0.204	0.204
0.256	0.171	0.171

3.2 Well A3 NC169a Analysis:

The Upper Tahara sand bed was penetrated in well A3 NC169a at a depth of 7688 feet, the thickness of sand bed was 50 feet, and the thickness of Tahara formation was 142feet, porosity value was 11.5% , the Net-Pay thickness of 13.5 feet and average water saturation was about37%(Fig.6&Table-2)

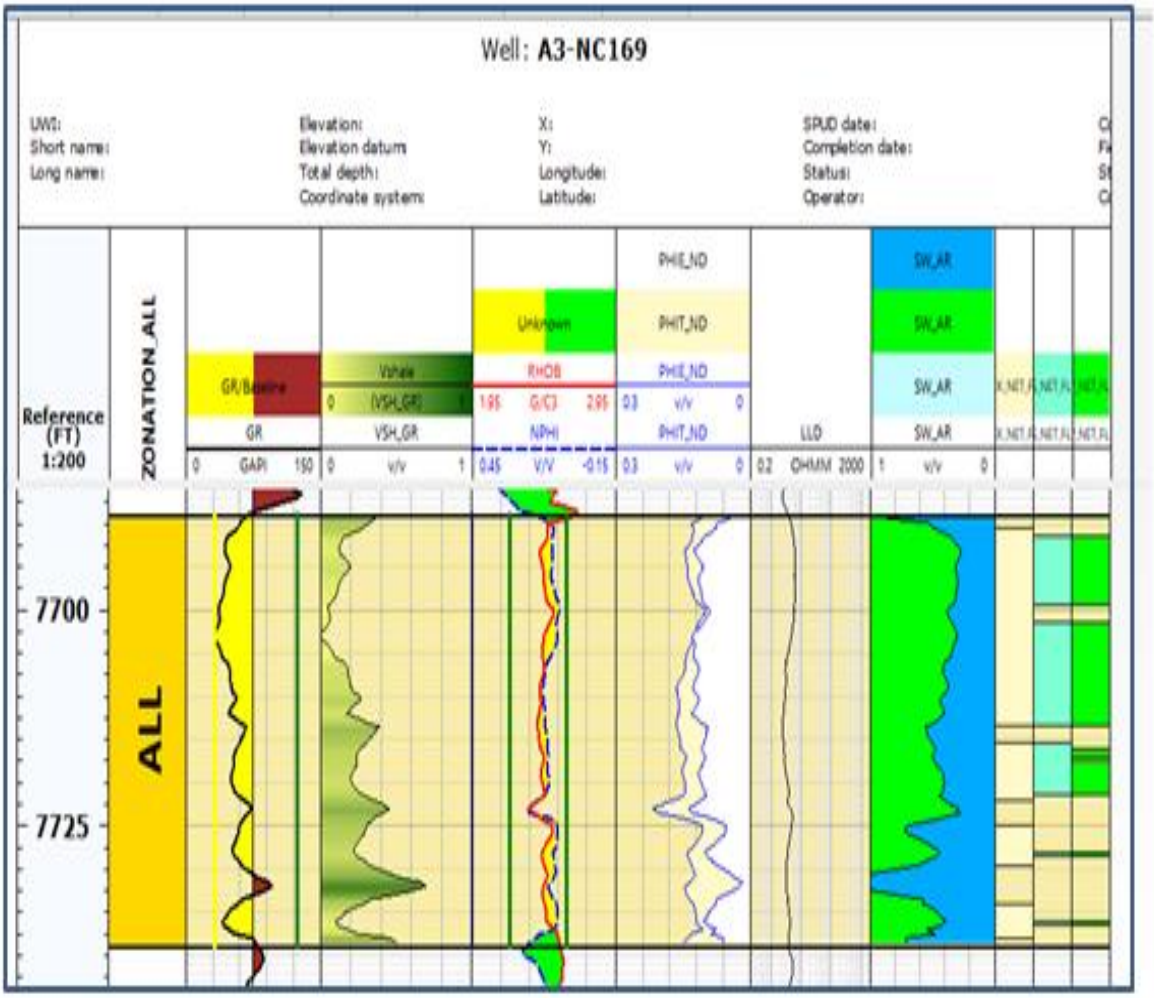
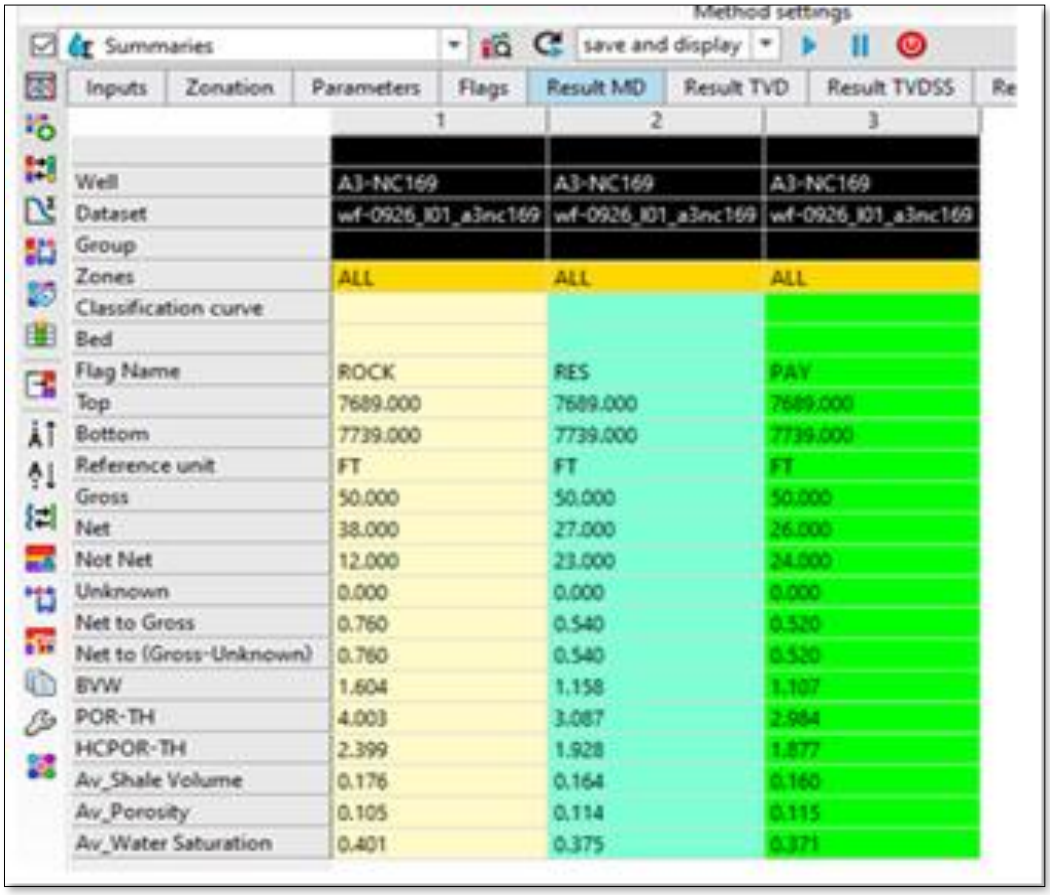


Fig.6: Log analysis plot of well A3-NC169a. (By Tech Log 2015)

Table - 2: The analysis results of well A3-NC169a



Method settings

Summaries | save and display

Inputs | Zonation | Parameters | Flags | Result MD | Result TVD | Result TVDSS | Re

	1	2	3
Well	A3-NC169	A3-NC169	A3-NC169
Dataset	wf-0926_l01_a3nc169	wf-0926_l01_a3nc169	wf-0926_l01_a3nc169
Group			
Zones	ALL	ALL	ALL
Classification curve			
Bed			
Flag Name	ROCK	RES	PAY
Top	7689.000	7689.000	7689.000
Bottom	7739.000	7739.000	7739.000
Reference unit	FT	FT	FT
Gross	50.000	50.000	50.000
Net	38.000	27.000	26.000
Not Net	12.000	23.000	24.000
Unknown	0.000	0.000	0.000
Net to Gross	0.760	0.540	0.520
Net to (Gross-Unknown)	0.760	0.540	0.520
BVW	1.604	1.158	1.107
POR-TH	4.003	3.087	2.984
HCPOR-TH	2.399	1.928	1.877
Av_Shale Volume	0.176	0.164	0.160
Av_Porosity	0.105	0.114	0.115
Av_Water Saturation	0.401	0.375	0.371

3.2 A3*6*-NC169a Analysis:

The Upper Tahara sand bed was penetrated in this well at a depth of 7777 feet, the thickness of sand bed was 48 feet, and the thickness of Tahara formation was 173feet. The porosity value is (10.9 %) and the Net-Pay thickness of 17.6 feet, where the average Water Saturation was 35% (Table-3).

Table - 3: The analysis results of well A36-NC169a

Summaries | save and display

Inputs | Zonation | Parameters | Flags | Result MD | Result TVD | Result TVD

	1	2	3
Well	A36-NC169a-Pilot	A36-NC169a-Pilot	A36-NC169a-Pilot
Dataset	Pilot-A36MainLog	Pilot-A36MainLog	Pilot-A36MainLog
Group			
Zones	ALL	ALL	ALL
Classification curve			
Bed			
Flag Name	ROCK	RES	PAY
Top	7777.000	7777.000	7777.000
Bottom	7824.000	7824.000	7824.000
Reference unit	ft	ft	ft
Gross	47.000	47.000	47.000
Net	24.500	17.500	17.500
Not Net	22.500	29.500	29.500
Unknown	0.000	0.000	0.000
Net to Gross	0.521	0.372	0.372
Net to (Gross-Unknown)	0.521	0.372	0.372
BVW	0.898	0.670	0.670
POR-TH	2.443	1.907	1.907
HCPOR-TH	1.545	1.237	1.237
Av_Shale Volume	0.143	0.120	0.120
Av_Porosity	0.100	0.109	0.109
Av_Water Saturation	0.368	0.351	0.351

The analysis results of petrophysical characterization of selected wells could be seen in the (Table-4).

Table - 4: The analysis results of all wells

Well name	A2	A3	A34	A36	A45
TOP upper Tahara -sand, (FT)	7584	7688	8802	7777	7734
THK, (FT)	50	50	44	48	30
Net pay	17.6	13.5	18.5	17.6	11
porosity	22.4	11.5	7	10.9	10.2
SW (%)	17.1	37.1	48	35	35.4

4. The Reserves Estimation:

To calculate the reserve need to calculate the initial Gas in place, original Gas in Place and Recoverable (3) as following:

4.1 The Hydrocarbon Pore Volume:

To calculate the hydrocarbon pore volume of NC169a field, of Tahara reservoir as following:

$$HPV = h \times \emptyset_{avg} \times (1 - Sw) \quad \ldots\ldots\ldots\ldots\ldots\ldots Eq(4.1).$$

Where:

- HPV : Net hydrocarbon pore volume (ft).
- h : Net pay thickness (ft).
- Ø : Net pay porosity (%).
- Sw : Net pay water saturation (%).

4.2 The Original Oil in Place:

To calculate the Original Gas in Place of NC169a field, of Tahara reservoir as following:

Calculating Oil in Place by the Volumetric Method Oil in place by the volumetric method is given by:

$$N(t) = \frac{V_b \phi(p(t)) \left(1 - S_w(t)\right)}{B_o(p(t))}$$

Where:

N(t) = oil in place at time t, STB

Vb = 7758 A h = bulk reservoir volume, bbl 7758 = bbl/acre-ft

A = area, acres h = thickness, ft

φ(p(t)) = porosity at reservoir pressure p, fraction

Sw(t) = water saturation at time t, fraction

Bo(p(t)) = oil formation volume factor at reservoir pressure p, bbl/STB

p(t) = reservoir pressure at time t, psia 4.3 The initial Gas in Place:

5. Discussion

From the thickness map of the selected wells it has been observed that the thickness of Tahara sand increases toward the South East and increasing opposite upward as well as porosity values. Wireline logging was only applied on some wells and core was cut recently but with only 30 feet recovery[7] because of technical problems encountered. The formation was even penetrated at another regions of Ghadames Basin with good results obtained from SCAL and testing. In Wafa area, the south part suffering a lack of data (pore Seismic data) but the last scheme of drilling showed results encouraging to carry out more investigations and put Tahara sand in priority especially by horizontal drilling. Integration with results from adjacent fields might be used to study the migration aspects of hydrocarbon from this sand.

6. Conclusion:

Five wells were selected from different locations in Wafa Field targeting the investigation of possibility consideration of Tahara sand as a secondary target of Hydrocarbon production after completing the development scheme of the field (Aouinet Ouenin F3sand). Petrophysical analysis and volumetric calculations results could be summarized as following:

- Upper Tahara sand has the best reservoir characteristics with an average porosity of **7**% to 20.4%.
- The thickness of sand is variable (gross thickness is about 50feet) where the reservoir Net Pay ranging from 11 to 18.5 feet.
- The reservoir has very low water saturation ranging from 17.1 to 48 %.
- The reserve estimation in Tahara Sand calculated with the Original Oil in place is **6940711.768 MMSTB.**
- The recoverable Oil is **2024374.266 MMSTB.**
- It is extremely recommended to adopt horizontal drilling plan for deep investigation of reservoir

quality of Tahara upper sand horizontally for not more than 500feet. Integration with data from adjacent fields is also recommended.

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