PETROPHYSICAL ASSESSMENT OF THE CRETACEOUS UPPER QAMCHUQA (MAUDDUD) FORMATION, KHABBAZ OILFIELD, NORTHERN IRAQ

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ABSTRACT

The wireline logs analysis have been used to study the cretaceous rocks of Qamchuqa formation in the Kirkuk oil field. The area is tectonically leaving the foothill zone. The field subsurface anticline is asymmetrical with a length of 20 km and width of 4 km. The field has a couple pay area. The Khabbaz oilfield reservoir is formed of two main parts which are tertiary (Jerbe reservoir) and cretaceous (upper and lower Qamchuqa reservoir). The upper part of Qamchuqa in the Khabbaz oilfield is divided into three groups. From the surface, unit A is between 156 to 180m and has an average thickness of 66 m. Unit B has an average thickness of 73m and unit C has an average of 34m. From the log data, the petrophysical properties of the Khabbaz oilfield's four wells [Kz-1, Kz-5, Kz-11 and Kz-16] have been assessed. The corrected useful log contains GR log, acoustic log, N-log, D-log and resistivity log. Both (Rxo and Rt) have the very good characteristic reservoir to unit A. The result shows that unit A have the best reservoir characteristics. The unit A is subdivided into six subunits (1-A, 2-A, 3-A, 4-A, 5-A and 6-A) which are distinguished by five non-reservoir subunits (1-N, 2-N, 3-N, 4-N, and 5-N). In addition, the unit B and unit C are less porous reservoirs. Unit B is divided into three subunits (1-B, 2-B, and 3-B) which are distinguished by two non-reservoirs (1-N and 2-N). Furthermore, the results have indicated high levels of hydrocarbon saturation, permeability and porosity in certain degrees of formation particularly in unit A.

KEYWORDS: Petrophysical Properties, North Iraq, Porosity, Qamchuqa Formation, Well Log, Khabbaz Oilfield, Carbonate.

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1. INTRODUCTION

Kurdistan Region falls between the northern part of the Zagros Folded Belt. It contains about 45 billion barrels (bbls) of the total Iraq's 115 billion barrels of oil reserves, which makes Iraq the sixth largest oil reserve in the world [1]. The field reserves are estimated to have between 0.5 and 1.0 billion barrels of crude oil in three formations. The creation capability of a hydrocarbon reservoir have been determined crucially by Well logging [2]. In this study, the lithology, porosity, liquid saturation and other petrophysical properties have been studied and analysed by computer processed interpretation (CPI) of geophysical well logs with the guide of Interactive Petrophysics (IP) programming Vi3.5 [3]. The Khabbaz Field is one all most of the Iraq's largest oil fields with multiple pay zones compared to the most of the northern Iraq oil fields [4]. Khabbaz Oil Field is located in Kirkuk Governorate about 20 km SW of Kirkuk and lies between Bai Hassan and Jambour oil fields and parallel to Kirkuk Oil Field (about 23 km SW Baba Dome of Kirkuk Field) (Fig 1) [4]. Tectonically, it is located in the Foot Hill Zone (Hamrin-Makhul Subzone) that belongs to the Folded Zone of the Unstable Shelf [5]. Sedimentology and lithostratigraphy of Qamchuqa out crop in north-east Iraq have been studied. The upper Qamchuqa formation has been classified into eight units based on lithology and content fossil. The upper Qamchuqa formation boundaries is a

sarmord formation in the lower and dokan formation in the upper[6].In this research, 10 wells of the Qamchuqa formation reservoirs in the Khabbaz oilfield have been selected. By using the core, thin section and well log interpretation, the upper Qamchuqa formation of the Khabbaz oilfield is divided into three lithological units from the top to the button (unit A, B and C)[4].

Figure 1: Major Petroleum Fields of Iraq and showing Location of the Study Area [7]

Figure 2: The Structural Contour Map of the Qamchuqare Servoir in the Khabbaz Oil Field (N.O.C.1982)[8]

Table 1: The Thickness of the Wells Studied in the Upper Qamchuqa from Top to Bottom

Upper Qamchuqa Formation	Wells	Kz-1	Kz-5	Kz-11	Kz-16
	Top (m)	2752.5	2832	2885.5	2905
	Bott (m)	2924	2991	2982	3061
	Thick (m)	171.5	159	171.5	156

1.1. Study Area

The Khabbaz oilfield is the small subsurface anticline with around 20 Km length and 4Km width at the pinnacle of Upper Qamchuqa formation (Figure 1.2). It is dipped in the southwest part is higher than in the northeast Khabbaz oilfield positioned between Jambur and Bai Hassan fields (Figure 1 and 2). Tectonically, the field is placed in the foothill zone (Hamrin-Makhul Subzone) which refers to the folded zone of the unstable shelf [5].

Figure 3: Column of Upper Qamchuqa Formation, in Khabbaz Oil Field, Well (Kz-1), showing the Log to Main Lithological Unit Characters (Gamma Ray Log, Sonic Log, N- Porosity Green Colour and D-Porosity Blue Colour).

Table 3: Descriptive Calculation of Average Vsh for Khabbaz Oil Wells

Units	Well Name	Shale Volume Percentage
A	Kz-1	10.26
	Kz-5	15.71
	Kz-11	9.33
	Kz-16	13.37
B	Kz-1	11.59
	Kz-5	17.22
	Kz-11	11.60
	Kz-16	14.67
C	Kz-1	15.85
	Kz-5	22.40
	Kz-11	13.35
	Kz-16	18.13

This learn about is targeted is to become aware of the petrophysical parameters and the lithological characteristics of four Khabbaz oil wells. The characteristics of Upper Qamchuqa formation through correction and interpretation of log data, log dimension can outline can define or least infer these properties resistivity, porosity, shale volume, lithology, and water and hydrocarbon saturation.

Table 4: Layer Thickness and Intervals of Units A, B and C for Wells Kz-1, Kz-5, Kz-11, and Kz-16

Wells	Interval(m)	Units	Units interval (m)	Units thick(m)
Kz-1	2752.5-2924(171.5)	A	2752.5-2821	68.5
		B	2821-2888	67
		C	2888-2924	36
Kz-5	2832-2991(159)	A	2832-2895	63
		B	2895-2969	74
		C	2969-2991	26
Kz-11	2885.5-3057(171.5)	A	2885.5-2950.5	65
		B	2950.5-3030	79.5
		C	3030-3057	27
Kz-16	2905-3061(156)	A	2905-2968.5	63.5
		B	2968.5-3035	66.5
		C	3035-3061	26

2. METHODOLOGY

For the realization of many petrophysical parameters, the data collected for the analysis selected wells in the Khabbaz oil field may be obstructed as follows:

- Wireline logs of the four well sections include sonic log, gamma ray log, and neutron log, and resistivity logs.
- Determining formation analysis and porosity estimation depending upon four wells penetrated of Qamchuqa reservoir for Khabbaz oil field using interactive petrophysics software V3.5.

- “Didger5” software program is used to digitize the logs and store the data in raw log information that enabled us to measure the Upper's petrophysical properties Qamchuqa reservoir for example lithology, volume of shale and porosity.

3. SHALE VOLUME

The hydrocarbon reservoir is usually associated with shale material most of the time. In the delineated reservoirs the gamma-ray log was used to assess the volume of shale. Firstly, the gamma ray index (IGR) is determined using the following equation from the gamma ray log [9]

$$IGR = \frac{GR_{log} - GR_{min}}{GR_{max} - GR_{min}} \quad (1)$$

Where

GR_{log} is reading the gamma rays from various depths.

GR_{min} is min gamma ray (clean sand)

GR_{max} is max gamma ray (shale)

The percentage of VSH is sometimes called the gamma ray index (IGR) (Rider and Kennedy, 2011).

$$V_{SH} = 0.083(2^{3.7 \cdot IGR} - 1.0) \quad (2)$$

Where

V_{SH} = volume of shale

IGR = gamma ray index

Table 5: Calculated Petrophysical Parameters of Unit A for Kz-1, Kz-5, Kz-11, and Kz-16 Wells

Lithology Unit	Sub Units	Properties	KZ-1	KZ-5	KZ-11	KZ-16	Average
Unit A	1-A	Interval (m)	2752.4-2754.9	2832-2834.7	2885.3-2890	2905.7-2907.3	
		Thick(m)	2.5	2.7	4.7	1.6	2.87
		Porosity	0.20	0.21	0.26	0.10	0.19
		Sw	7.23	11.22	11.13	10.13	9.92
		So	92.77	88.78	88.87	89.87	90.07
	2-A	Interval (m)	2756.8-2765.4	2838.4-2844.3	2894-2899.7	2911.3-2917.6	
		Thickness(m)	8.6	5.9	5.7	6.3	6.62
		Porosity	0.19	0.18	0.21	0.20	0.19
		Sw	12.26	13.81	10.26	7.11	10.86
		So	87.74	86.19	89.74	92.89	89.14
	3-A	Interval (m)	2772-2779.9	2849.6-2857.6	2906.1-2908.4	2923.8-2932.3	
		Thick(m)	7.9	8.0	2.3	8.3	6.62
		Porosity	0.15	0.16	0.15	0.11	0.14
		Sw	11.41	9.32	9.32	11.21	10.31
		So	88.59	90.68	90.68	88.79	89.68

	A	Interval (m)	2787-2798.9	2863-2873.5	2919.8-2931.6	2939.1-2948.3	
		Thick(m)	11.8	10.5	11.8	9.2	10.82
		Porosity	0.17	0.16	0.22	0.12	0.16
		Sw	8.22	10.11	8.37	8.37	8.76
		So	91.78	89.89	91.63	91.63	91.23
	5-A	Interval (m)	2799.2-2810.8	2873.5-2885.5	2931.6-2940.1	2949.3-2959.8	
		Thick(m)	11.3	13.0	8.5	10.5	10.82
		Porosity	0.17	0.16	0.19	0.15	0.16
		Sw	8.39	12.58	9.13	10.81	10.22
		So	91.61	87.42	90.87	89.19	89.77
	6-A	Interval (m)	2810.5-2822.7	2887.5-2896.1	2944.6-2951.5	2962-2968.1	
		Thick(m)	12.2	8.6	6.9	6.1	8.45
		Porosity	0.18	0.19	0.17	0.17	0.17
		Sw	12.26	12.87	10.21	7.39	10.68
		So	87.74	87.13	89.79	92.61	89.31

3.1. Lithologic Units

Upper Qamchuqa has variable lithological units porosity formation. The reservoir's ordinary lithological characters have been represented using the wireline log Neutron-Density (N-D) Combination of formation lithology consists of dolostone and dolomitic limestone with marly limestone and shale intercalation (Figure 3), Khabbaz well lithologies are divided into three units.

3.2. Porosity Unit Calculations

Four wells are selected to learn about which Upper Qamchuqa Formation is penetrating Khabbaz oilfield was Rock porosity can be purchased from sonic log, N-D porosity, density log. Complete porosity consists of primary and secondary porosity, the show porosity decreases with depth, the reservoir porosity varies from 0.07-0.26. The table is split (5 and 6).

Table 6: Calculated Petrophysical Parameter of Unit B and C for Kz-1, Kz-5, Kz-11 and Kz-16 Wells

Lithology Unit	Units	The properties	Kz-1	Kz-5	Kz-11	Kz-16	Average
Unit (B)	B1	Interval (m)	2831-2838	2916.2-2926.7	2885.4-2975.9	2987.7-3002	
		Thick(m)	7.0	10.5	11.5	14.3	10.82
		Porosity	0.11	0.10	0.08	0.11	0.1
		Sw	10.88	9.11	7.28	10.11	9.15
		So	89.12	90.89	92.72	89.89	90.85
	B2	Interval (m)	2840.6-2863	2930.1-2937.5	2977.9-2983.4	3014.9-3018.5	
		Thick(m)	22.4	7.4	5.5	3.6	9.72
		Porosity	0.10	0.07	0.11	0.10	0.095
		Sw	5.33	7.80	8.30	7.32	9.72

	B3	So	94.67	92.2	91.7	92.68	92.81
		Interval (m)	2867.3-2873.2	2951-2969	3009.5-3028.5	3026.3-3034.1	
		Thick(m)	5.9	18.0	19.0	7.8	12.67
		Porosity	0.12	0.12	0.10	0.08	0.105
		Sw	5.11	8.37	8.12	8.39	7.49
		So	94.89	91.63	91.88	91.11	92.5
Unit(C)	C1	Interval (m)	2888.7-2894.9	2971.4-2973.6	3029.6-3037.5	3044.3-3046.1	
		Thick(m)	6.2	2.2	7.9	1.8	4.52
		Porosity	0.12	0.12	0.09	0.10	0.107
		Sw	13.70	14.22	7.29	12.34	11.88
		So	86.30	85.78	92.71	87.66	88.11

Figure 4: CPI of Composite Geophysical Logs for Reservoirs in WellKz-1: Water Saturation, Shale Content, Porosity.

Figure 5: CPI of Composite Geophysical Logs for Reservoirs in wellKz-5: Water Saturation, Shale Content, Porosity

Figure 6: CPI of Composite Geophysical Logs for Reservoirs in wellKz-11: Water Saturation, Shale Content, Porosity

Figure 7: CPI of Composite Geophysical Logs for Reservoirs in Well Kz-16: Water Saturation, Shale Content, Porosity

3.3. Unit A

The thickness of the upper lithological portion of the reservoir ranges between 62-69.5m [Table 3]. This exact reservoir unit is correctly defined from the mixed porosity neutron-density log, which is distinguished by the use of a high porosity interval. The unit is bounded from the top by through an unconformity surface with Dokan formation. At the bottom of the underlying upper sarmord formation, the porosity logs such as (neutron, density, and sonic). This unit consists of six essential

reservoir subunits (1A,2A,3A,4A,5A,and 6A).The subunits detached by five non-reservoir subunits (1-N,2-N,3-N,4-N,and 5-N).The characteristics of this units light gray hard to fine crystalline dolomite, and dolomitic limestone.

3.4. Reservoir Subunit 1-A

This subunit positioned below Dukan formation.The thickness of upper lithologic partsia 2.5m in Kz-1, 2.7 m in Kz-5, 4.7 m in Kz-11 and 1.6 in Kz-16 [table 5]. This unit is the best saturation and porosity properties inside upper Qamchuqa, which ranging between 0.10 to 0.26 [table 5].The record falls between dolomite and limestone lines and suggest that it is dolomitic limestone of subunit A1.In well Kz-1, the points are taken near limestone line while in well Kz-11,it is the opposite,water saturation range between 7.23-11.22 and oil saturation of range between 88.78–92.7 in wells Kz-1, Kz-5,Kz-11 and Kz-16.

3.5. Reservoir Subunit 2-A

The 2-A Subunits have variable thicknesses in the wells.Well Kz-1 has a maximum thickness of approximately 8.6m while well Kz-11 has minimum thicknesses of approximately 5.7m [Table 5].This subunit is distinguished from subunit 1-A by a non reservoir layer 1-N. The lithology of this unit is limestone,dolomitic limestone to pure dolomite. The subunit has very properly porosities ranged from 0.18 to 0.20, The water saturation of Kz-1,Kz-5,Kz-11and Kz-14 is 7.11 to 13.81, and oil saturation ranging between 86.19 and 92.89 [Table 5].

3.6. Reservoir Subunit 3-A

The Subunit A3 underlies the Subunit A2 (Figures 3) and is seperated by non-reservoir layer 2-N.The average thickness of subunit A3 is around 6.6m.The most thicknesses found in well Kz-16 which is over 8.3m.The net thickness is reduced to 2.3m in Kz-11.The lithologic of this subunit is dolomite, dolomitic limestone and limestone. Subunit porosity of 3-A grade 0.11 to 0.16 [Table 5and its specific water saturation, oil saturation, is 10.86%, 89.14%, respectively [Table 5].

3.7. Reservoir subunit 4-A

The subunit 4-A lies under subunit 3-A and seperated by non-reservoir unit 3-N.The average thickness of this subunit is over 10m.The lithology of this subunit is dolomitic limestone to dolomitewith the domination of dolomite (Figures 4,5,6 and 7).The porosity of the subnit range between 0.12- 0.22 (Table 5).The average water saturation and oil saturation is 8.22% and 91.78%, respectively (table 5).

3.8. Reservoirsubunit 5-A

The subunit 5-A lies under a subunit A6or is combined with an overlay subunit A4 with an average thickness of approximately 10.82. Dolomite lithology dominated the subunit[Figure 4,5,6 and 7]. This unit's porosity ranged from 0.15 to 0.19 [Table 5], and its specific water saturation, oil saturation, is 8.39%, 91.61%, respectively [Table 5].

3.9. Reservoir subunit 6-A

The subunit 6-A lies under subunits 5-A.The average thicknesses is 8.45m.The the porosity range between 0.17-0.19with an average of 0.17,the lithology of this subunit is mostly dolomite to dolomitic limestone [Figures 4,5,6 a7] and the average water saturation, oil saturation, this subunit are 7.39%, 62.61%, respectively [table 5].

3.10. Unit (B and C)

The units B and C are the two lower parts of Qamchuqa Formation.The thickness of unit B is between 66.5 - 79.5 m and the thickness of unit C is between 19.5 - 42.0m[table 6].Unit B has three interval subunits 1-B,2-B and 3-B with four non-

reservoir subunits 1-N, 2-N, 3-N and 4-N. Unit C has one interval subunit named 1-C. The downward reducing of this porosity unit is mostly composed of limestone and dolomite to dolomitic limestone.

3.11. Reservoir subunit 1-B

The subunit 1-B lies under subunit 6-A (Figure 3). The wells in this subunit have variable thickness ranging from 7.0m in Kz-1 to 14.3m in Kz-16 [Table 6]. The porosity of this subunit ranges between 0.08-0.11. The lithology of the subunit is dolomite to dolomitic limestone. The water saturation and oil saturation are 7.28% and 92.72% respectively [Table 6] (Figure 4, 5, 6 and 7).

3.12. Reservoir subunit 2-B

This subunit B-2 below reservoir subunit 1-B has assorted thickness from well to well, its maximum thickness 22.4 m in Kz-1 and minimum 3.6 m in properly well Kz-16 [Table 6]. The lithology of this subunit is mainly dolomite to dolomitic limestone. The porosity of this subunit is also variable. Average porosity about 0.11 in well Kz-11, 0.10 in wells Kz-1, Kz-5 and Kz-16. Sub-unit 2-B averages water and oil saturation 7.18 and 92.81, respectively [Table 6] (figure 4, 5, 6, and 7).

3.13. Reservoir subunit 3-B

Subunit 3-B is the ultimate part of reservoir unit B. It has variable thicknesses with the maximum of 19.0m in Kz-1 and the minimum of about 5.9 in Kz-11. The porosity of this subunit ranges between 0.08-0.12 [Table 6]. The lithology is dolomitic limestone in Kz-1. Figure (4, 5, 6, 7). The average water saturation and oil saturation are 7.49% and 92.5% respectively [Table 6].

3.14. Reservoir Subunit C1

The subunit C-1 is beneath reservoir subunit 3-B with thickness between 1.8m-6.2m [Table 6]. The porosity ranges between 0.9-0.12 [Table 6]. This subunit lies under the base of upper Qamchuqa Formation. It grades to the upper Sarmord Formation. The shale and marl decrease. The average water saturation and oil saturation are 11.88% and 88.11%, respectively [Table 6].

4. CONCLUSIONS

The use of unique types of interpretation of logging while studying four wells of the Khabbaz oilfield. The computed porosity and shale content ranges from 10 to 16 percent and 9.33 to 22.40 respectively. The average water saturation for units (A, B and C) ranges from 8.76 to 10.86 and 7.49 to 9.72, 11.88 respectively. The good characteristics are in unit A. It is classified into six reservoir subunits from the surface (A1, A2, A3, A4, A5 and A6). The lithology of the upper Qamchuqa Formation is limestone and dolomite and dolomitic limestone in unit A, B and C.

The shale volume contents increase with depth; the upper Qamchuqa has least shale volume.

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