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INVESTIGATING OF PETROPHYSICAL AND LITHOLOGICAL PARAMETERS OF ASMARI FORMATION IN BIBI-HAKIMEH OIL FIELD, SW OF IRAN

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Abstract

Carbonate rocks, along with sandstone, constitute the main reservoirs of oil and gas in the world. Examination of petrophysical properties includes parameters such as porosity, permeability and fluid saturation, lithological variations according to depth and hydrocarbon properties including effective and ineffective thickness and effective hydrocarbons column. Asmari reservoir of Bibi- Hakimeh oilfield is one of the tertiary carbonate reservoirs in Iran located 210 km southeast of Ahwaz. The reservoir is divided into 8 zones, each zone having its own petrological characteristics and lithology. Considering the fact that all three major lithologies of reservoirs (limestone, dolomite and Shale) exist in the Asmari reservoir of Bibi- Hakimeh oilfield, lithological study and its impact on petrophysical parameters of reservoirs are very important. Based on the assessments, zone 1 with more than 85% limestone has the most effective hydrocarbon column, the highest net thickness and the highest net to total thickness ratio, and due to its low water saturation (about 20% for effective zones), it has the best reservoir quality among the other zones. Following zone 1, zones 2 and 3 take the second and the third places, respectively. Zones 4 to 8 are below the water-oil interface, hence they are not included in productive zones and have lower reservoir quality. Zone 1 is considered as the best oil producing layer with respect to petrophysical parameters.

***Keywords**: Petrophysical parameters, Water saturation, Porosity, Bibi- Hakimeh oil field.*

1. Introduction

The main objective of studying reservoir characteristics is to reconstruct petrophysical properties such as porosity, permeability and fluid saturation. The porosity distribution can be a common relationship between these characteristics. In this regard, well logging charts are a good tool [1]. The relationship between petrophysics and geology (lithology) has been a subject of great study since 1955. The porosity and permeability of the carbonate layer are due to the reaction between the various types of precipitated primary materials and a variety of diagenetic processes. Well logging diagrams provide continuous recording of constructive parameters relative to depth, which is very useful for geological applications [2]. The composition of formations can be expressed as mineral or chemical elements using well logging diagrams (such as density, neutron and gamma), and therefore there is a relationship between petrophysical parameters and rock composition. The resulting information could lead to a better interpretation of the exploration and production, and hence the advanced characteristics of the reservoir [3].

Carbonate rocks, along with sandstone, constitute the main reservoirs of oil and gas in the world. The hydrocarbon deposits in these rocks are essentially associated with dolomite [4-5]. Dolomite accounts for about 30% of the world's carbonate reservoirs, accounting for roughly 80% of North American carbonate rocks. Two-thirds of Middle Eastern oil is located in carbonates, and Asmari reservoirs of Iran with the age of Oligo-Miocene (tertiary) are also listed as dolomite reservoirs [6]. These types of reservoirs are very heterogeneous to the plastic (e.g. sandstone) reservoirs [5]. For example, with increasing depth, dolomite creates better reservoirs than calcareous stones. Considering that all three major lithologies of reservoirs

(Limestone, Dolomite and Shale) are presented in the Asmari reservoir of Bibi- Hakimeh oil-field, the study of lithologies and their impact on petrophysical parameters of reservoirs is very important.

This issue is essentially related to the sedimentary environments of numerous facies, tectonic and diagenetic processes (cementation, dolomitization, recrystallization, fracturing, etc.) that accompany carbonate rocks [7-8]. In addition, the fracture also plays an important role in the reservoirs, and the generated porosity and permeability cause major anisotropy in the reservoir [5,9]. Therefore, studying different lithologies and their effect on petrophysical parameters of reservoirs is very important [10].

2. Bibi- Hakimeh oil field

Bibi- Hakimeh oilfield is located in 210Km southeast of Ahwaz (Fig. 1) and lacks any surface structure and is essentially determined by seismology. This field was discovered in 1928 and has several reservoir formations (Asmari, Sarvak and Khami formation). This field was exploited since 1962, and by June 2017, about 120 wells were drilled. Based on maps drawn from seismic studies and underground structure mapping, the Bibi- Hakimeh oilfield can be considered as an anticline from the northwest to the southeast. The slope of the northern lamb is slightly higher than that of the southern lamb which is around 11-13 degree and 6-9 degree, respectively. The slope of eastern and western capes is about 2-2.5 degree.

The Asmari reservoir contain oil with 30 °API and 2% sulfur [11]. Dimensions of the Asmari reservoir at the water-oil interface are about 70 km in length and 7 km in width. The water-oil contact in this reservoir is determined at a depth of 1979 meters below sea level. Given that the reservoir crest on the structural map is about 1729m below the sea level, and considering the last closed curve of the reservoir (2014m), the vertical closure is calculated to be about 285m, the height of the oil column in the central regions of the reservoir is about 250 meters, which decreases with moving to the reservoirs crest.

Figure 1. Located of Bibi- Hakimeh oil field in Dezful embayment, near the other oil fields, Southwest of Iran.

3. Lithology

Petrographical investigations of thin sections and study of the graphs indicated that the Asmari reservoir in this field are periodic consists of limestone, dolo limestone, dolomite, shale limestone and shale. Asmari reservoir is divided into 8 zones (layers) and each zone has its own petrophysical lithology properties. Zone 1 is mostly shaly carbonate (shaly limestone and shaly dolomite), zones 2, 3, 4 and 5 are mainly limestone (with some dolomite), zone 6 is a combination of limestone, dolomite and shale, and zones 7 and 8 are calcareous. Fig. 2 and Fig. 3 show the percentage of limestone, calcareous dolomite and clay in various zones of wells 39 and 116 in this field.

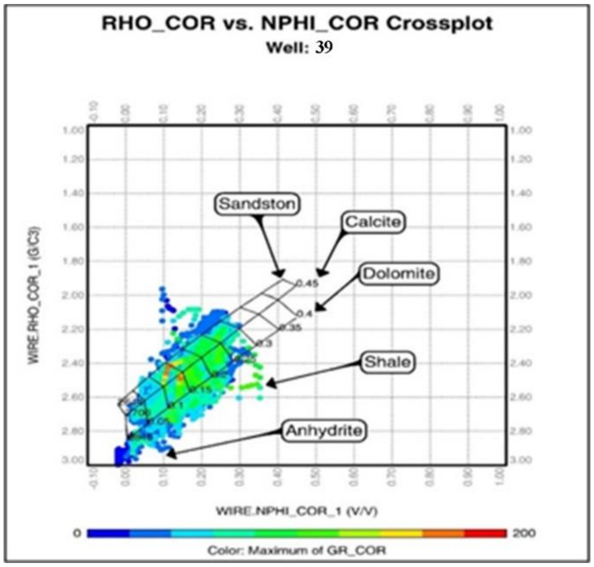

Figure 2. Cross plot of Neutron-Density-GR, Well No.39 in Bibi- Hakimeh oil field

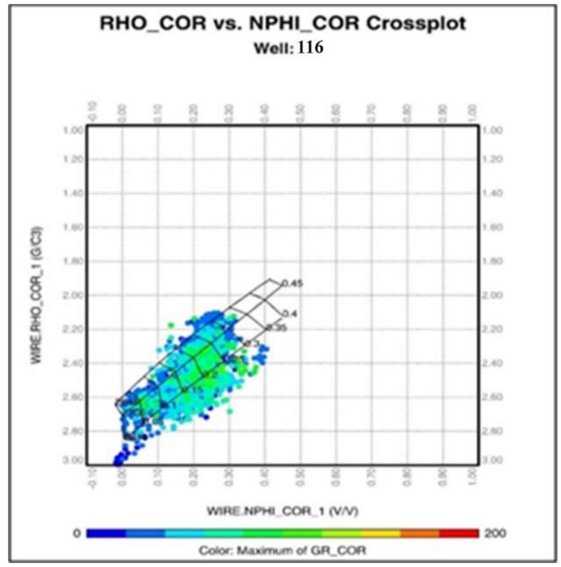

Figure 3. Cross plot of Neutron-Density-GR, Well No.116 in Bibi- Hakimeh oil field

4. Petrophysical parameters

Asmari reservoir in Bibi- Hakimeh oil field is divided into 8 zones (Table 1 and 2). Zones 1, 2 and 3 contain hydrocarbons, and the each zones are saturated with water. Zone 1 in this reservoir has a remarkable reservoir capacity over the rest of the zones. In Fig.4 and 5 shows a number of petrophysical parameters log of the reservoir for Bibi- Hakimeh in wells No. 39 and 116. The petrophysical assessment of these zones is as follows:

Zone 1:

This layer is composed mainly of limestone and calcareous dolomite and a layer of shale lime, and has a good to very good porosity. The net thickness in this zone ranges from less than 1 meter to 25 meters. The net thickness in the central regions of the anticline is more than that of the edges and the crest of the anticline. The net to total thickness ratio varies as well and it is higher in central parts anticline, especially around the wells 29, 39, 51, 116 and 18 which is higher than 0.6. This ratio is the highest (0.95) around well No.116. The average water saturation of net thicknesses is between 17.8% and 47.8% and it is not lower than 17% in any well. The level of the effective column of hydrocarbons in this zone reaches a maximum of 6.4 meters (Well No. 39).

Zone 2:

This layer is composed mainly of Limestone shale lime and calcareous, and is characterized by the development of good and very good, and sometimes moderate porosity, and it contains hydrocarbon. According to the estimates, this zone has better reservoir quality than other zones. The net thickness and net to total thickness ratio as well as the effective column of hydrocarbons in this zone were high, so that the net thickness and hydrocarbon column in some wells are more than 24m and 7.2m, respectively. Basically, zones 2, 3, 4 and 5 in Bibi-Hakimeh oil field are composed mainly of Limestone with high density of fracture, the reservoir quality of these horizons is very high.

Zone 3:

This layer is composed mainly of Limestone, Shaly Limestone and Dolomite Limestone, and has a periodic transition from very good to low porosity, and in the middle part it has thick veins of hydrocarbon. The major part of this carbonate zone plays an important role in increasing the quality of the reservoir. According to this studies, generally, in this field, the net to gross ratio is lower than that of zone 2, although sometimes it exceeds 0.73 (Well No.51), this layer has a good hydrocarbon column. This layer is productive and has a relatively good reservoir quality.

Zones 4 to 8:

Since the oil-water contact for the entire field is located at a depth of 1979 meters below the sea level, the lower part of zone 3 and zones 4, 5, 6, 7, and 8 of Asmari reservoir is located below the water-oil interface, and the net thickness, the effective column of hydrocarbon and the net to gross ratio in these zones are zero or very small.

Table.1 Average porosity foe each zone of Asmari formation, Bibi- Hakimeh oil field

Zone	1	2	3	4	5	6	7	8
Well No39	17	13	14	6.7	1.5	5.3	2	4.6
Well No 116	16	15	16	3.5	3	5.9	0	5

Table.2 Average water saturation for each zone of Asmari formation oil field

Formation	Zone	Well No39	Well No 116
Asmari	Z.1	17.7	22.2
	Z.2	21.8	23.4
	Z.3	23.6	22.1
	Z.4	41.6	38
	Z.5	42	47.8
	Z.6	42.5	31.7
	Z.7	43.9	46.7
	Z.8	38.7	47.4

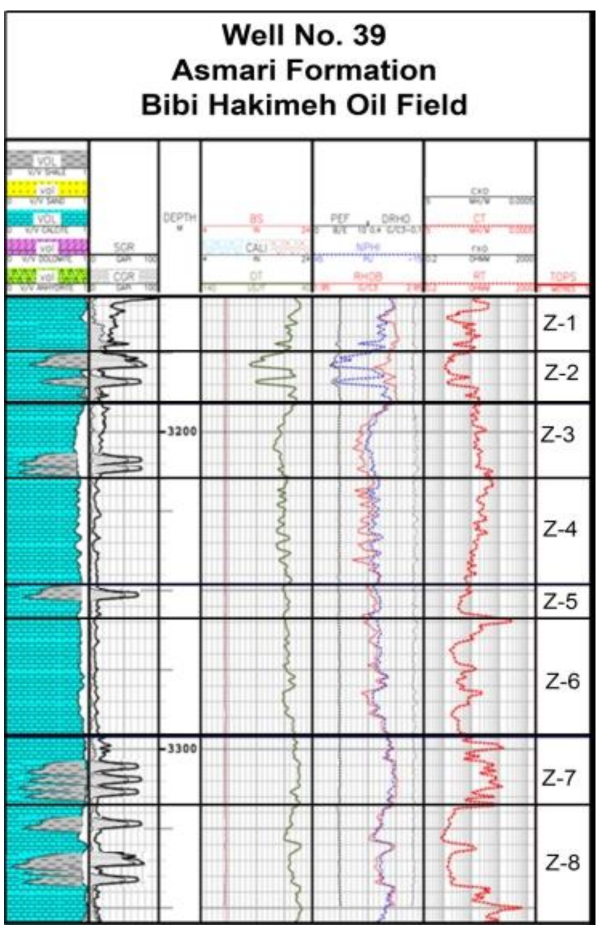

Figure 4. Petrophysical and lithological logs in well No.39, Bibi- Hakimeh oil field

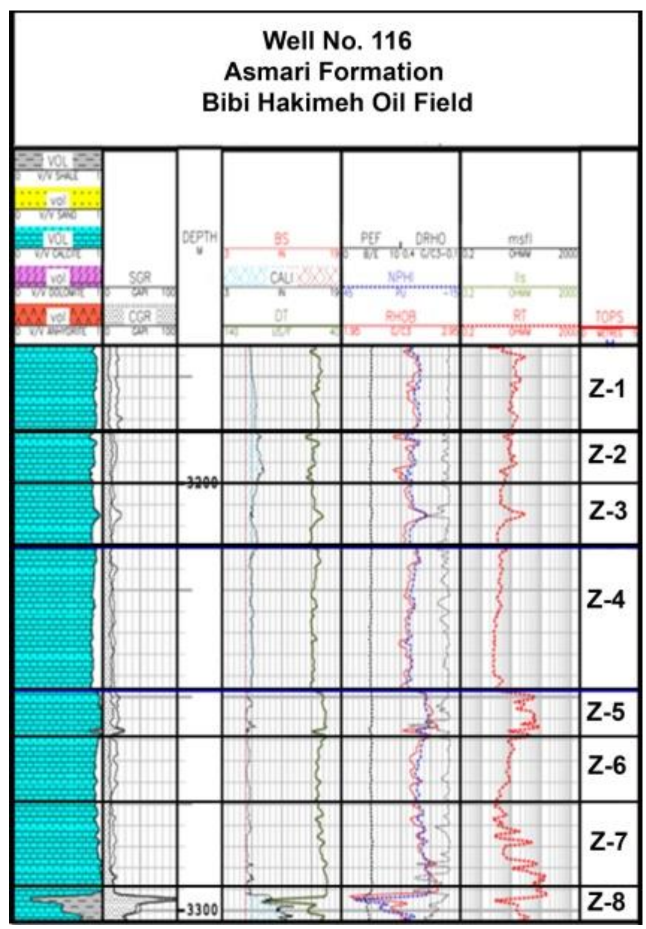

Figure 4. Petrophysical and lithological logs in well No.116, Bibi- Hakimeh oil field

5. Conclusions

The Asmari reservoir is divided into 8 zones (layers), each zone having its own petrophysical lithology and characteristics. Zone 1 is mainly carbonate (limestone and dolomite) with some Shale, zones 2, 3, 4 and 5, mostly limestone, zone 6 is a combination of limestone, dolomite and shale, and zones 7 and 8 are calcareous and shale.

Comparison of different reservoir zones in Wells No. 39 and 116 shows that with increasing depth, the amount of shale and limestone is increased relatively. The amount of dolomite is reduced by increasing depth and its highest amount is observed in zone 1.

The saturation percentage of oil in Wells No. 39 and 116 in zones 2 and 3 decreases, indicating that the concentration of oil is more in the limestone layer. In zone 1, which is a calcareous-dolomite zone, the changes of these two parameters are significant, the percentage of oil saturation is more than that of zone 2 and 3.

Based on the evaluations, zone 1 with more than 85% limestone has the highest value of effective hydrocarbon column, net thickness and the net to gross ratio, and due to its low water saturation (20% for the effective zones), it has the best reservoir quality among other zones. Following zone 1, zones 2 and 3 are ranked as the second and the third, respectively. Since the zones 4 to 8 are below the water-oil contact, they are not productive and have a low reservoir quality.

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