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Reservoir modeling of the Jeribe–Euphrates Formation in selected oil field, Missan Governorate, southeastern Iraq

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ABSTRACT

The reservoir model represents a validated mathematical simulation based on a set of geological data and petrophysical parameters for the studied section. The study provides a realistic three-dimensional subsurface image of the spatial distribution of the reservoir properties of that section. The target of this study is to determine the reservoir characteristics of the Jeribe/Euphrates Formation within one of the Missan oil fields in southeastern Iraq. When the main petrophysical parameters (water saturation, effective porosity, and shale volume), which were mathematically processed in the Excel program, were used in designing three-dimensional reservoir models using the Surfer-13 program. The formation was divided into two reservoir units (jr-1, jr-2), where the results of the reservoir analysis of the petrophysical properties of both units showed good values for hydrocarbon saturation and effective porosity with a low ratio of shale volume in most of the study sections. Effective porosity maintains its favorable ratios in most directions, but water saturation ratios are increasing at the expense of hydrocarbon saturation ratios in the northwestern part of the field, which negatively impacts reservoir efficiency in that direction. Otherwise, the reservoir characterization of both units is improving significantly in all other directions, especially towards the site of well-1 at the crest of the anticlinal structure.

Keywords: *Geological model, Jeribe-Euphrates formation, Missan governorate, Petrophysical properties*

1 INTRODUCTION

The geological reservoir model represents the spatial distribution of rock layers beneath the Earth's surface. [1] Creating the geological reservoir model is considered an essential step in reviewing and evaluating the reservoir characteristics of the formation in the oil field. It depends on using quantitative results extracted from mathematical equations [2]. The reservoir units are evaluated using well-log data, and quantitative calculations of petrophysical parameters are applied. Reservoir models are then built to determine the hydrocarbon content and quantity, as well as to evaluate the source rocks [3]. Building an integrated and more reliable reservoir model depends on providing accurate, extensive data and modern and advanced automated technologies [4]. In surface sections, the two formations can be distinguished based on the presence of the index fossil of the Euphrates, Borelis melo melo, and the index fossil of Jeribe, Borelis melo curdica [5]. In the study area, the boundaries and thickness of the Jeribe and Euphrates formations were not distinguished, as well as the similarity in distribution and lithology [6, 7]. Therefore, the two formations are described as one formation and are often called in geological reports the Jeribe Formation or as Jeribe/Euphrates Formation.

The present study aims to determine the most important petrophysical and reservoir characteristics of the Jeribe/Euphrates Formation in H. Oil Field (Figure 1), such as volume of shale, effective porosity, and water saturation. And presented in detail by building a three-dimensional petrophysical-structural model and interpreting its vertical and lateral changes within the studied wells.

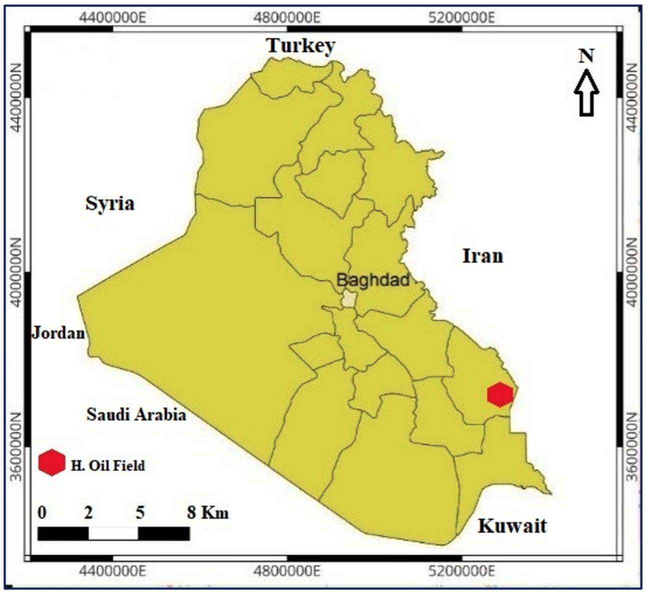

Fig. 1 Location map of the study area

1.1 Geological setting

The stages of tectonic development in Iraq depended on Iraq's location in the northeast of the Arabian plate. It was full of dynamic events that varied in intensity throughout the geological period. Most of these complex events occurred during the Mesozoic Era, when the sedimentary basin was exposed to faults and expansion. It was exposed during the Tertiary period to the processes of collision and compression [8]. The H. oil field is located north of the Arabian Gulf basin on the unstable shelf [9]. The location of the current study area in southern Iraq is 30 km southeast of Amara city [10]. The structure of the field is composed of dome runs along a NW-SE direction and a gentle, elongated anticline about 32 km long and 9 km wide, [11].

The first description of the Jeribe and Euphrates formations was provided by researchers with unpublished studies; however, the type section of the formations was identified and its rocks described by Bellen and others in 1959 [5]. The rocks of the formations consist of dolomitic carbonate rocks and limestone with interlayers of evaporates [6]. The Early-Mid Miocene (Burdigalian-early Langlhan) represents the geological depositional age of the formations [12]. The formations were deposited in lagoon and reef environments [13], restricted lagoon and shoal environments [14]. The available study wells are distributed throughout the fold structure at different locations, as shown in Figure 2 [15].

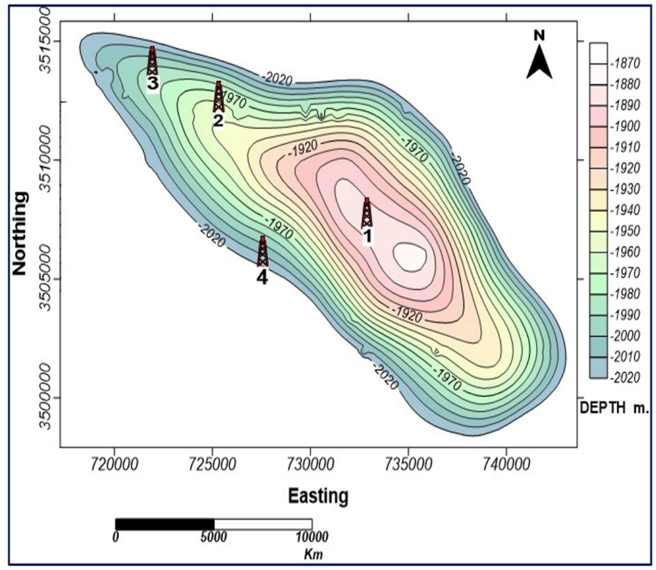

Fig. 2 Structural contour map of the top of the Jeribe/ Euphrates Formation.

The Jeribe/Euphrates Formation in the study area was divided into two lithologic units; the total thickness of the formation within the study wells does not exceed 11 m. The Jeribe/ Euphrates Formation is connected with the Fatha Formation from above and from below with Kirkuk group.

2 MATERIALS AND METHODS

Reservoir modeling provides complete and detailed visual information about the Earth's internal structures [16]. Surfer-13 software was used to build a three-dimensional petrophysical reservoir model for the formation. The coordinates of the study wells and petrophysical parameters were calculated mathematically using Microsoft Excel 2010, which was used as the input. Input petrophysical parameter data includes shale volume, effective porosity, and water saturation. All study steps were carried out using well log data obtained from geological reports. The available logs include: Spontaneous Potential, Gamma Ray, Density, Sonic, Neutron, and Resistivity logs. Using the Tech log - 2015 program, the most important logs used and the results of quantitative calculations of the

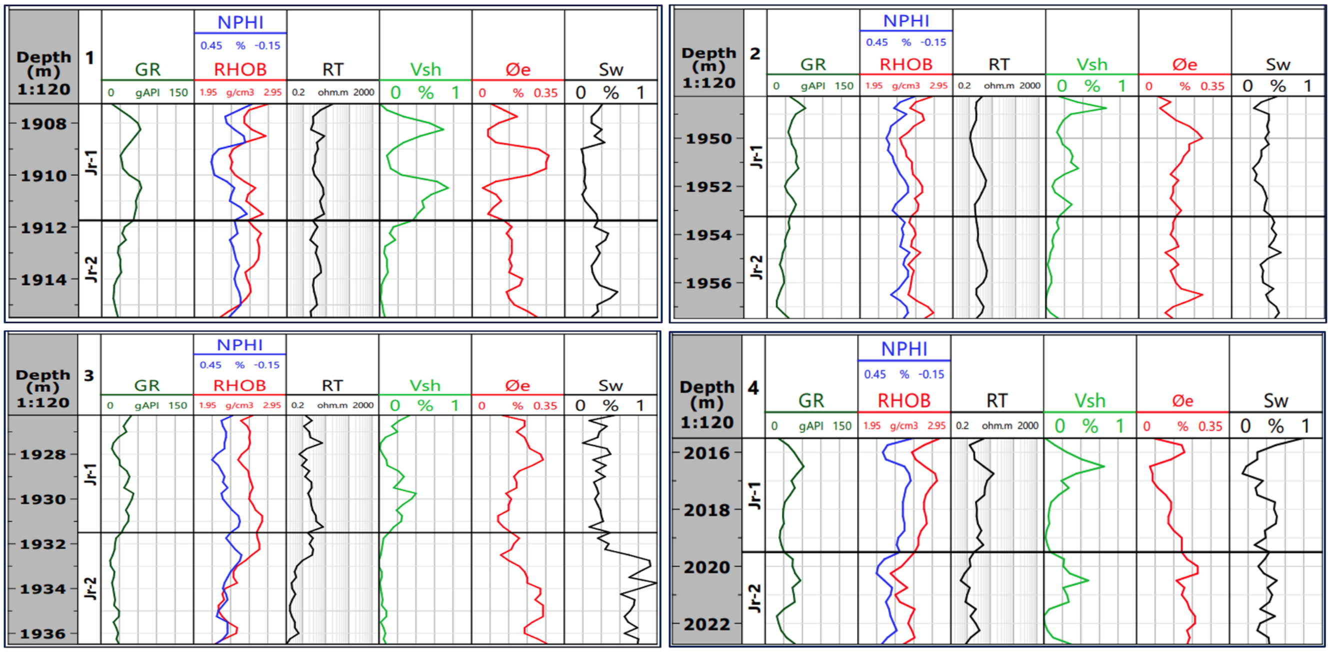

Fig. 3 Logs and petrophysical parameters for the units of the Jeribe/ Euphrates Formation in study wells No. 1, 2, 3 & 4

basic parameters of the two reservoir units in the study wells are represented in Figure 3.

2.1 Petrophysical reservoir model

Reservoir modeling involved the static distribution of reservoir parameters in 3D grid cells to obtain an accurate economic evaluation of oil field reservoirs [17]. Many tectonic factors and depositional conditions affect the petrophysical properties of the reservoir units in both horizontal and vertical directions [18]. Therefore, building a geological model for these reservoir characteristics contributes to understanding how fluids flow through the pores of the formation, determining the quantity and location of the hydrocarbons present in the reservoir, and making a better choice of site for drilling wells [19].

The modeling process gives a realistic and clear three-dimensional picture of the distribution of petrophysical properties within the layers of the formation. The results of the quantitative interpretation adopted in building reservoir models showed that the Jeribe/Euphrates Formation in H. oil field includes two reservoir units: the upper reservoir unit (Jr-1) and the lower reservoir unit (Jr-2). The thickness of the upper unit is slightly larger than the thickness of the lower unit, as its thickness ranges from (4-5.25 m) and (3-4.75 m), respectively (Table 1).

Table 1 Petrophysical results of the reservoir units

Units	Well No.	Thickness (m)	V_{sh} %	Φ_e %	S_W %
Jr-1	1	4.5	0.35	0.14	0.28
	2	5	0.22	0.15	0.35
	3	5.25	0.18	0.17	0.38
	4	4	0.17	0.12	0.39
Jr-2	1	3.5	0.07	0.16	0.38
	2	4	0.06	0.14	0.42
	3	4.75	0.04	0.21	0.72
	4	3	0.19	0.20	0.40

The following is a description of the reservoir models:

Volume of Shale (V_{sh})

The model was created using mathematically calculated shale volume values from the gamma ray log. Equation was used to calculate the shale volume:

$$\mathrm{V_{sh}} = 0.083\left[2^{(3.7{\star}IGR)} - 1\right]$$

I_{GR} is the Gamma ray index, which is calculated through the equation:

$$\mathbf{I_{GR} = GR_{log} - GR_{min}./GR_{max.} - GR_{min}.}$$

$GR_{log}$is the gamma ray log reading of the formation, GR_{min} is the minimum reading gamma ray log, and GR_max is the maximum reading gamma ray log; measured in units (API).

Porosity (Φ) The values of effective porosity (Φ_e) for neutron and density logs were adopted in constructing the three-dimensional porosity model. The mathematically calculated effective porosity values were entered using the following equations:

$$\Phi_e = \Phi^* \left(1 - V_{sh}\right)$$
$$\Phi_t = \Phi_D + \Phi_N/2$$

Φ_t is total porosity, Φ_D is porosity derived from a density log, and Φ_N is porosity derived from a neutron log.

Water Saturation (S_w)

Water saturation was calculated mathematically based on the deep resistivity log, and the results were used to build a water saturation model. The equation below was used:

$$S_w = \sqrt{\boldsymbol{R_w * F/Rt}}$$

R_w is Formation Water Resistivity, F is Formation factor, and Rt is Deep resistivity log reading (ohm.m).

$$\mathbf{F} = \frac{a}{\Phi^m}$$

a is the tortuosity factor = 1 for Carbonate rocks, and m is the cementation factor = 2 for Carbonate rocks.

3 RESULTS AND DISCUSSION

The 3D models built for the study wells showed the following results:

1-Shale is present in low quantities in all units of the study wells. The three-dimensional model showed an increase in shale volume in the upper part of the formation (unit Jr-1), especially towards well-1 (Fig. 4). The average of shale volume in the first unit ranged from 17 to 35%. While the shale content decreased in the lower part of the formation (unit Jr-2), specifically towards wells 2 and 3. The average volume of shale varies from 4 to 19 % (Figure 5).

2- The effective porosity values were good in most studied wells and ranged in unit Jr-1 between 12 – 17 % and increased towards well-3 (Figure 6). Their rates rose more in unit Jr-2, especially in wells 3 and 4, as shown in Figure 7.

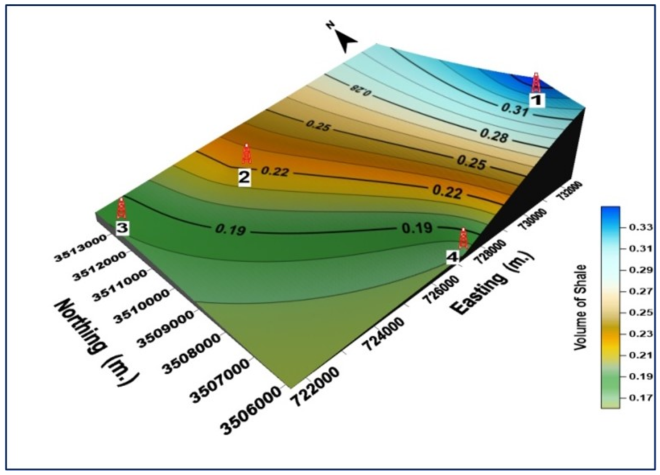

Fig. 4 The volume of the shale 3D model for unit (Jr-1)

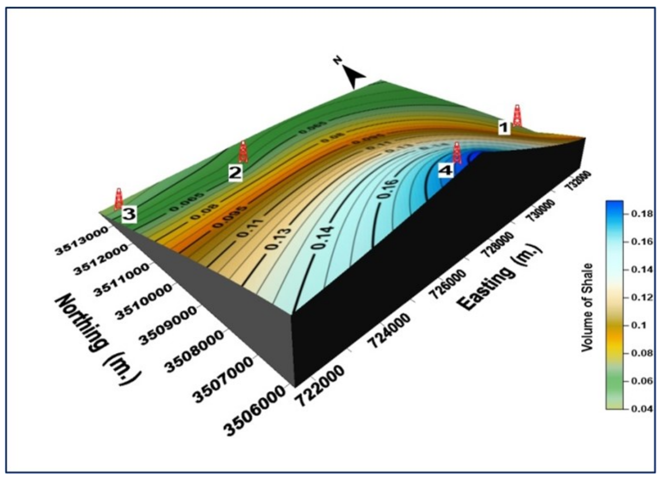

Fig. 5 The volume of the shale 3D model for unit (Jr-2)

3- The water saturation in the upper part was lower than in the lower part, which indicates that the amount of hydrocarbon saturation in the upper part is greater. In both units, Jr-1 and Jr-2, the values of water saturation increased towards well-3. Its ratio ranged from 28 to 39% in unit Jr-1 (Figure 8) and from 38 to 72% in unit Jr-2 (Figure 9).

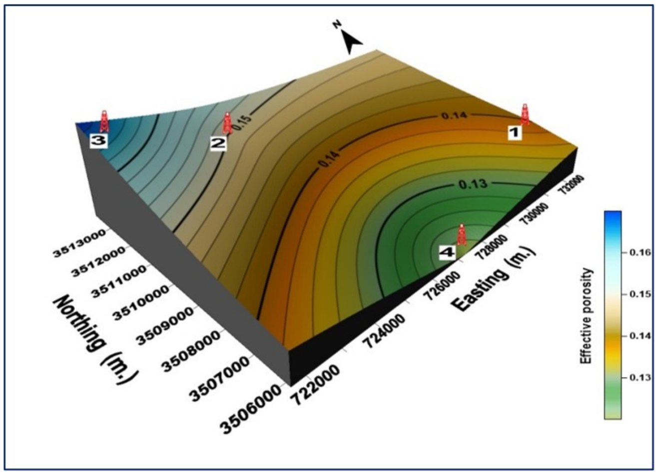

Fig. 6 The effective porosity 3D model for unit (Jr-1)

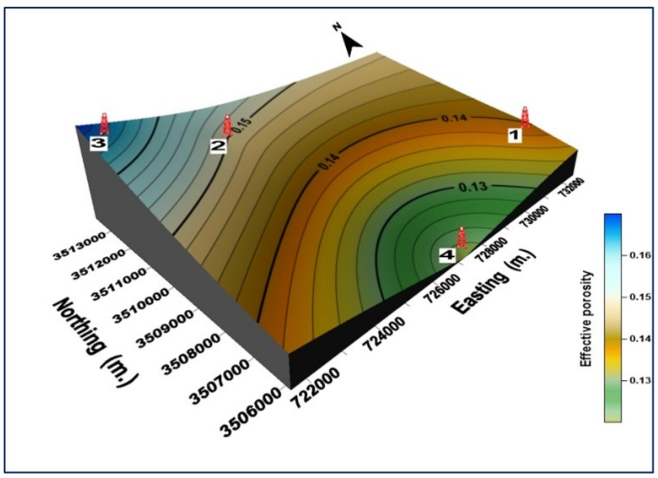

Fig. 7 The effective porosity 3D model for unit (Jr-2).

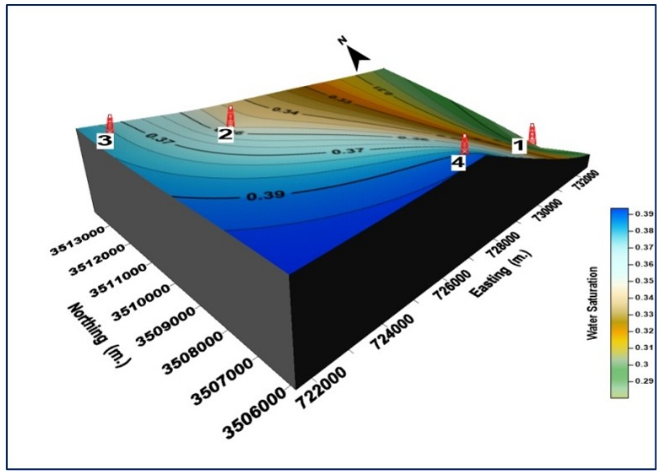

Fig. 8 The water saturation 3D model for unit (Jr-1).

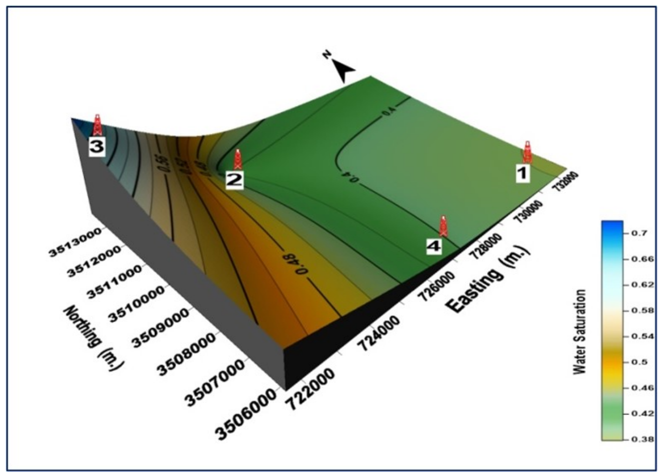

Fig. 9 The water saturation 3D model for unit (Jr-2).

4 CONCLUSION

The reservoir model for the potential units of the Jeribe/Euphrates Formation within one of the Missan oil fields in southeastern Iraq was created based on the main petrophysical parameters, where it was possible to divide the formation into two reservoir units (Jr-1 and Jr-2). The two units were characterized by different reservoir properties that varied horizontally and vertically across the selected sections as follows:

- The shale volume model indicates an increase in shale content at unit (Jr-1) compared to unit (Jr-2), where unit (Jr-1) recorded an average of 17-35%, noting that the highest percentage was towards the crest of anticlinal structure at the site of well-1, while unit (Jr-2) recorded a low average of 4-19%, most parts of the unit were almost clean except for well-4, which recorded a low shale content.
- The effective porosity model indicates that the formation units have good proportions in all parts of the field, at a rate of 12-17%, which increases towards the northwest of the field, specifically at unit (Jr-1), particularly at the sites of wells 2 and 3. Unit (Jr-2) also maintains good effective porosity in most of the study wells, with the exception of well-2, in which the porosity values decrease slightly.
- The water saturation model indicates low to moderate ratios at unit (Jr-1), ranging between 28% and 39%, which increase significantly at unit (Jr-2) to reach 38-72%, specifically at well sites 2 and 3.
- Generally, the Jeribe / Euphrates Formation's reservoir model indicates that most of the study wells are characterized by good reservoir properties in terms of porosity

and hydrocarbon saturation.

- In more detail, the reservoir properties improve towards the upper part of the formation at unit (Jr-1) compared to unit (Jr-2) in terms of effective porosity and hydrocarbon saturation. It is also noted that the reservoir properties improve towards the crest of the structure, specifically at the site of well-1, which recorded the best reservoir indicators.

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DATA AVAILABILITY

N/A

DECLARATIONS

Conflict of interest

There is no conflict of interest.

Consent to publish

NA

Ethical approval

N/A

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