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FULL LENGTH ARTICLE

Using of Pickett's plot in determining the reservoir characteristics in Abu Roash Formation, El-Razzak Oil Field, North Western Desert, Egypt

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Abstract The present work was devoted to evaluate the reservoir characteristics of the Abu Roash Formation in the vicinity of El-Razzak Oil Field, North Western Desert, Egypt. The area of study is bounded by latitudes 30° 25′ and 30° 55′ N and longitudes 27° 50′ and 28° 40′ E. Nine distributed wells were utilized for this study.

A new technique has been applied through Pickett's plot, to develop some of reservoir petrophysical parameters. These parameters include capillary pressure, pore throat aperture radii, height above the free water table and bulk volume of water. This technique depends on the use of log–log plots of effective porosity versus resistivity combined with empirical relationships for calculating the capillary pressure expressed as a function of permeability, porosity and water saturation. Also, this technique gave the values of petrophysical exponents (m, n and a) which were used to calculate the accurate value of water saturation in both clean and shaly rocks and then adjust estimation of hydrocarbon saturation. The integration of these petrophysical parameters on a log–log graph of porosity versus resistivity gives the importance for Pickett plot to be used in reservoir interpretation.

1. Introduction

The use of Pickett plots (Resistivity–Porosity Relationship) as an aid in characterizing petrophysical flow units in carbonate reservoirs has been documented by [1] and [2]. This technique was utilized for calculating some of reservoir petrophysical parameters of Abu Roash Formation (G member) for nine wells namely: (IG30-1, IJ30-1, IG33-1, IH35-2, IG34-1, IF32-1, IF34-2, IE34-6 and IE36-1) scattered in the oil field as

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shown in Figs. 1 and 2. Sanyal and Ellithorpe [3] and Greengold [4] have shown that, Pickett's plot should result in a straight line with a slope equal to m.

This plot shows a useful model for putting together the petrophysical parameters including water saturation, permeability, capillary pressure, pore throat aperture radii and height above free water table [5]. This technique highers Pickett's plot as one of the most important plots for reservoir evaluation, where the use of this plot enables the log analyst to see within one single plot several keys of geological and reservoir engineering parameters.

2. The theory of Pickett's plot

The theory of this plot started with Archie's formulae [6]. By rearranging the Archie equation we get:

$$S_W = I^{-1/n} \quad (1)$$

$$I = R_t/R_0 = R_t/(FR_w) \quad (2)$$

$$F = a\Phi_t^{-m} \quad (3)$$

Eqs. (1) and (3) can be combined to yield.

$$R_t = a\Phi_t^{-m} R_w I = a\Phi_t^{-m} R_w S_w \quad (4)$$

By using the logarithm with base 10, the Eq. (4) [7] leads

$$\log\ R_t = -m \log\ \Phi_t + \log(aR_W) + \log\ I \quad (5)$$

This is the equation of a straight line on log–log paper. The line has a slope of (−m) which is determined manually by measuring a distance on the R_t axis (in cm) and dividing it by the corresponding distance on the porosity axis. The intercept when PHI = 1 is the value of aR_W as shown in Fig. 3, and by knowing the value of R_w, the value of tortuosity factor (a) can be determined.

According to [8], the saturation exponent "n" which is a function of water saturation equals the value of porosity exponent "m". The results of the petrophysical exponents obtained from Pickett's plot for the G member of Abu Roash Formation are tabulated in Table 1.

Many lines are drawn at different values of porosity (90%, 60%, and 20%) equivalent to the first drawn line.

Aguilera [5] used the following steps to show how to construct Pickett's plot incorporating capillary pressure, pore throat aperture radii and height above the free water table, where the technique is applied on the nine wells for the G Member of Abu Roash Formation in the El-Razzak Oil Field. IE36-1 well is taken as an example in this paper.

2.1. Permeability

Reservoir rock must have the ability to allow petroleum fluids to flow through its interconnected pores. The rocks ability to conduct fluids is termed as permeability which depends on its effective porosity.

Many empirical equations are derived to estimate the relative permeability. The following equation estimates the permeability [9] in terms of irreducible water saturation, as follows:

$$K^{1/2} = 250\Phi_t^3/S_{wi} \quad (6)$$

The water saturation in Eq. (6) is irreducible, that corresponds to the beginning of a Krw, which equals zero.

The irreducible water saturation, in turn, can be solved by using the following equation:

$$S_{wi} = \Phi_t \times S_w/\Phi_{eff} \quad (7)$$

After incorporating into Eq. (4), the following formula is obtained [10]

$$R_t = a\Phi_t^{-m} R_w (250\Phi_t^3/K^{1/2})^{-n} \quad (8)$$

$$\text{or} \quad R_t = a\Phi_t^{-3n-m} R_w (250/K^{1/2})^{-n} \quad (9)$$

By having the logarithm of both sides, the proceeding equation becomes [11]:

$$\log\ R_t = (-3n - m) \log\ \Phi_t + \log[aR_w(250/K^{1/2})^{-n}] \quad (10)$$

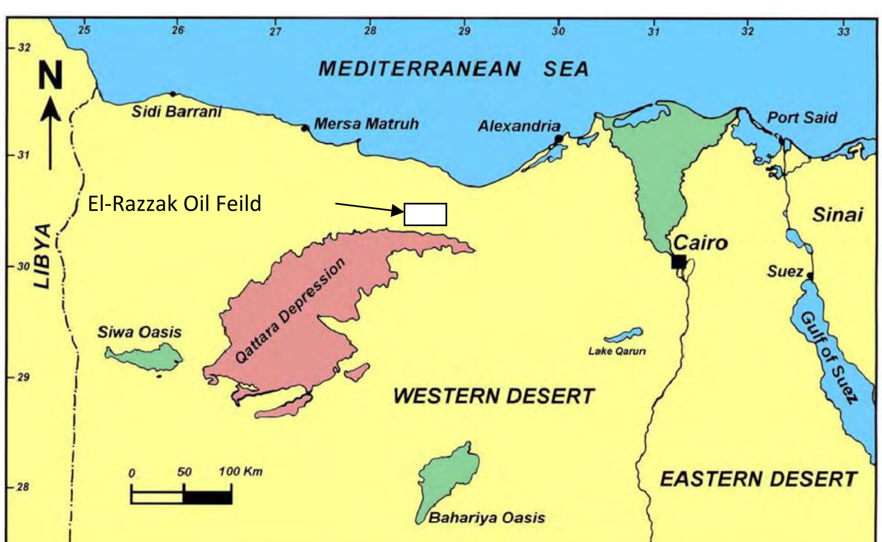

Figure 1 Generalized sketch map of Egypt showing the location of the studied area.