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COMPUTING OF PETROPHYSICAL PROPERTIES FOR DOLOMITE AND QUARTZITE RESERVOIR FORMATIONS

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Abstract. Petrophysical properties remain very important to the oil and gas industry; from quantification of hydrocarbon reserves and developmental strategies to time decision making for reservoir navigation. Among the main objects of petrophysical properties is determining whether the rock formation is a potential oil or/and gas reservoir or not. Environmentally, shale and lithology corrections conducted to raw data of neutron porosity log, bulk density log, and gamma ray borehole correction, in order to calculate the total corrected porosity, and estimating oil initial in place.

This study aims to determine porosity, net pay thickness, shale content, and fluid saturation of two different formations in the same reservoir. On the basis of petropysical data, sediments of dolomite and quartzite formations were found to have effective porosities of 11.8% and 7.8%, respectively. Hydrocarbon saturation between 21.9 to 48% for dolomite formation, and 22 to 63% for quartzite formation

Keywords: petrophysical properties, reservoir, log, oil initial in place, formation.

INTRODUCTION

Reservoir is producing from both dolomite and quartzite formations, which they refer to cretaceous age and cambro-ordovician age (quartzite sandstone the basal cretaceous sand). The dolomite is the main producing reservoir formation, quartzite overlies it, however, the carbonate is absent on the top structure of the field due to non-deposition or erosion.

The geology of the reservoir is complex as the area was tectonically active during the time of deposition, and rendering formation identification is difficult. Major faults run NNE-SSW along the side of the reservoir, and local faults also exist inside. Generally, the reservoir rocks are composed from very loose, unconsolidated sand to hard dense sandstone, limestone, and dolomite. Grains are bounded together with other material as silica, calcite, and clay.

BACKGROUND

Rocks are made up of mixtures of minerals, consequently their physical properties influence the measured log response [1]. Well log analysis and interpretation are the most important task to detect the reservoir petrophysical parameters such as porosity[2], water saturation and locating hydrocarbons zones [3].

Well logs have been proved to be used successfully in exploration and development wells as part of drilling practice [4] and to provide more information and greater accuracy of reserve evaluation [5]. Well logs can also be utilized to identify the depth and thickness of productive zones, to distinguish between oil, gas and water in reservoir, and to estimate hydrocarbon reserves [6].

Deterministic inversion has been previously used to refine petrophysical interpretations across thin beds[7]. Fast inversion methods, in particular, have enabled practical field applications over long depth sections of logs. Wang et al. (2009), Zhang et al. (1995), and Zhang et al. (1999) proposed simulation and inversion methods for quick interpretation of array-induction resistivity measurements. Mendoza et al.developed a fast method to simulate density, neutron and GR logs based on calculated linear weighting functions. Sanchez-Ramirez (2009) describes examples of combined inversion for the applications [8].

METHODOLOGY

Prediction of rock and fluid properties such as porosity, shale content, and water saturation are essential for exploration and development of hydrocarbon reservoirs.

Three basic methods are used to predict reservoir rock petrophysical properties. These methods are well logging, well testing, and core analysis. One of these basic approaches is well logging. Gamma Ray logging "GR" is a recording of the natural radio activity of formation, thorium and potassium present in the rock and it can be obtained by pulling a sound or attaching a cable upwards from the bottom of the well bore.

Electrical, nuclear or acoustic energies are sent into the formation and the response of the rock to those induced energies is recorded as the sound raised from the bottom of the borehole at a specific speed. Radioactive elements tend to be concentrated in impermeable clays and shale and are much less concentrated in permeable sandstone and carbonate rocks**.** In large boreholes gamma ray coming from the formation is attenuated by the drilling fluid in the boreholes. The degree of attenuation depends also on the mud weight.

The higher the mud weight the higher the degree of attenuation and the lower the gamma ray detected by the tool detector. If the thickness of the bed is small, the gamma-ray tool will not attain the correct value as a result of the surrounding layers. In cased borehole gamma ray is attenuated to different degrees depending on the type of fluid in the borehole, type of casing, tubing and the type of cement behind the casing.

Spontaneous Potential log is a log of potential difference between a movable electrode in the borehole and fixed surface electrode. The purpose of SP log is to show permeable from non permeable zone. The deflection due to the sand may be either to the lift (-ve) (negative) or to the right (+ve) (positive) depending on the relative salinities of the formation water and mud filtrate.

The spontaneous potential in front of shale is usually very small because the flow of current into impermeable shale is small. Sonic log is a porosity log that measures interval transit time (Δt) of a compression sound wave traveling through formation. The sonic log device consists of one or more sound transmitters, and two or more receivers.

Neutron log is the neutrons of high energy are emitted from a chemical source. They interact with the nuclei of the formation in different stages. In this process, the concentration of hydrogen (hydrogen index) in the formation is measured.

In porous clean sandstone or carbonate formations, neutron log reflects the amount of rock porosity. The formation density log is a porosity log that measures electron density of formation. Electrical resistivity methods involve the measurement of the apparent resistivity of soils and rock as a function of depth position.

The purpose of this work is to better understand the basic log types analysis for dolomite and quartzite reservoir, which have different properties and contain the same type of hydrocarbon.

DISCUSSION AND ANALYSIS

Porosity, resistivity, neutron, sonic and induction logs have been used to record and calculate the porosity, water saturation, net pay thickness, hydrocarbon pore volume, original oil place, recoverable oil, and shale content for some Libyan wells of different formations, however, contain the same hydrocarbon.

In this work shale content volume was calculated by gamma ray logs. Formation recording procedure differs due to the depositional age "geological age"[7], whereas equation (1) used for quartzite formation, and equation (2) for dolomite formation, however, overall average shale content was obtained from equation (3).

$$V_{sh} = 0.33 \times \{2^{(2 \times I_{GR})} - 1\} \quad (1)$$

$$V_{sh} = 0.083 \times \{ 2^{(3.71 \times I_{GR})} - 1\} \quad (2)$$

$$V_{sH} = \frac{\sum h_i \; V_h}{\sum h_i} \quad (3)$$

The volume of shale content for dolomite formation ranges between 3.23% to 4.43%, and for quartzite formation between 7.77% to 10.59% .

The neutron porosity has been directly read from the neutron logs and corrected for shaleness by following equation:

$$(\phi_{neutron})_{corrected} = [\phi_{neutron} - \{V_{sh} \times (\phi_{neutron})_{sh}\}] \quad (4)$$

The average porosity of dolomite formation of all wells ranges between 6.9 to 11.8%, while for quartizite formation ranges between 6.5 to 7.9%.

The cementation exponent (m) and saturation exponent (n) are very important to calculate water saturation. These factors play important role for the relation that bind between reservoir parameters"[8], and were obtained using the relation between the porosity and total resistivity as shown in table (1), and figures (2) and (3).

Table 1. Cementation and saturation exponents

Well	Cementation Exponent (m)	Saturation Exponent (n)
X1	1.9	1.96
X2	1.76	2.5
X3	1.7	2.07
X4	1.94	2.5

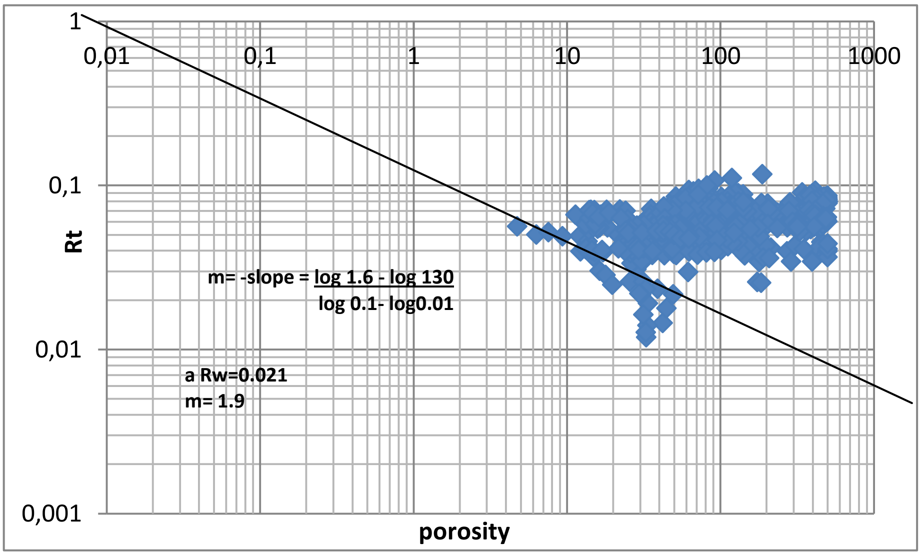

Figure 2. Cementation exponent

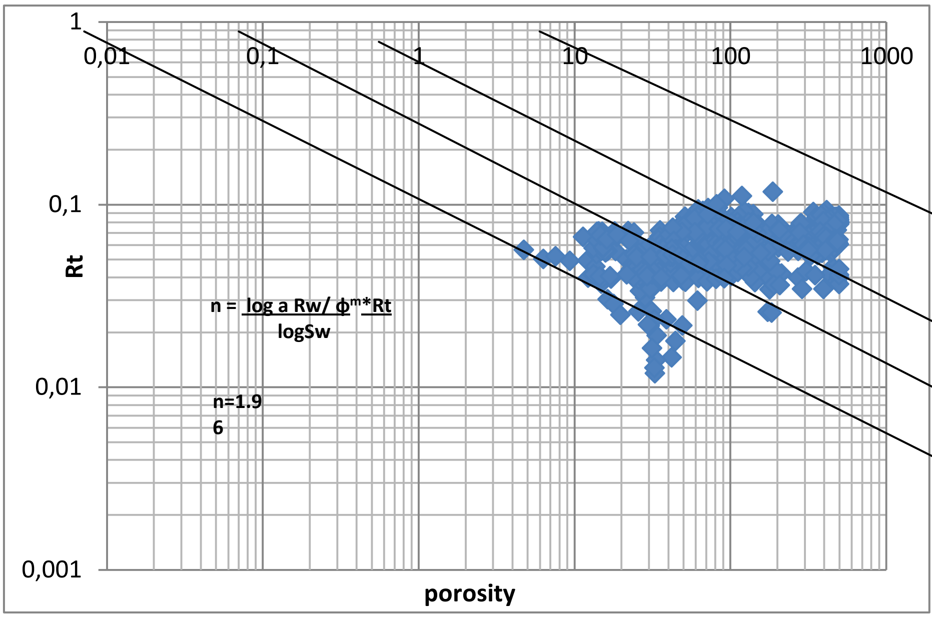

Figure 3. Saturation exponent

The formation water resistivity value is equal to 0.021Ω.m at temperature of 202 F° and salinity is 145,000 ppm.

Water saturation for dolomite formation is ranging from 21.9% to 48%, while for quartzite formation ranging from 22% to 63%. The average net pay thickness for the dolomite formation is ranging from 13.5 ft to 46.5 ft, while for the quartzite formation is ranging from 6.5 ft to 139.5 ft.

Original oil in place can be estimated using volumetric method "Static Method" equation (5).

$$OOIP = \frac{7758\, A\, h_{ave}\phi_{ave}\,(1-S_{w_{ave}})}{B_{o_i}} \quad (5)$$

Total original oil in place, recovery factor, oil recoverable, and other reservoir parameters are listed in table (3).

Table 2. Reservoir parameters

Parameters	dolomite formation	quartzite formation
Oil initial in place (MMST)	167	571
Recovery factor (%)	31.3	77.3
Oil recoverable (MMSTB)	52.3	441.4
Formation volume facor (rbbl/STB)	1.09	1.09
Average porosity (%)	9.4	7.5
Average net pay thickness (ft)	24.1	49.6
Average water saturation (%)	33.8	33.6
Average permeability (md)	500	500

SUMMARY AND CONCLUSION

- The importance of integrating petrophysical and engineering data is apparent, as log analysis, core analysis, and dynamic test results indicate.
- Petrophysical properties depend on lithology, depth, and formation age. Effective porosity for dolomite formation was found to range between 6.9 and 11.8%, and for quartzite formation from 6.5 to 7.8%.
- Water saturation ranged between 21.9 to 48% for dolomite formation, and 22 to 63% for quartzite formation. Average net pay thickness ranged from 13.5 to 46.5 ft, and from 6.5 to 152.5 ft for both formations respectively.
- Original oil in place, recovery factor, and estimated recoverable oil were 167MMSTD, 31.3%, and 52.3 MMSTD respectively for dolomite formation, while for quartzite formation were 571MMSTD, 77.3% and 441.4 MMSTD respectivly.

RECOMMENDATIONS

- It is recommended to include special core analysis in order to obtain further accurate values.
- Measuring petrophysical properties by both core analysis and logs to obtain precise results.

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ПОДСЧЕТ НЕФТЕФИЗИЧЕСКИХ СВОЙСТВ В ДОЛОМИТОВЫХ И КВАРЦИТОВЫХ ПЛАСТАХ

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Аннотация. Нефтехимические свойства имеют огромное значение для нефтегазовой промышленности, от определения количества углеводородных запасов и стадий разработки до момента принятия решения по навигации месторождения.

Одним из важнейших объектов нефтефизических свойств, считается определение того, является ли горная порода потенциальным месторождением нефти и/ или газа, или нет. С точки зрения окружающей среды, был проведен учет сланца и литологии при определении пористости по данным нейтронного каротажа, плотностной гамма-гамма каротаж и гамма-лучевая поправка на влияние скважины для того, чтобы подсчитать общую скорректированную пористость и оценить исходную нефть на участке.

Целью данного исследования является определение пористости, толщины продуктивной части пласта, содержания сланца и флюидонасыщения двух различных пластов в одном месторождении. На основе нефтефизических данных было обнаружено, что осадок доломитовых и кварцитовых пород имеет эффективную пористость 11,8% и 7,8% соответственно.

Насыщение углеводородом составляет от 21,9% до 48% для доломитовой породы и от 22% до 63% для кварцитовой породы.

Ключевые слова: нефтефизические свойства, месторождение, каротаж, исходная нефть на участке, пласт

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