

Original Article: The Effect of Hydraulic Flow on the Experimental Relationships Caused by Porosity and Permeability in Oil Reservoirs in Southern Iran

Seyed Behrouz Keshavarz

Master of Petroleum Engineering, Iran

Use your device to scan and read the article online



Citation S.B Keshavarz, The Effect of Hydraulic Flow on the Experimental Relationships Caused by Porosity and Permeability in Oil Reservoirs in Southern Iran, *EJCMPR*. 2024; 3(3):782-787



<https://doi.org/EJCMPR/20241016>

Article info:

Received: 10 March 2024

Accepted: 18 Jun 2024

Available Online:

ID: EJCMPR-2406-1191

Checked for Plagiarism: Yes

Peer Reviewers Approved by:

Dr. Frank Rebout

Editor who Approved Publication:

Dr. Frank Rebout

Keywords:

Hydraulic flow units, resistivity coefficient, porosity and permeability

ABSTRACT

Today, one of the most important problems in the field of oil and gas studies is the real prediction of the amount of hydrocarbon in situ in the reservoirs. Accurate calculation of hydrocarbon in the reservoir requires the determination of water saturation and resistivity of the formation. As a result, providing a way to bring the values of the basic parameters of water saturation closer to reality is of particular importance. Since there is no simple relationship between porosity, permeability and electrical resistivity in the rocks of heterogeneous carbonate reservoirs, therefore, in order to improve the relationship between petro physical parameters of the reservoir, the carbonate reservoir plug samples were classified and evaluated using hydraulic flow units. In this study, by measuring the electrical resistivity of plug plugs from each unit of hydraulic flow, improving the relationship between the resistivity of the formation with porosity and permeability has been shown. Using this classification, the values of the coefficients determined for calculating water saturation are closer to reality.

Introduction

The calculation of water saturation is carried out using well water metering logs using water saturation formulas. One of the most important formulas for calculating water saturation is the Archi formula (1942), which can be deduced from this relation (1).

$$S_w = \left(\frac{a}{\phi^m} * \frac{R_w}{R_t} \right)^{\frac{1}{n}}$$

The Archie equation is based on porous rock conductivity, which consists of a solid matrix as an insulator and a porous filler fluid phase (saltwater) as conductive. In general, the strength of a stone depends on the specific resistance of water found in the porous rock, lithology, and rock texture. Methods of evaluation and evaluation of ARP parameters

*Corresponding Author: Seyed Behrouz Keshavarz (b.keshavarz1372@gmail.com)

are based on laboratory measurements and studies on sandstone and carbonate reservoirs. In this context, researchers have been struggling to find out the relationship between specific resistance and fringe.

Since the relationship between structural and porosity resistance to two parameters of cementation coefficient (m) and scintillation coefficient (a), the specific resistance of porosity has always been a serious challenge and has led to a researcher in terms of properties Physical rocks and according to the results, report different values for these parameters.

Reservoir zoning by hydraulic flow units

In fact, hydraulic flow units are a method for classifying rock types and predicting flow properties based on geological parameters and flow physics in pore and pore sizes.

Cohen (1927) and Carmen (1937) modeled the porous medium as a collection of capillarity in order to find the proper connection between porosity and permeability. They introduced a new relationship between porosity and permeability by combining Darcy's law to move the fluid in the porous medium and the Poiseuille law for fluid flow in the pipes.

In this regard, a factor called the relationship factor is added because in a real model, the hairpin pipes are not straight and have different curvatures. This relationship is presented as follows

$$k = \left[\frac{\phi_e^3}{(1-\phi_e)^2} \right] \frac{1}{F_s \tau^2 S_{gv}^2}$$

In this regard, τ is the twist action and K is permeable to the square meter micrometer and ϕ_e is expressed as a fraction. F_s is a shape factor, and its value for muineal tubes with a circle cross section is equal to 2. $F_s \tau^2$ Couch is fixed. In fact, the term $F_s \tau^2 S_{gv}^2$ is a function of the geological characteristics of the porous medium

and changes in the geometry of the cavities. For this reason, it can be used as a criterion for differentiating hydraulic flow units.

Amyfol et al. (1993) examined the relationship between (1) on Φ_e Couchen's fixed changes and presented the following relationship.

$$0.0314 \sqrt{\frac{k}{\phi_e}} = \left(\frac{\phi_e}{1-\phi_e} \right) \frac{1}{\sqrt{F_s \tau S_{gv}}}$$

The above equation can be used to define the reservoir quality index, the region of flow and the normalized porosity as follows.

$$RQI = 0.0314 \sqrt{\frac{k}{\phi_e}}$$

$$FZI = \frac{1}{\sqrt{F_s \tau S_{gv}}}$$

$$\phi_z = \left(\frac{\phi_e}{1-\phi_e} \right)$$

In this relationship, K is in milliseconds, and the constant number of 0.0314 is given to convert K from μm to square millimeter.

With respect to relations 4 to 6, the relation 7 can be written as follows:

$$RQI = \phi_z \times FZI$$

In order to determine the number of hydraulic flow units, reservoir samples were first prepared. Then, their porosity and permeability were determined by measuring devices and using the relations (7), (4) and (6) of the flow region index (FZI) for each sample were calculated.

After determining the FZI of each sample using Matlab software, on the logarithmic data of the flow region index, the histogram analysis was performed and, based on the normal distributions, 5 hydrodynamic flow units were determined. Then, using the K-means cluster analysis, a set of data similar to each other was grouped into a group. Under ideal conditions, the RQI logarithmic diagram is based on Φ_z a

linear graph with a constant gradient of 45, each of which represents a hydraulic flow unit. The intersection of each line with $\Phi_z=1$ is the average FZI for the same hydraulic flow unit (Figure. 1).

Resistance Factor F

In 1942 Archi presented the relation of water saturation to a clean formation as follows:

$$S_w^n = F \frac{R_w}{R_t}$$

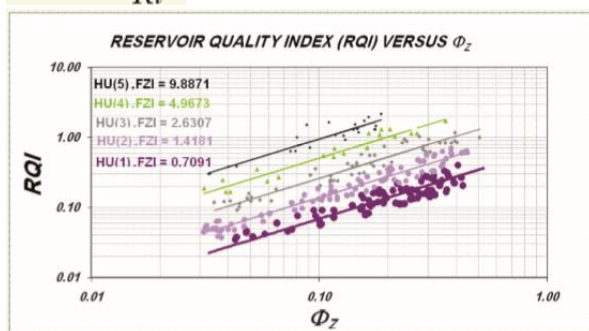


Figure 1. Residual Quality Index is normalized in porosity

In his recent relationship (F), he described the resistivity factor and defined it as follows

$$F = \frac{R_w}{R_o}$$

Also, Archi found out in a porous specimen in terms of the resistivity and porosity coefficient of the resistivity factor and expressed it in the form of relation (10). In this regard, he has considered the value of a (the form of a deduction) unit, while the researchers reported after him the value of an as non-unitary.

$$F = \frac{1}{\phi^m}$$

In this regard, S_w the saturation of water as a part, R_w the water resistance of the meter in terms of ohm, R_t the total resistance of the formation in terms of ohm meter, n saturation or saturation power, and m the coefficient of cementation and ϕ porosity as a part is.

In order to calculate the F factor, the specific strength of the carbonate saturated water sample was determined by the measuring apparatus. After the temperature correction and the determination of the slag charts, the factorization from equation 8 was calculated for each sample.

This factor depends on factors such as the physical properties of the classes, especially the layers that separate the classes, the nature and nature of the fractures, the initial saturation of the water and its degree of salinity, the amount of clays, the temperature and the factor, the minerals Conductor in stone, path twist, porosity type and shape.

Relationship (8) shows that the most dependence of the resistivity factor is on porosity, path twist and cementation coefficient. The cation coefficient in the Archi equation has a great influence on the electrical current and the resistance of the formation in the porous medium. This parameter depends on the shape, type and size of the grains, the shape and size of the vents, the number and size of the vents. Fuck and Mann (1987) describe the range of m changes in carbonate reservoirs between 1.5 for a porosity system between particles or between crystals and up to 5.4 for porosities that have weak links with each other.

Spacecraft is defined as the actual or effective ratio of the length of the flow path to the length of the porous rock, which is parallel to the general direction of flow. The bending or twisting factor is called rock texture factor.

Vensor (1952) generalized the Archi formula to factor a and proposed it in general $F = \frac{a}{\phi^2}$. The variation ranges a is theoretically for grains between 0.25 and 10.

From the measurements of the electrical resistance of carbonate rock samples from Middle East oil reservoirs, by Fuck and Mann (1987), it was found that the calculated values for a variety of petrophysicases in carbonates vary greatly, and with the range of a changes that

have so far occurred for natural stones. It's calculated to be inconsistent. Due to the incremental increase in porosity, permeability decreases, and the creep resistance factor and cement factor increase.

Investigation of the Relationship between Special Resistance and Perforation

In fact, in carbonate reservoirs due to the complexity of the pore system and as a result of the electric current, there can be no logical connection between the electrical resistance and permeability (Figure. 2), while the same relationship has been investigated in each hydraulic flow unit, and the relationship Experimental $K-aF^u$ is the proper processing in this type of communication (Figureures 3 to 6). The relative correlation coefficient of the graphs also confirms this.

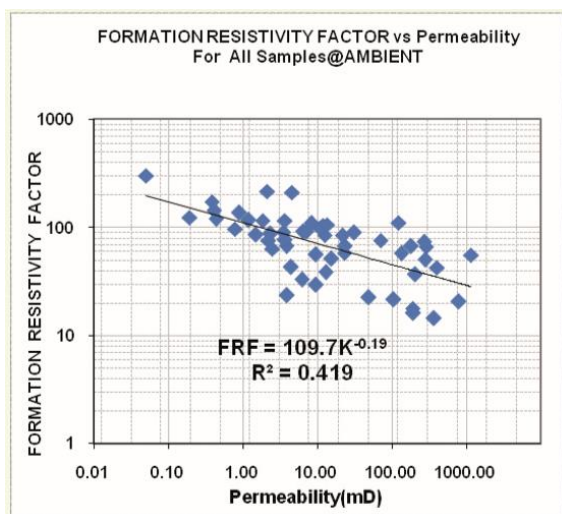


Figure 2. Relation of the special resistance to perforation for all specimens

Investigation of the Relationship between Specific Resistance to Porosity Formation

In the general method, the logarithmic diagram of F in terms of ϕ will be obtained by a line whose slope M and the width from the origin of a will be. In justifying the different values of a and m , the increase in the degree of cementitiousness has a greater effect on the formation factor than on the porosity. Therefore, in this case, the value

is m and the value is less than s . While the reduction of spherical grain sorting has less effect on the formation factor than the cement coefficient. Therefore, m is less and the value of a is much higher. These two parameters are largely influenced by the pore space and the general characteristics of the pores such as the shape of the alignment, the size and pore deformation, the scintillation coefficient, the type of porosity system (intergranular, crystalline, fracture), compression, and clay content.

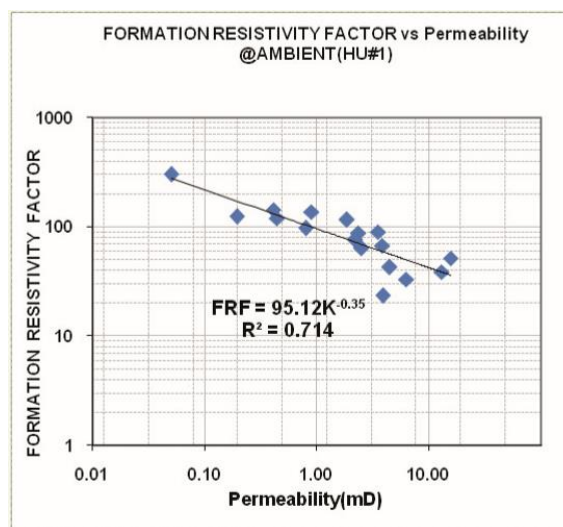


Figure 3. Correlation of Resistance Specific Resistance to Perforation Unit 1

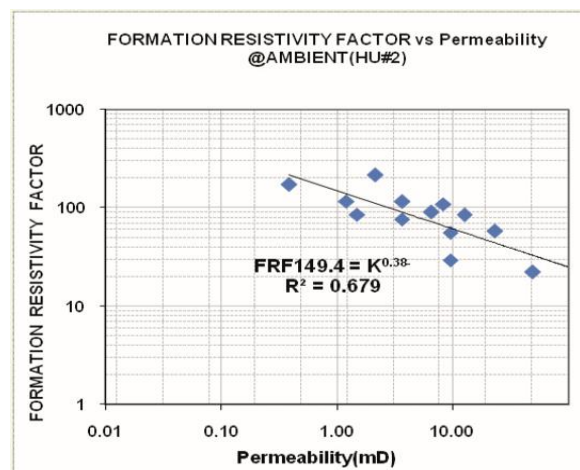


Figure 4. The relationship between the resistance of the formation with permeability for the flow unit 2

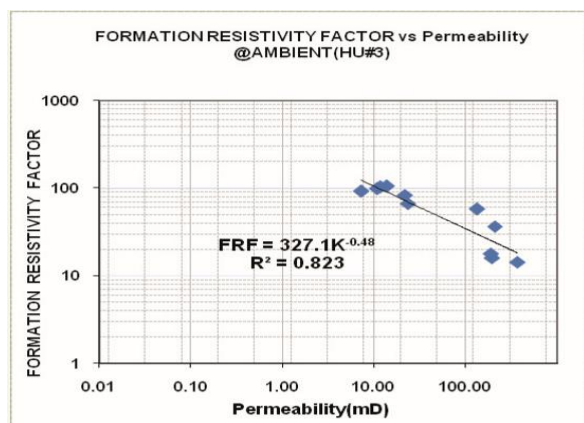


Figure 5. The relationship between the resistance of the formation with permeability for the flow unit 3

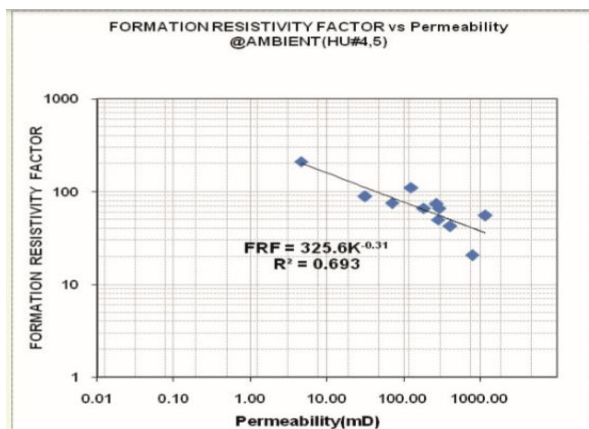


Figure 6. The relationship between the resistance of the formation with permeability for the flow unit 4 and 5

Figure 7 shows the relationship between porosity specific resistance for all samples of carbonate reservoir. As can be seen, in this type of connection, the data dispersion decreases with the porosity enhancement.

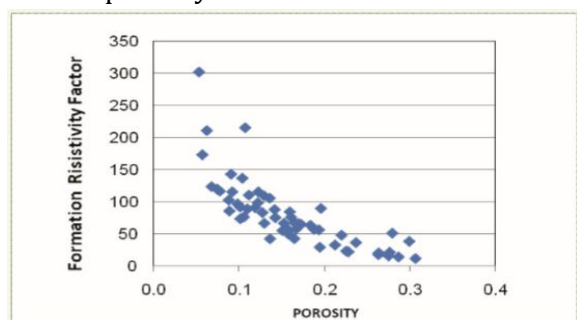


Figure 7. Relationship between special resistivity and porosity for all specimens

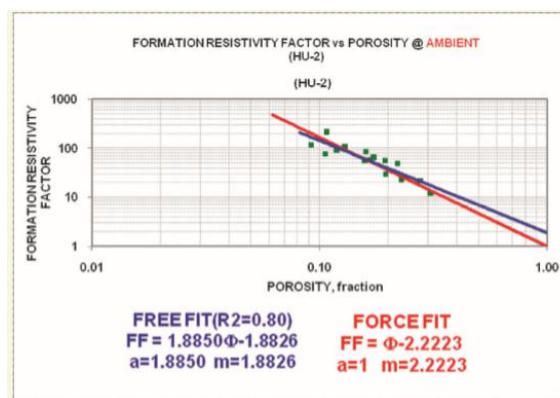


Figure 8. Specific Resistance and Porosity Resistance for Unit 1 in Ambient Pressure

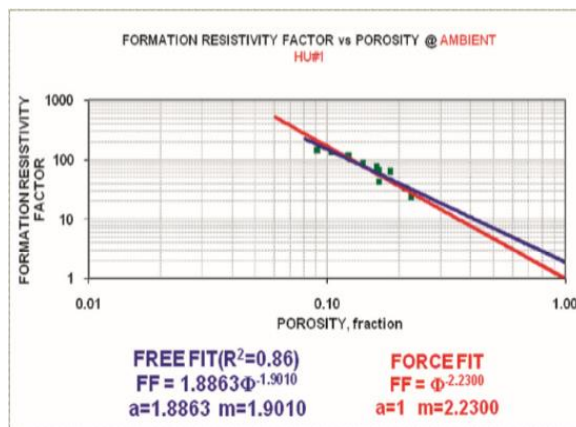


Figure 9. Specific Resistance and Porosity Resistance for Unit 2 in Ambient Pressure

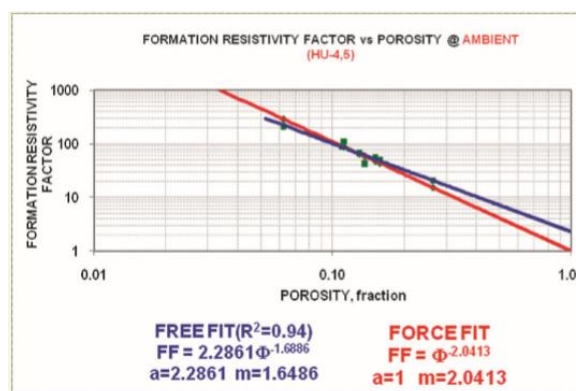


Figure 10. Specific Resistance and Porosity Resistance for Flow Unit No. 3 at ambient pressure

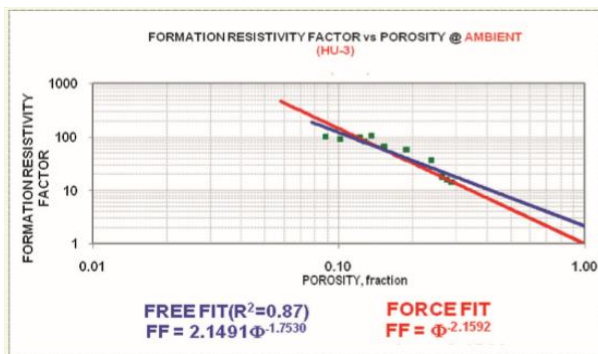


Figure 11. Specific resistance of the formation and the resistance of the flow unit 4 and 5 at ambient pressure

Logarithmic graphs (8 to 11) show the same type of connection in each hydraulic flow unit. Charts In addition to determining a and m in two modes of force and free, in each unit, 5 units of the given connection flow are presented as empirical formulas. The relatively high correlation coefficient in these diagrams implies the suitability of the data classification method.

Conclusion

1. The reason for viewing the correlation between permeability and electrical resistivity in the reservoir of the study could be the uniformity of the path of the electric current and the flow of fluid in the hydraulic flow units.
2. Due to the increased correlation between porosity and the specific electrical resistance of each unit of hydraulic flow of the reservoir studied, the values of the arithmetic coefficient (a , m) are closer to reality. As a result, the estimation of hydrocarbon in the reservoir will be closer to reality.

3. By increasing the number of hydraulic unit units in the reservoir which will increase FZI, the amount of m (cement factor) decreased.

References

- [1] P Fotland., et al., Detection of asphaltene precipitation and amounts precipitated by measurement of electrical conductivity, Fluid Phase Equilibria, **2011** 96:194-122. [[Google Scholar](#)], [[Publisher](#)], [[Crossref](#)]
- [2] JS Buckley., Prediction the Onset of Asphaltene Precipitation from Refractive Index Measurements, Energy Fuels, **2014** 13:369 [[Google Scholar](#)], [[Publisher](#)], [[Crossref](#)]
- [3] P Ekholm., et al., A quartz crystal microbalance study of the adsorption of asphaltenes and resins onto a hydrophilic surface, J. Colloid and Interface Sci., **2002** 247:342-350. [[Google Scholar](#)], [[Publisher](#)], [[Crossref](#)]
- [4] N Nashaat., et al., Iron oxide nanoparticles for rapid adsorption and enhanced catalytic oxidation of thermally cracked asphaltenes, Fuel, **2010** 95:257- 262. [[Google Scholar](#)], [[Publisher](#)], [[Crossref](#)]
- [5] A Tirjoo., et al., Molecular dynamics simulations of asphaltene aggregation under different conditions. Elsevier Journal of Petroleum Science and Engineering. **2019** 177: 392-402. [[Google Scholar](#)], [[Publisher](#)], [[Crossref](#)]
- [6] M Alhreez, D Wenb., Controlled releases of asphaltene inhibitors by nano-emulsions. Fuel. **2018** 234:538-548. [[Google Scholar](#)], [[Publisher](#)], [[Crossref](#)]

This journal is a double-blind peer-reviewed journal covering all areas in Chemistry, Medicinal and Petroleum. EJCMPR is published quarterly (6 issues per year) online and in print. Copyright © 2024 by ASC ([Amir Samimi Company](#)) which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.