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Extended Abstract

A Comparison of the Impact of Different Pore Types on the Electrical Properties of the Dalan and Kangan Carbonate Formations in the Central Part of the Persian Gulf

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Abstract
Porosity and its types are among the most important reservoir characteristics. Formation resistivity is another crucial petrophysical property of reservoirs that allows for the calculation of water saturation and subsequently hydrocarbon saturation. Therefore, investigating the impact of pore type on electrical resistivity will enhance our understanding of the relationship between geological and petrophysical properties and reservoir evaluation, especially in carbonate reservoirs. In this study, cores, plugs, microscopic thin sections and resistivity logs from a well in the Dalan and Kangan carbonate-evaporite formations with a thickness of 342.92 meters were used. A total of 1367 thin sections were prepared from the prepared plugs, and the lithological characteristics, sedimentary textures, pore types and diagenetic processes were determined. Archie's coefficients and water saturation were determined and calculated for each pore type using laboratory and well log data. Then, using water saturation data and laboratory porosity values, the impact and comparison of each identified pore type on electrical resistivity were investigated. The results showed that porosity has a significant impact on electrical resistivity. With an increase in porosity in all pore types, electrical resistivity decreases, but the rate of change and average electrical resistivity in different pores vary. Vuggy porosities, with the highest porosity values, have lower electrical resistivity, while no visible porosities (microporosity), with the lowest porosity values, have a higher average electrical resistivity compared to other identified porosities. In addition, water saturation also plays a significant role in electrical resistivity, and with a decrease in water saturation in all studied porosities, electrical resistivity increases. Diagenetic processes that increase porosity, such as dissolution in moldic porosities and dolomitization in intercrystalline porosities, lead to a decrease in electrical resistivity, and processes that reduce porosity, such as anhydrite cementation and pore-filling anhydrites by reducing pore space, lead to an increase in electrical resistivity.

1. Introduction

The pore system and its modifying factors play a crucial role in controlling fluid distribution and petrophysical characteristics. Given the complexity and heterogeneity of carbonate reservoirs, the use of constant Archie coefficients for water saturation calculations is not reasonable and can lead to significant errors [1,2]. The electrical resistivity of sedimentary rocks saturated with fluid is primarily controlled by their pore structure. Consequently, pore size, shape, connectivity and throat size influence electrical current flow. Different pore types control both fluid flow and electrical current. Numerous studies have investigated pore structure and its impact on resistivity factor and formation resistivity [3-5]. These studies have confirmed the effects of pore structure and geometry on electrical resistivity; however, the impact of different pore types on the formation resistivity in

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carbonate reservoirs, along with well log, laboratory and microscopic data, has not been comprehensively studied.

2. Methodology

Cores from a well with a total depth of 342.92 meters were used for plug and thin section analysis. Deep resistivity log data from the same depth as the cores were also utilized. Thin sections were prepared from the extracted plugs, resulting in a total of 1367 thin sections from the Dalan and Kangan formations in the Persian Gulf. Microscopic studies were conducted on these thin sections to investigate petrographic characteristics such as lithology, sedimentary textures, pore types and diagenetic processes. The formation water resistivity at 25 degrees Celsius was determined to be 0.0431 ohm.m through formation water testing. 58 plugs were used for formation factor tests and 20 plugs for resistivity index tests to determine Archie's coefficients (a, m, n) for each pore type. Water saturation was calculated using Archie's equation [6], which is one of the most important and widely used formulas for calculating water saturation.

3. Results and Conclusions

The frequency distribution of electrical resistivities for each pore type is also shown in Figure 1. The frequency of high resistivities (1000 to greater than 2000 ohm.m) is higher in no visible and fracture porosities compared to other porosities (Fig. 1). Resistivities of 1 to 10 ohm.m have the highest frequency in vuggy and intercrystalline porosities. Except for no visible and fracture porosities, other porosities have the highest frequency of resistivity between 10 and 100 ohm.m (Fig. 1).

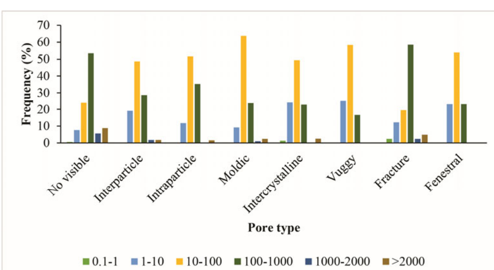

Fig. 1. Frequency distribution of electrical resistivity within the range of 0.1 to greater than 2000 ohm.m for the studied pore types.

Results showed that porosity plays a significant role in altering electrical resistivity, with increasing porosity and water saturation leading to decreased resistivity. Diagenetic processes that enhance porosity, such as dissolution and dolomitization in the studied sequence, resulted in lower electrical resistivity. Diagenetic processes that reduce porosity, particularly anhydrite cements and pore-filling anhydrite, led to increased electrical resistivity. Vuggy and intercrystalline porosities exhibited lower electrical resistivities compared to Interparticle and Intraparticle porosities.

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