Abstract

Reservoir modeling of carbonate rocks requires a proper understanding of the pore space distribution and its relationship to permeability. Fractal geometry is one way to characterize the distribution of pore spaces in rock samples. Pape et al. (1987) described a pigeonhole fractal model for characterizing the pore space in rock samples. They also extracted the fractal dimension and described its relationship to the tortuosity and the formation factor of the studied samples. In this study we apply the pigeonhole fractal model to moldic pore spaces observed in thin-section photomicrographs obtained from the Happy Spraberry Field in Garza County of the Midland Basin. The pigeonhole fractal model is particularly useful for approximating moldic pores due to their circular-like like shapes. We describe and use the Minkowski-Bouligand box-counting method to estimate the fractal dimension of the moldic pore spaces. We then combine the Kozeny-Carman equation together with the fractal theory of porous media to estimate the nonlinear increase in permeability at porosities increases and derive an empirical relationship between permeability and porosity expressed as \( k = 4.3 \times 10^{11} r_{\text{grain}}^2 \Phi^{7/5} \) (where \( k \) is permeability and \( \Phi \) is porosity and \( r_{\text{grain}} \) is average grain size radius). The permeability calculated using the empirical relationship shows a good match with measured permeability.

References Cited


Imsalem, M., P. Pondthai, and A. Raymond, 2018, Preliminary Establishment of Al-Athrun, Uwayliah and Apollonia Formations Based on Magnetostratigraphic Investigation, NE Libya.


The concept of fractals was introduced by Benoit Mandelbrot (1983) and can be observed extensively in many areas of geology and geophysics (Turcotte, 1992; Xie, 2010). Scale invariance of intrinsic patterns is an important concept in geology that can be observed in numerous geological objects and phenomena. These geological objects and phenomena are described as containing statistically self-similar patterns often modeled with fractal geometry.

Fractal geometry has been used extensively to characterize pore space and fracture distribution of both carbonate and clastic rocks as well as the transport properties of porous media and fluid flow in reservoirs. The fractal properties are usually estimated from thin-section photomicrograph images or scanning electron microscope images. The fractal dimension obtained is approximately 2.05; we substitute it in the 2nd and 3rd equations and combine the results with the first equation to obtain:

\[ T = 1.34 \frac{T_{\text{grain}}^2}{T_{\text{eff}}} \]
\[ \phi = 0.5 \frac{T_{\text{grain}}^2}{T_{\text{eff}}} \]
\[ k = 4.3 \times 10^{11} \phi^{5/3} \]

The Happy Spraberry Field
Texas is located in Garza County on the northern part of the Midland Basin.

It produces oil from heterogeneous shallow shelf carbonates of the Permian-aged Lower Clear Fork Formation. The reservoir facies have cemented and dissolved enhanced pore types caused by facies selective diagenesis. Molds pores are the most abundant across the field and dominate the dolitic skeletal granito-pakstone facies.

We make use of this section photomicrographis of the reservoir facies from a well in the Happy Spraberry Field.

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