Permeability dependence of porosity and P-wave velocity in carbonate rocks

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This paper shows a petrophysical characterization of carbonate rocks extracted from two outcrops in the Middle East. Carbonates are heterogeneous that affect the relationship between porosity and permeability and other properties. By using a multivariate analysis, it was possible to find out an empirical model to correlate permeability to porosity and P-wave velocity. The porosimeter was used to estimate bulk volume then calculate pore volume and porosity. A poroperm instrument was used to determine rock permeability. For estimating the mineral content XRD and XRF were used. Main textures found in OM and SEM images consisted in grainstones of A1 rocks and crystalline dolostones of B1, B2 and BX samples. The crossplot between porosity and the natural logarithm of the gas permeability shows a linear behavior except for A1/1 5.2D (1) and BX/1 D2F (1). The first presented low permeability and the latter presented a strong dolomitization process. Such linear trend resulted in a fairly coefficient of determination (R^2 =0.54). Elastic velocities were obtained using ultrasonic transducers in the room-dried samples. The correlation between P-wave velocity (Vp) porosity resulted in high R^2 (0.80) through a power law fitting. The permeability model was performed through a comparison between the measured permeability and estimates obtained using the linear regression (LR). Using a multivariate linear regression, it was possible to observe the dependence of permeability not only to porosity but also to other properties. A low P-value (< 0.5), a high t-Stat (>0.8) and high R^2 (0.78) assures the efficiency of the resulting linear model. In conclusion, although those rocks exhibit different textures and mineral contents (A1 showed a predominance of calcite while B1, B2 and BX, showed calcite and dolomite), the permeability dependence to porosity showed a fairly correlation. An MRL analysis provided an empiric model that could enhance this prediction by including the permeability dependence to P-wave velocity. The characterization of the physical properties of the rocks can help the general understanding of the analogous reservoirs in the Middle East.

Keywords: Permeability, Porosity, P-wave.